AGRICULTURAL WATER USE AND DEVELOPMENT PLAN UPDATE

STATE OF HAWAII DEPARTMENT OF AGRICULTURE

December 2019
Revised 2021

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Prepared for:
State of Hawai‘i
Department of Agriculture
Agricultural Resource Management Division

Prepared by:
EKNA Services, Inc.

ACKNOWLEDGMENT

The authors would like to thank the farmers, ranchers, irrigation system managers and representatives, and other agriculture stakeholders for their time, effort, interviews, and discussions on various agricultural water topics. These interviews and discussions provided valuable input and information on topics such as agricultural water use, issues and concerns, and irrigation systems. Without these hardworking individuals, the agricultural industry would not survive, and sustainability would not be possible.

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LIST OF ACRONYMS

A&B	Alexander & Baldwin
ALISH	Agricultural Lands of Importance to the State of Hawai‘i
ADC	State of Hawai‘i, Agricultural Development Corporation
ARMD	Agricultural Resource Management Division
AWUDP	Agricultural Water Use and Development Plan
BMP	Best Management Practices
CIP	Capital Improvement Program
CMP	Corrugated Metal Pipe
CRM	Concrete Rock Masonry
CWRM	DLNR Commission on Water Resources Management
DBEDT	State of Hawai‘i, Department of Business, Economic Development and Tourism
DHHL	State of Hawai‘i, Department of Hawaiian Home Lands
DI	Ductile Iron
DLNR	State of Hawai‘i, Department of Land and Natural Resources
EKIS	East Kaua‘i Irrigation System
EMI	East Maui Irrigation System
FOB	Free-on-board
GGT	George Galbraith Trust
GIS	Geographical Information System
GLIS	Galbraith Lands Irrigation System
gpd	Gallons per day
gpd/acre	Gallons per day per acre
GPS	Global Positioning System
HASS	Hawai‘i Agricultural Statistics
HC&S	Hawaiian Commercial & Sugar Company
HDOA	State of Hawai‘i Department of Agriculture
HDPE	High-density polyethylene plastic

HHFDC	Hawai‘i Housing Finance and Development Corporation
HRS	Hawai‘i Revised Statutes
IAL	Important Agricultural Lands
IIFS	Interim Instream Flow Standards
IWREDSS	Irrigation Water Requirement Estimation Decision Support System
KEDIS	Kekaha Ditch Irrigation System
KODIS	Kōke‘e Ditch Irrigation System
KSBE	Kamehameha School Bishop Estate
KSWRS	Kula Stormwater Reclamation Study
LCC	Land Capability Classification
LF	Linear Feet
LHD	Lower Hāmākua Ditch
MG	Million gallons
MGD	Million gallons per day
MG/yr	Million gallons per year
MIS	Moloka‘i Irrigation System
NASS	USDA National Agricultural Service Statistics
NRCS	National Resources Conservation Service
SCADA	Supervisory Control and Data Acquisition
UHD	Upper Hāmākua Ditch
USDA	United States of America Department of Agriculture
USGS	United States of America Geological Survey
WDIS	Waiāhole Ditch Irrigation System
WIS	Waimānalo Irrigation System or Waimea Irrigation System
WMA	Water Management Area
WUP	Water Use Permit
WWTP	Wahiawā Wastewater Treatment Plant

EXECUTIVE SUMMARY

The essential need for water to grow crops and maintain a viable agricultural industry led to legislation to prepare an Agricultural Water Use and Development Plan (AWUDP). The State of Hawai‘i, Department of Agriculture published the original AWUDP in December 2003, revised December 2004.

This document is an update to the 2004 AWUDP. This AWUDP Update is a culmination of research of past studies, scientific data, publicly available information, onsite inspections, and interviews with water system managers and farmers throughout the state. This revised 2021 edition includes updated information received from the Hawaii Commission on Water Resource Management (CWRM).

The objectives for this AWUDP Update are as follows:

- Meet the requirements of Hawai‘i Revised Statutes 174C-31e;
- Inventory water systems not inventoried in the 2004 AWUDP;
- Update agriculture planning water demand rate and water demand forecasts; and
- Propose a five-year program to repair the systems and set up a long-range plan to manage the systems.

Inventory

This AWUDP Update includes an inventory of water systems that were not examined in the 2004 AWUDP (shown in Table ES-1). The inventory provides information and maps of the agricultural water systems, including system alignments and components, agricultural potential, land use (crop categories), Important Agricultural Lands, condition of the systems, and proposed improvements, if applicable. This study found most of the agricultural water systems in use, and in relatively good or fair condition. Limited portions of systems found to be in poor condition have the potential to be rehabilitated with additional resources.

This document also updates the status of systems inventoried in the 2004 AWUDP (Table ES-1) and associated capital improvements. These water systems are still in use, and various capital improvement projects have since been completed. Additional capital improvement projects are underway.

Table ES-1
Hawai‘i Agricultural Water Systems Reviewed for the AWUDP Update and 2004 AWUDP

AWUDP Update	2004 AWUDP
Kaua‘i - Kaloko and Pu‘u Ka Ele Ditches - Stone Dam and Kalihiwai Irrigation Subsystems - Anahola Ditch - Upper and Lower Līhu‘e Ditches and portion of Waiahi-‘Ili‘ili‘ula Ditch - Upper and Lower Ha‘ikū Ditches - Wai‘aha-Ku‘ia Aqueduct, por. Waiahi-‘Ili‘ili‘ula Ditch, and Kōloa & Wilcox Ditches - Olokele Ditch O‘ahu - O‘ahu Ditch (Wahiawā, Helemano, Tanaka, and Ito Ditches) - ‘Ōpae‘ula, and Kamananui Ditches - Kahuku Irrigation System - Galbraith Lands Irrigation System Hawai‘i - Ka‘ū Agribusiness Irrigation System - Kohala Ditch - Kehena Ditch	Kaua‘i - East Kaua‘i Irrigation System - Kekaha Ditch Irrigation System - Kōke‘e Ditch Irrigation System - Kaua‘i Coffee Irrigation System O‘ahu - Waiāhole Ditch Irrigation System - Waimānalo Irrigation System Molokai - Moloka‘i Irrigation System Maui - Maui Land and Pineapple/Pioneer Mill Irrigation System - East Maui Irrigation System - West Maui Irrigation System - Upcountry Maui Irrigation System Hawai‘i - Lower Hāmākua Ditch Irrigation System - Waimea Irrigation System

2014 Farmer Survey

The cost of water, other farm inputs, and availability of labor all affect the economic viability of Hawai‘i’s agriculture industry, especially when competing with cheaper imports and foreign commodities in state and offshore markets.

The underlying sentiment expressed by system managers and farmers during the development of this AWUDP is the importance of keeping water systems and flow at current levels to maintain or increase agricultural production.

Several agricultural areas are restricted from fully utilizing the available land area due to lack of water or prohibitive water costs. During the development of this plan, farmers suggested several areas where additional water resources could potentially increase diversified agriculture and use of irrigated pastures. These areas are within the North and South Kohala regions of Hawaiʻi and the lower and upper Kula areas of Maui. The development plan recommends funding for initial studies of these potential systems to determine feasibility, development cost, stakeholders, and management.

Recommended Water Demand Rates

Planning for agricultural water demand is key to reserving enough water to sustain and grow the agricultural industry. For planning purposes this AWUDP Update reevaluates the water demand rate. The 2004 AWUDP found the water demand rate to be 3,400 gallons per day per acre, based on an analysis of actual metered water demand from one growing area. This AWUDP Update expands on this analysis by evaluating water demand from 113 farms growing different crops in various growing regions throughout the state; water demand rates from farms in Kunia, Oʻahu; and published historical demand rates. Based on this evaluation, the planning-level agricultural water demand rates at the farm-level water meter are as follows:

- 3,900 gpd/acre for diversified agriculture, for usable acreage that is 50 percent planted (average condition);
- 7,800 gpd/acre for diversified agriculture, for usable acreage that is 100 percent planted;
- 8,100 gpd/acre for diversified agriculture, for usable acreage that is 50 percent planted, under drought conditions or in dry areas;
- 16,200 gpd/acre for diversified agriculture for usable acreage that is 100 percent planted, under drought or dry conditions; and
- 8,000 gpd/acre or more for irrigated pastures (usable acreage that is 100 percent planted.

These water demand rates are for statewide planning for agricultural water demand. If a specific site is being studied, a site-specific water demand analysis should be completed.

Forecast

This AWUDP Update develops new forecasts for water demand. As most of the existing agricultural water systems are or will soon be over a hundred years old, future water delivery will be significantly influenced by these systems' condition and ability to provide water. To address the vulnerability and reliance on these systems, forecasts are based on capital investment into the agricultural water systems for maintenance and improvement. Therefore, the forecast has three scenarios: 1) no-action, 2) continued maintenance, and 3) increased capital investment. The water demand at the planning horizon is as follows.

- No-action scenario. The no-action scenario assumes that no resources are used to maintain or upgrade the system. Water flow in the system will shut down due to a failure in the water system. At the planning horizon, the forecast water demand will be zero (0) million gallons per day, and agricultural production will significantly decrease.

- Continued maintenance. The continued maintenance scenario assumes that resources are available to maintain the current system and will be able to meet the forecast agricultural farm value growth rate. The forecast agricultural farm value growth rate is based on historical trend analysis and is less than one percent (1%) per year. Therefore, the forecast water demand in this scenario is estimated to be 734 million gallons per day by 2035.

- Increased capital investment. The increased capital investment scenario, or high forecast, assumes greater agricultural production to assist the state in achieving policies such as sustainability, self-sufficiency, and import replacement. In addition, water systems need to be resilient to the impacts of climate change, as espoused in the smart and resilient city concepts. The forecast water demand in this scenario is estimated to be 1,170 million gallons per day by 2035.

Development Plan

The development plan includes proposed maintenance and capital improvement projects for continued use of the studied irrigation systems (continued maintenance scenario). To maintain the current systems and conduct initial studies for expanded water systems, the cost is estimated to be 167.5 million dollars (2018 dollars) for the first five years.

The development plan also includes potential long-range strategies for system management. Details for long-term investment will not be determined until initial maintenance and capital improvement projects are completed.

Conclusion

Agriculture is an essential component for the state to achieve its goals of sustainability and a diversified economy. The agricultural industry relies on these water systems to deliver inexpensive water to meet and expand agricultural production in normal and drought conditions. By supporting, maintaining, improving, and expanding these water systems, farmers have the potential to maximize the use of agricultural lands and produce agricultural commodities to meet state and export market demands.

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CHAPTER 1
INTRODUCTION

The State shall conserve and protect agricultural lands, promote diversified agriculture, increase agricultural self-sufficiency, and assure the availability of agriculturally suitable lands.
State Constitution

In the late 1990s, the transition of ownership and management of the plantation water systems to other entities, including the State of Hawaiʻi, was increasing. To protect the water systems affected by plantation closures, the State of Hawaiʻi legislature and Governor Benjamin Cayetano enacted Act 101 in 1998, which became Hawaiʻi Revised Statutes (HRS) Chapter 174C-31(e). The HRS 174C-31(e) created the objectives of the Agricultural Water Use and Development Plan (AWUDP) and directs the Commission on Water Resource Management (CWRM) to include the AWUDP in the Hawaiʻi State Water Projects Plan. The statute states that the State of Hawaiʻi, Department of Agriculture (HDOA) shall prepare a master irrigation inventory plan to cover the following topics.

- Inventory public and private irrigation water systems.
- Identify the extent of rehabilitation needed for each system.
- Identify source(s) of water used by agricultural operations, particularly those on lands identified and designated as important agricultural land under part III of chapter 205.
- Identify current and future water needs for agricultural operations, particularly those on land identified and designated as important agricultural lands under part III of chapter 205.
- Subsidize the cost of repair and maintenance of the systems.
- Establish criteria to prioritize the rehabilitation of the systems.
- Develop a five-year program to repair the systems.
- Set up a long-range plan to manage the systems.

This revised edition (2021) incorporates data from CWRM and addresses relevant comments provided during agency and public review. The agency and public comments are presented in the Appedix. The AWUDP is intended for inclusion in the state's Water Projects Plan by CWRM. In 2000, CWRM developed a set of guidelines for the AWUDP, titled the *Statewide Framework for Updating the Hawaiʻi Water Plan* (Framework). The Framework is provided in Appendix B, and the objective of the AWUDP in the Framework is stated below.

> ***Agricultural Water Use and Development Plan (AWUDP)***
> *The major objective of the AWUDP is to develop a long-range management plan that assesses state and private agricultural water use, supply, and irrigation water systems.*
>
> *The plan shall address projected water demands and prioritized rehabilitation of existing agricultural water systems.*

1.1 2004 AGRICULTURAL WATER USE AND DEVELOPMENT PLAN

The 2004 AWUDP was developed as an initial document to meet the requirements of the Hawaiʻi State Water Plan and HRS 174C-31(e). Its two main objectives were to 1) assess and plan for an orderly rehabilitation of former plantation irrigation systems, which are considered to be the most important infrastructural requirement to expand Hawaiʻi's diversified agriculture industry; and 2) ensure that irrigation water supply will be reliable and adequate to meet the current and future water requirements of Hawaiʻi's diversified agriculture industry.

The 2004 AWUDP identified 21 operational irrigation systems in the state. It focused its evaluation on 13 water systems which, at that time, were considered important and viable to Hawaiʻi's growing diversified agriculture industry and existing monocrop industry. These systems, as listed below, are owned and managed by HDOA-Agricultural Resource Management Division (ARMD), the Agricultural Development Corporation (ADC), or private owners. For each system, the AWUDP provided an inventory of the system components, a description of the existing condition of the system components, an assessment of needs to improve the system, and proposed capital and maintenance improvements.

- HDOA-ARMD Systems
  - Waimānalo Irrigation System
  - Molokaʻi Irrigation System
  - Upcountry Maui Irrigation System
  - Waimea Irrigation System
  - Lower Hāmākua Ditch Irrigation System

- ADC Systems
  - Kekaha Ditch Irrigation System
  - Kōkeʻe Ditch Irrigation System
  - East Kauaʻi Irrigation System
  - Maui Land and Pineapple/Pioneer Mill Irrigation System
  - Waiāhole Ditch Irrigation System

- Private Systems
  - East Maui Irrigation System
  - Kauaʻi Coffee Irrigation System
  - West Maui Irrigation System

The AWUDP defined the two categories of improvements as follows:

- *Capital improvements*[1] are those that add to and improve the value of the system, and require professional engineering design and construction by licensed contractors; whereas

[1] Capital improvements are funded by the owners. Typically, government owned systems are funded by public funds and privately owned systems are funded by private funds.

- *Maintenance improvements* are those that are necessary to maintain operational efficiency and viability of the system and can be constructed by the system staff with little or no subcontracting work.

In addition to the system inventory, the AWUDP provided source and resource data, as well as forecast water demand. As water demand for diversified agriculture was considered different from monocrops by legal entities, the AWUDP also analyzed water demand for diversified agriculture. Analysis of metered agricultural water demand over an eight-year period provided an estimated diversified agriculture water demand of 3,400 gallons per day per acre (gpd/acre). This agricultural water demand assumed the use of good agriculture practices, such as crop rotation in production fields. Based on the AWUDP's estimated daily water demand for diversified agriculture, the forecast analysis provided agricultural water demand for the 20-year planning period.

1.2 AWUDP UPDATE GOALS AND OBJECTIVES

As in the 2004 AWUDP, this update reaffirms that agricultural water systems (irrigation systems) are the most important infrastructural requirement to expand Hawai'i's diversified agriculture industry; and that irrigation water supply should be reliable and adequate to meet the current and future water requirements of Hawai'i's diversified agriculture industry.

Therefore, the goals of this AWUDP Update are to 1) provide a comprehensive plan to protect and increase the agriculture water resources available to the diversified agriculture industry; and 2) maintain and improve the agricultural water systems in the State of Hawai'i to support an economically viable diversified agricultural industry for the state, achieving the state's goals of agricultural growth, economic diversity, and sustainability.

To achieve these goals, the primary objectives of this AWUDP are to:

- Meet the requirements of HRS 174C-31(e);

- Inventory those water systems which were not inventoried in the 2004 AWUDP;

- Develop a Capital Improvement Program for each of the agricultural water systems;
- Update water demand forecasts; and
- Propose a development plan to meet existing and future needs.

1.3 REPORT ORGANIZATION

This AWUDP Update is organized into nine (9) sections, which are briefly described below.

Chapter 1 contains a brief introduction, a description of the goals and objectives for this AWUDP Update, and the report organization.

Chapter 2 provides the methodology for creating the maps for each irrigation water system studied in this AWUDP.

Chapter 3 contains an inventory of public and private water systems that were not studied in the 2004 AWUDP but have the potential to be important to the diversified agriculture industry. The following systems were inventoried in this AWUDP.

Kaua‘i

- Kaloko and Pu‘u Ka Ele Ditches
- Stone Dam and Kalihiwai Irrigation Subsystems
- Anahola Ditch
- Upper and Lower Līhu‘e Ditches and a portion of Waiahi-‘Ili‘ili‘ula Ditch
- Upper and Lower Ha‘ikū Ditches
- Wai‘ahi-Ku‘ia Aqueduct, por. Waiahi-‘Ili‘ili‘ula Ditch, and Kōloa & Wilcox Ditches
- Olokele Ditch

O‘ahu

- O‘ahu Ditch (Wahiawā, Helemano, Tanaka, and Ito Ditches)
- ‘Ōpae‘ula, and Kamananui Ditches
- Kahuku Irrigation System
- Galbraith Lands Irrigation System

Hawai‘i

- Ka‘ū Agribusiness Irrigation System
- Kohala Ditch
- Kehena Ditch

Chapter 4 provides an update of the system components studied in the 2004 AWUDP. It describes any modifications to the systems since the 2004 AWUDP and provides the current Capital Improvement Program (CIP) for each water system.

Chapter 5 discusses areas with the potential to increase diversified agriculture production if new water systems are developed.

Chapter 6 presents a farm survey for agriculture water demand and the analysis to determine agricultural water demand rate.

Chapter 7 presents the major limitations, concerns, and policies which may affect crop water demand and the diversified agricultural industry, such as system losses and water rights and management.

Chapter 8 provides a forecast for the agricultural water demand in the short and long term.

Chapter 9 presents a development plan which includes the short-term improvement program and provides suggestions for long-term management of the agricultural water systems.

CHAPTER 2
INVENTORY METHODOLOGY

Farming looks mighty easy when your plow is a pencil, and you're a thousand miles from the corn field.

Dwight D. Eisenhower

The AWUDP Update includes an inventory of 13 private and public irrigation systems in the counties of Kaua‘i, O‘ahu, and Hawai‘i. The system inventory includes a condition assessment of the irrigation system components, if possible; the potential service area associated with the irrigation system; the agricultural use (land use) within the service area; land capability (soil capability) for agriculture; the identification of IAL and water sources; and proposed CIP for the next five (5) years.

The information gathered for the system inventory is graphically depicted in a map series for each agricultural water system and used to develop a CIP. The following subsections provide a description of the methodology used to collect the information and develop the CIP. This chapter provides a general discussion of the information and maps. The detailed information for each agricultural water system is presented in Chapters 3 and 4, and the map series are presented in Appendix A.

Section 2.1 describes the general background information and methodology used to collect the system alignments and component information, as well as the development of the CIP. Section 2.2 describes the methodology used to identify the various land uses (crop categories) for each water system, and section 2.3 discusses the Agricultural Land of Importance to the *State of Hawai‘i* (ALISH) map. Section 2.4 discusses the land capability maps, presenting the land capability for non-irrigated and irrigated conditions. Section 2.5 discusses the IAL map.

2.1 SYSTEM ALIGNMENTS, COMPONENTS, AND CIP

2.1.1 METHODOLOGY AND ANALYSIS

The system alignment verification and system component inventory utilized a walkthrough, as well as analysis of satellite and aerial imagery. The initial step was to acquire access to the irrigation system. If granted,[2] a condition assessment of irrigation system components was performed by walking the length of the system. The walkthrough provided a visual inspection of system components, including the water source, and a handheld global positioning system (GPS) was used to record the location of each component. The GPS location data had an accuracy of one (1) meter and was inputted into a geographical information system (GIS).

The condition of the system components did not utilize any destructive or nondestructive testing. The condition of the system used three (3) broad categories for the condition rating, as follows:

- poor – the component had large areas of deterioration, structural damage, or both;

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[2] HDOA does not have statutory authority to require that owners/managers grant access to their irrigation systems and considered enlisting the CWRM's authority to gain access. However, upon further consideration, the HDOA determined the following:

1. Private owners are committed to providing agricultural water to farmers in their service area. In this effort, they are sharing HDOA's mission of supporting agricultural efforts in the state. The use of CWRM's authority to gain access may create the impression that the AWUDP Update is not solely a product of HDOA.
2. Private owners are ultimately responsible for any maintenance and rehabilitation efforts on their system(s). The AWUDP assists in determining rehabilitation efforts to maintain and improve systems, as well as to prevent system failure. Copies of the AWUDP Update will be provided to private system owners/operators as a tool to review their system and identify any necessary improvements.
3. Other sources could still be used to provide information about irrigation systems, their agricultural capacity, and crop categories.

As such, HDOA elected against using CWRM's authority to gain access to irrigation systems. HDOA believes that the information included in the AWUDP Update is beneficial. It should be noted that HDOA will also pursue access and additional cooperation for future AWUDP updates.

- fair – limited deterioration, no structural damage, and/or moderate overgrowth; and
- good – minor deterioration, maintained with little overgrowth.

The condition rating is one of the criteria used to determine whether or not a system or portion of the system should be rehabilitated. In addition, the condition assessment may be used to determine priority of improvement projects and is not the sole factor in determining improvements or priority.

If access was not granted, the condition of the system was performed by using data from publicly available reports on the condition of the irrigation system, and discussions with the system owner or irrigation manager, if possible. In cases where a visual inspection of the irrigation system was impossible, a condition assessment of system components could not be performed, water source information and system components were not verified, and the five (5)-year CIP is unknown. Therefore, as the system is supporting agriculture purposes with adequate water delivery, the system is considered to be in fair to good condition. The private system owner/operator is maintaining the system, and establishes the improvement projects to maintain or improve their system. That information is confidential to the private system owner/operator.

Information for each system's dams, reservoirs, and water sources were obtained from the DLNR, Engineering Division; and CWRM.[3] The hydrologic units (aquifers) were identified using publicly available maps. The potential service area for each system was determined through interviews with system owners, maps, imagery analysis, HDOA data, proximity to the distribution mains, and topography. A compilation of reported water flow data is presented in Appendix D.

2.1.2 ALIGNMENTS AND SYSTEM COMPONENTS MAP

The first map in the map series (Appendix A) is the *Alignment and System Component* map. This map presents the system alignment; the location and identification of the active, inactive, and unverified system components, such as ditches, tunnels, flumes, intakes, siphons, penstocks, reservoirs, and

[3] CWRM has limited authority on water sources, and these systems have reported to CWRM voluntarily.

dams; the potential service area; and neighboring systems. The neighboring systems are shown, as the systems may be physically linked and may share water resources, currently or in the past.

2.1.3 CAPITAL IMPROVEMENT PROGRAM

The AWUDP Update is intended to address the repair, maintenance, and rehabilitation of the system through the development of a CIP for each agricultural water system. The CIP funding source is dependent upon the system owner and whether it is a public or private system.

Based on the interviews with system owners and the condition inventory (described in Section 2.1.1), a CIP was developed for each system. For most systems, a long-term plan was not available; therefore, the proposed CIP is based on short-term projects. The short-term projects are priority projects for that system, with lesser priority and/or larger projects slated as medium or long-term and as funding is available. As part of the CIP program discussion, long-term management options are discussed in other chapters of this document.

2.2 LAND USE

Since the plantation era, and even since the 2004 AWUDP, the definition of diversified agriculture[4] has changed. Previously, diversified agriculture was typically defined as agricultural crops other than sugarcane and pineapple. However, as there are no large sugarcane growers in the state today and only one large pineapple farm, that definition of diversified agriculture is outdated. Therefore, in this document, “diversified agriculture” encompasses all agricultural crops in the State of Hawai‘i.

2.2.1 DEFINITIONS OF FARMING AND AGRICULTURAL LAND

To provide a uniform evaluation of the various water systems in this AWUDP, two terms are defined. The following definitions from the relevant HRS are presented for farming and agricultural land. HRS Chapter 165-2 defines a farming operation as follows:

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[4] Philipp, Perry F. "*Diversified Agriculture of Hawai‘i*," University of Hawai‘i Press, 1953.

"Farming operation" means a commercial agricultural, silvicultural, or aquacultural facility or pursuit conducted, in whole or in part, including the care and production of livestock and livestock products, poultry and poultry products, apiary products, and plant and animal production for nonfood uses; the planting, cultivating, harvesting, and processing of crops; and the farming or ranching of any plant or animal species in a controlled salt, brackish, or freshwater environment.

HRS Chapter 167 defines agricultural land and farming as follows:

- *“Agricultural land” means that portion of the land of a land occupier lying within an existing or proposed irrigation project and of such location and character as may be profitably employed in the growing of irrigated crops; and "pasture land" means that portion of the land of a land occupier lying within an existing or proposed irrigation project and of such location and character as may be suitable with the use of water for irrigated pasture and may be profitably employed in the production of livestock or poultry.*

- *“Farming” means agricultural pursuits, including the care and production of livestock and poultry, engaged in by a land occupier owning or leasing land, within any existing or proposed irrigation project.*

2.2.2 METHODOLOGY AND ANALYSIS

For each irrigation system, a land use analysis was performed using publicly available aerial imagery and satellite imagery, and new aerial imagery for specific areas with diversified crop mix. The publicly available satellite imagery resolution of two (2) meters was acquired in 2011. The new aerial imagery was obtained in 2014 for this project at a resolution of four centimeters (4 cm) to assist in crop determination in specific production areas, using a piloted aircraft with multiple GPS sensors to obtain an accurate location of the imagery.

Satellite and aerial imagery were processed with vegetation-recognition software, which was calibrated to crops in Hawaiʻi. To the extent possible, the land use information was verified with an aircraft overflight, discussions with system owners, or by visual inspection from the ground. Exhibits 1 to 6 are examples of the aerial and satellite images. Exhibits 7 and 8 are examples of the processed images. A detailed methodology of the imagery analysis is presented in Appendix E.

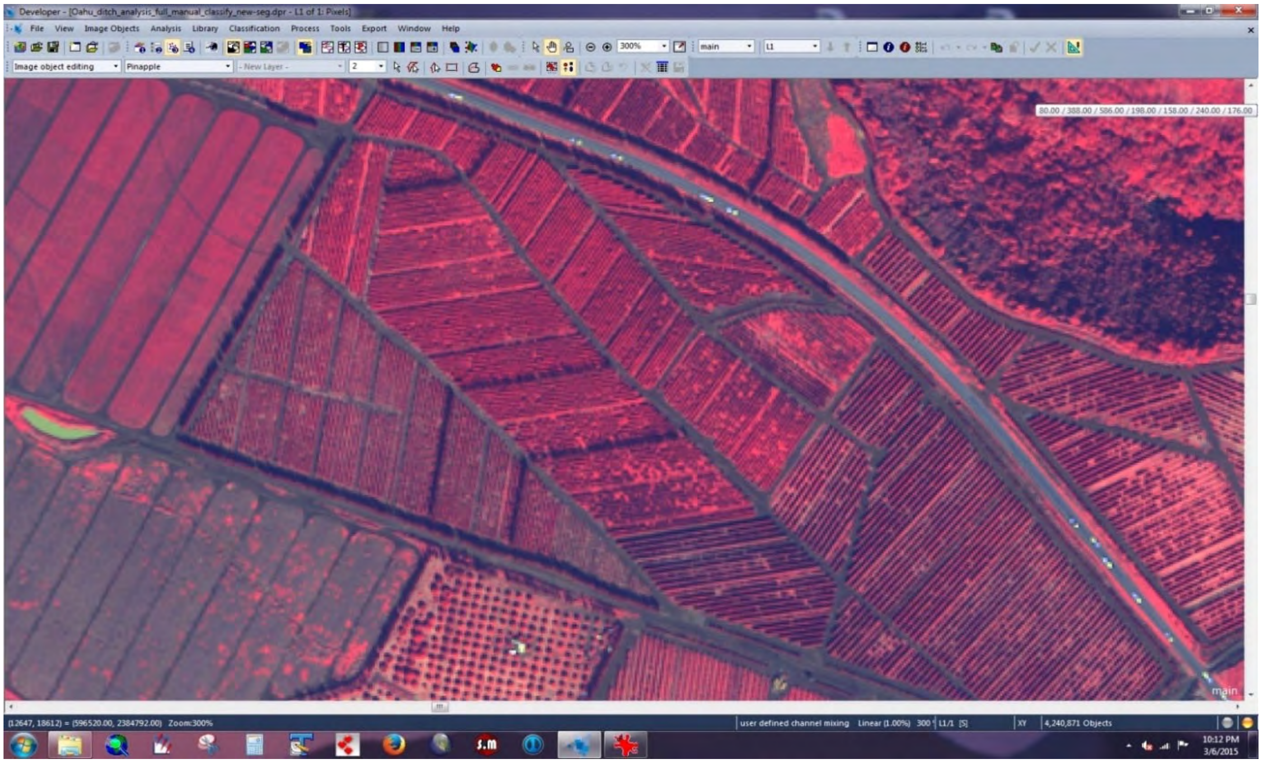

Exhibit 1. World View II satellite (2-meter resolution) - Coffee

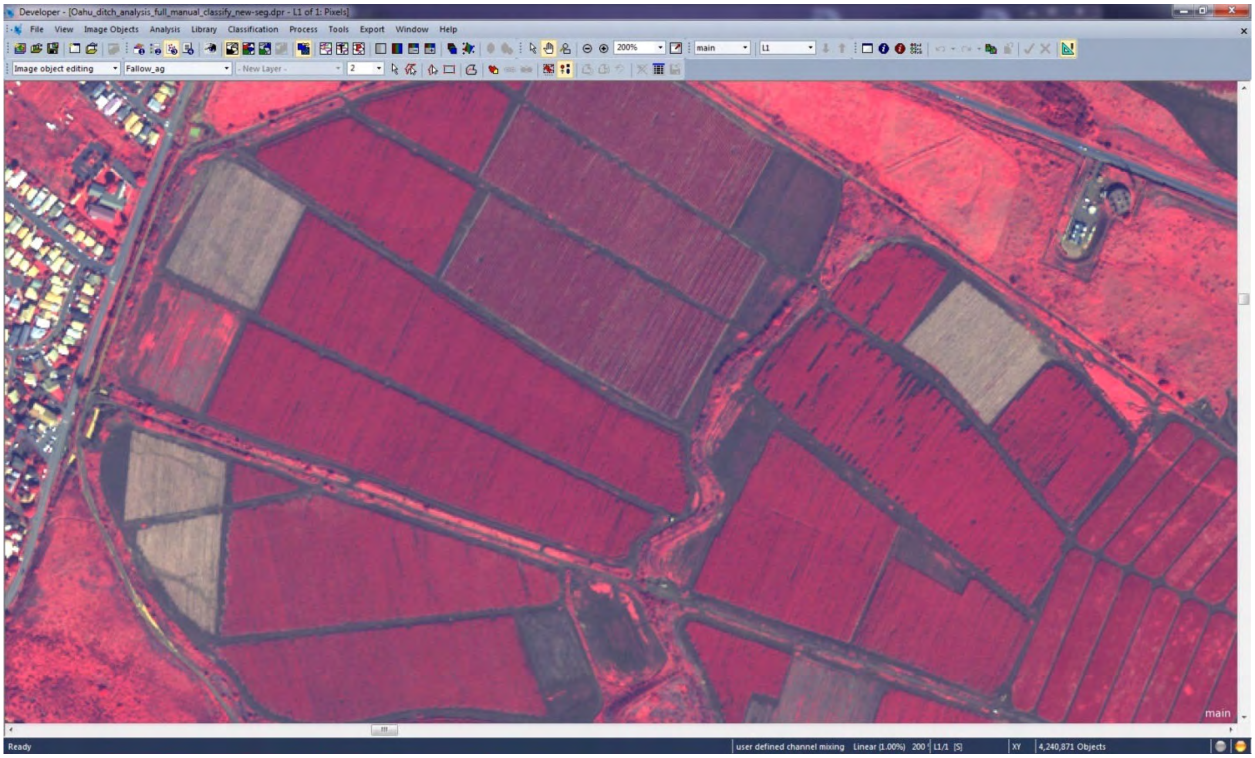

Exhibit 2. World View II satellite (2-meter resolution) - Corn

Exhibit 3. Aerial Imagery (4-centimeter resolution) - Fruit and nut trees

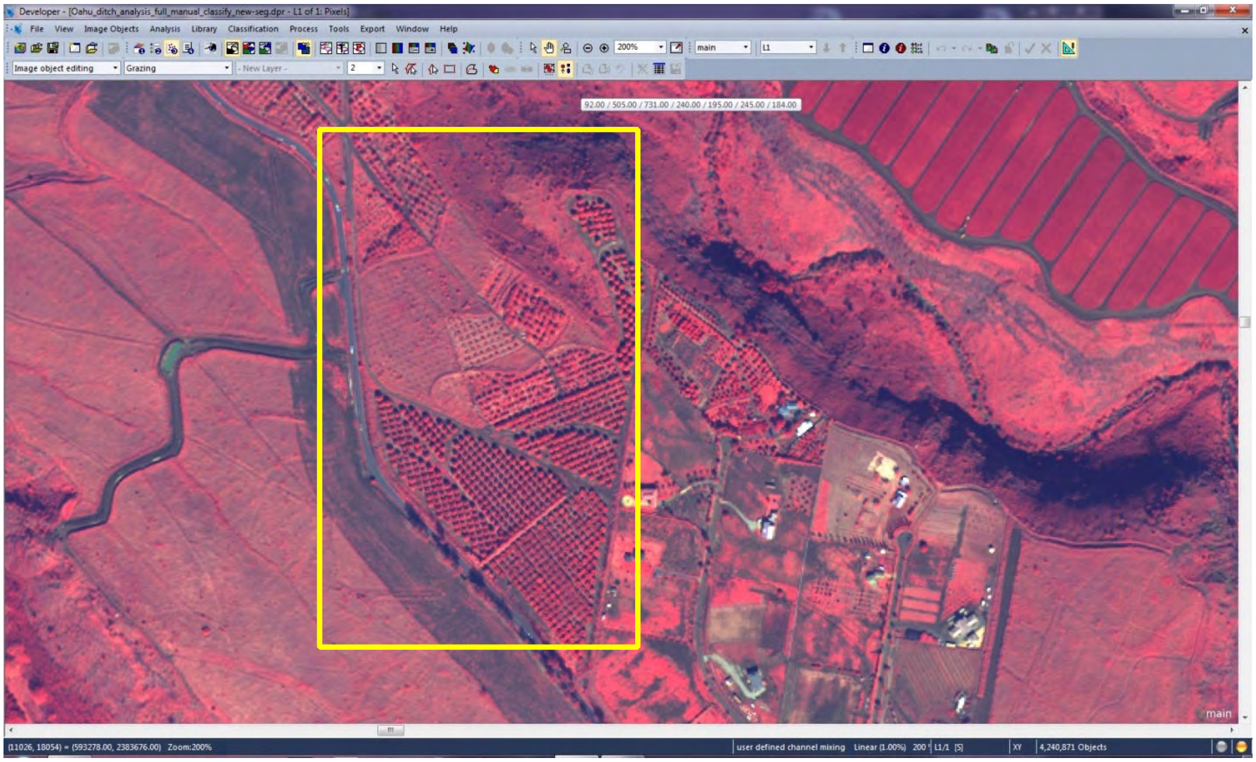

Exhibit 4. World View II satellite (2-meter resolution) - Fruit and nut trees

Exhibit 5. Aerial Imagery (4-centimeter resolution) - Miscellaneous produce

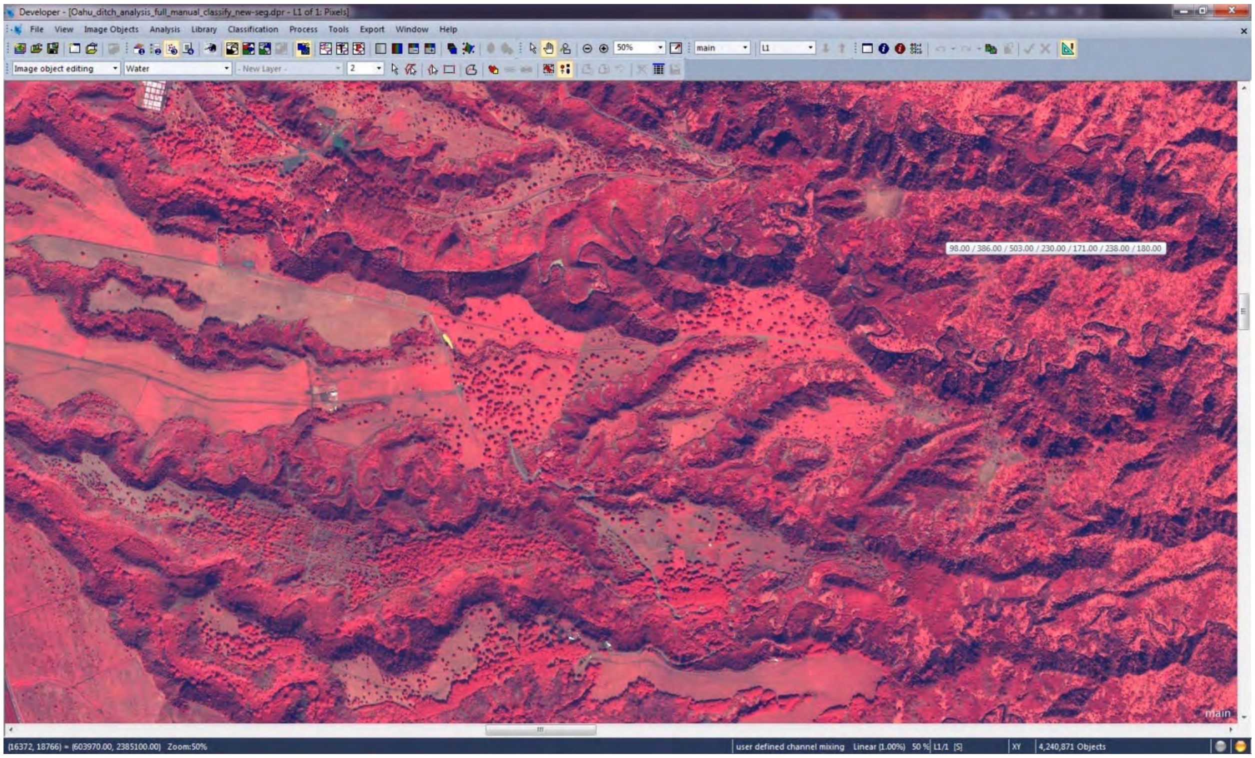

Exhibit 6. World View II satellite (2-meter resolution) - Grazing

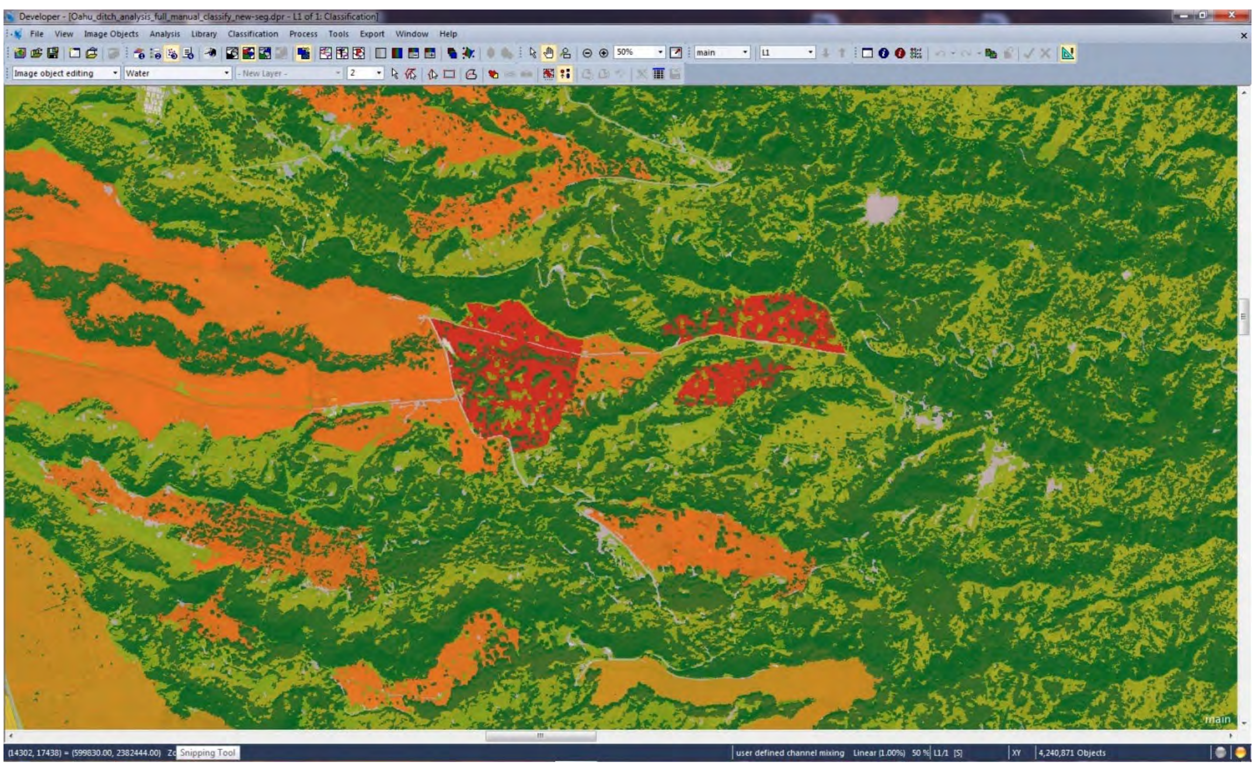

Exhibit 7. eCognition™ Processed Data - Active grazing lands in orange; inactive grazing in red

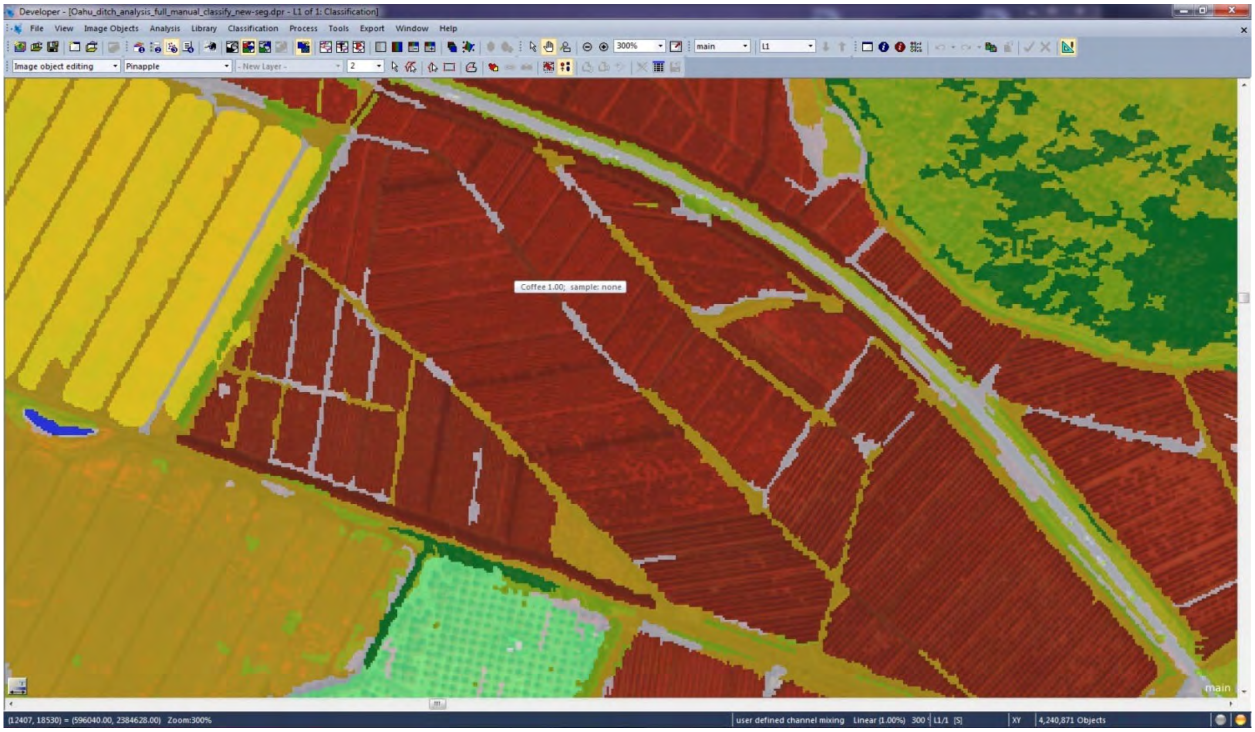

Exhibit 8. eCognition™ Processed Data – Coffee in red

2.2.3 LAND USE MAP

The second map in the series (Appendix A) is the land use map that shows agricultural crop categories occurring within the system's service area. The map depicts land use as one of three (3) broad categories of land use (crops): 1) Grazing, 2) Field Crops, and 3) Other Crops. The Grazing category is the area used for animal grazing. The Field Crops category includes crops such as, but not limited to, agroforestry, sugarcane, pineapple, coffee, and grain corn. The Other Crops category includes crops such as, but not limited to, vegetables, papaya, landscaping, fruit trees, and nut trees.

2.3 AGRICULTURAL LANDS OF IMPORTANCE TO THE STATE OF HAWAI'I

2.3.1 METHODOLOGY AND ANALYSIS

The *Agricultural Lands of Importance to the State of Hawai'i* (ALISH) maps are based on the publicly available GIS data set from the State of Hawai'i. The

ALISH map series was developed in 1977 by HDOA, with assistance from the Soil Conservation Service, U.S. Department of Agriculture, and University of Hawaiʻi. The ALISH maps are used to determine lands that are important farmlands in the state. The ALISH study excluded the following land use or land types:

- developed urban lands over 10 acres;
- natural or artificial enclosed bodies of water over 10 acres;
- forest reserves;
- public use lands such as parks and historical sites;
- lands with slopes in excess of 35 percent; and
- military installations, except undeveloped areas over 10 acres.

The analysis grouped the remaining lands into three (3) importance categories: Prime, Unique, and Other Important. Each category is described below.

- **Prime Agricultural Land** is land best suited to produce food, feed, forage, and fiber crops. The land has the soil quality, growing season, and moisture supply needed to produce sustained high yields of crops economically when treated and managed, including water management, according to modern farming methods.
- **Unique Agricultural Land** is land other than Prime Agricultural Land that is used to produce specific high-value food crops. These lands have the special combination of soil quality, growing season, temperature, humidity, sunlight, drainage, elevation, aspect,[5] moisture supply, or other conditions, such as nearness to market, that favor the production of a specific crop of high quality and/or high yield when the land is treated and managed according to modern farming methods. In Hawaiʻi, some examples of such crops are coffee, taro, rice, watercress, and non-irrigated pineapple.

[5] Aspect - direction that the slope faces for agriculture, as it relates to sun exposure.

- **Other Important Agricultural Land** is land other than Prime or Unique Agricultural Land that is of statewide or local importance to produce food, feed, fiber, and forage crops. The lands in this classification are important to agriculture in Hawai‘i, but they exhibit properties, such as seasonal wetness, erodibility, limited rooting zone, slope, flooding, or drought potential that exclude them from the Prime or Unique Agricultural Land classifications.

  Two examples of Other Important Agricultural Land include lands that do not have an adequate moisture supply to qualify as Prime Agricultural Land, and lands that have similar characteristics and properties as Unique Agricultural Lands, except that these lands are not currently in use to produce a "unique" crop. These lands can be farmed to produce fair to good crop yields when managed properly, such as by applying greater inputs of fertilizer and other soil amendments, drainage improvement, erosion control practices, and/or flood protection.

2.3.2 AGRICULTURAL LANDS OF IMPORTANCE TO THE STATE OF HAWAI‘I MAP

The ALISH map is the third map of the series, and presents the prime, unique, and other agricultural land within the service area. There are certain areas that do not have an ALISH land category and are depicted on the map as “service area without ALISH designation.”

2.4 LAND CAPABILITY CLASSIFICATION

The Land Capability Classification (LCC) was developed by the USDA Soil Conservation Service in 1972, based on Agriculture Handbook No. 210, which was issued in 1961.[6] Each capability classification is a grouping of soils with similar agricultural potential and limitations. Hawai‘i soils were classified using soil surveys by the U.S. Department of Agriculture and University of Hawai‘i. The agricultural productivity element of the analysis was based on soil and climatic conditions, with a preference for field crops (sugarcane, pineapple, pasture, and woodland) and mechanization.

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[6] Klingebiel, A. A. and P. H. Montgomery, "*Land-Capability Classification*," Soil Conservation Service, Agriculture Handbook N. 210, September 1961.

2.4.1 METHODOLOGY AND ANALYSIS

Similar to the ALISH data, the LCC data set is publicly available from the National Resources Conservation Service (NRCS). The LCC has eight (8) broad groups, numbered I to VIII.

- Class I soils have few limitations that restrict their use, are suited for a wide range of plants, and may be used safely for cultivated crops, pasture, range, woodland, and wildlife.
- Class II soils requires careful soil management, including conservation practices, to prevent deterioration or to improve air and water relations when the soils are cultivated. The soils may be used for cultivated crops, pasture, range, woodlands, or wildlife food and cover.
- Class III soils have severe limitations that reduce the choice of plants or require special conservation practices, or both. These soils may be used for cultivated crops, pasture, woodland, range, or wildlife food and cover.
- Class IV soils have very severe limitations that restrict the choice of plants, require very careful management, or both. These soils may be used for crops, pasture, woodland, range, or wildlife food and cover.
- Class V soils have little or no erosion hazard but have other limitations to remove that limit their use largely to pasture, range, woodland, or wildlife food and cover.
- Class VI soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture or range, woodland, or wildlife food and cover.
- Class VII soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to grazing, woodland, or wildlife.
- Class VIII soils and landforms have limitations that preclude their use for commercial plant production and restrict their use to recreation, wildlife, water supply, or aesthetic purposes.

The LCC are based on a non-irrigated and in-situ state. The USDA's classification system indicates that certain soils have a limitation due to water availability (arid or semi-arid areas). Therefore, if this limitation is mitigated by irrigation, there is a potential for the soil to be reclassified to a higher classification. An analysis was performed based on an irrigated state for the soils.

2.4.2 LAND CAPACITY CLASSIFICATION MAPS

The LCC maps are the fourth (non-irrigated) and fifth (irrigated) maps in the series (Appendix A). The LCC non-irrigated map is the LCC based on the soil ratings from USDA. To show the importance of irrigation relative to soil productivity, the LCC irrigated map shows the potential LCC when irrigation is applied. There are some areas in which the LCC does not improve the classification and are shown on the LCC irrigated map with the cross-hatching. On both maps, USDA did not classify certain areas; these are shown as "service area without soil designation."

2.5 IMPORTANT AGRICULTURAL LANDS

2.5.1 IMPORTANT AGRICULTURAL LANDS DESCRIPTION

As required by state statute, the AWUDP must identify the water sources and existing and future water needs for Important Agricultural Lands (IAL). The IAL statutes are found in HRS Chapter 205-Part III, and the purpose of the IAL follows.

> *It is declared that the people of Hawai'i have a substantial interest in the health and sustainability of agriculture as an industry in the State. There is a compelling state interest in conserving the State's agricultural land resource base and assuring the long-term availability of agricultural lands for agricultural use to achieve the purposes of:*
>
> *(1) Conserving and protecting agricultural lands;*
> *(2) Promoting diversified agriculture;*
> *(3) Increasing agricultural self-sufficiency; and*

> *(4) Assuring the availability of agriculturally suitable lands, pursuant to article XI, section 3, of the Hawai‘i state constitution.*

2.5.2 IDENTIFICATION OF IMPORTANT AGRICULTURAL LANDS

The list and areas granted IAL[7] status were obtained from the Land Use Commission website (http://luc.hawaii.gov/maps/important-agricultural-lands-ial-maps/). As of 2018, approximately 134,510 acres of agricultural land have been designated as IAL on four islands and are shown on Map 1. Tables 1 to 3 list the IAL in each county and identifies their locations and water source. The associated "Agricultural Water System" for each IAL area, as defined for this study, is shown in the respective tables. The associated water use and current water demand for each IAL is identified in its respective IAL Petition and Decision and Order. These current water demands are presented in the corresponding Agricultural Water System discussions detailed in Chapters 3 and 4 of this report.

Future water demand for IALs are not forecast to change from the current water demand values, as they are expected to reflect the same planted acreage, farming method, and crop type. Modifications to any of these factors may result in different water demand values for the affected IALs. Climate change is expected to potentially reduce rainfall and may affect other growing factors, resulting in an increase to future agricultural water demand.

2.5.3 IMPORTANT AGRICULTURAL LANDS MAP

The IAL map is the sixth of the map series (Appendix A) for those agricultural water systems that have IAL. The IAL maps show the IAL area as a cross-hatched area that may be larger than the potential service area and/or associated with multiple water systems. Those IAL areas that are not associated with agricultural water systems, such as Punalu‘u, Parker Ranch, Inc., and Kualoa Ranch, Inc., are not shown on any maps.

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[7] Declaratory orders were obtained from: http://luc.hawaii.gov/completed-dockets/declaratory-orders-decisions-and-order/declaratory-orders-oahu-county/declaratory-orders-important-agricultural-lands-designations/

Table 1
Important Agricultural Lands in Kaua‘i County

Map Index	Island Location	Landowner	Area (Acres)	Predominant Agriculture Uses	Water Source**	Agricultural Water System
1	Kaua‘i, Kōloa	Kaua‘i Coffee (Alexander & Baldwin)	3,773	Coffee, seed corn	Wells, surface water Pump 3 and Alexander system	Kaua‘i Coffee Irrigation System
2	Kaua‘i, Kōloa	Māhā‘ulepū Farm, LLC (Grove Farm)	1,533	Taro, seed corn, forage crops, cattle ranching	Waitā Reservoir	Not Stated in ‘Decisions and Orders’
3	Kaua‘i, Hā‘upu/ Līhu‘e	Grove Farm Company, Inc.	11,206	Biomass production for renewable energy, cattle ranching, livestock, diversified agriculture	Rainfall, various on-site and off-site water sources Waitā Reservoir	Līhu‘e and Ha‘ikū Ditch Systems
4	Kaua‘i, Lumaha‘i/ Waipā	Kamehameha Schools	190	Taro, diversified vegetable and fruit crops, plant nursery, cattle ranching	Lumaha‘i: Lumaha‘i River Waipā: Waipā Stream	Not Stated in ‘Decisions and Orders’
5	Kaua‘i, Makaweli	Robinson Family Partners	20,888	Ranching and crop production	Kō‘ula Ditch System and Olokele Ditch System	Kō‘ula Ditch System and Olokele Ditch System

Note: ** Various 'Decisions and Orders,' State of Hawai‘i, Land Use Commission, circa 2018.

Table 2
Important Agricultural Lands on O‘ahu

Map Index	Island Location	Landowner	Area (Acres)	Predominant Agriculture Uses	Water Source**	Agricultural Water System
6	O‘ahu, Central and North Shore	Castle and Cooke Homes Hawai‘i, Inc.	902.1 (3 parcels)	Diversified vegetable and fruit crops, flowers, foliage	Dole Ditch System (Tanada Reservoir and gulch) and rainfall	Oahu, Wahiawa, Helemano, and Ito Irrigation System
7	O‘ahu, Kawailoa/ Punalu‘u	Kamehameha Schools	9,591.8	Grazing, diversified agriculture	Kawailoa: Waimea & Anahulu Rivers; Ka‘alaea, Kawailoa, & Laniākea Streams Punalu‘u: Punalu‘u Stream and rainfall	Not Stated in ‘Decisions and Orders’
8	O‘ahu, Kunia	Monsanto Company	1,550	Agriculture	Waiawa, Waiāhole, Waikāne, Uwao Tunnels and Ko‘olaupoko aquifer Waiāhole Ditch	Waiāhole Ditch System
9	O‘ahu, Kunia	Hartung Brothers Hawai‘i, LLC	462.967	Crop production, and soil conservation	Waiawa, Waiāhole, Waikāne, Uwao Tunnels and Ko‘olaupoko aquifer Waiāhole Ditch	Waiāhole Ditch System
10	O‘ahu, Kualoa	Kualoa Ranch, Inc.	761.55	Ranching, diversified agriculture and aquaculture	City and County of Honolulu Board of Water Supply, Hakipu‘u Stream in Hakipu‘u Valley, two drilled wells in Ka‘a‘awa Valley	Not Stated in ‘Decisions and Orders’

Note: ** Various 'Decisions and Orders,' State of Hawai‘i, Land Use Commission, circa 2018.

Table 3
Important Agricultural Lands in Maui and Hawaiʻi Counties

Map Index	Island Location	Landowner	Area (Acres)	Predominant Agriculture Uses	Water Source**	Agricultural Water System
11	Maui, Central	Alexander & Baldwin	27,102	Sugarcane As of 2016, diversified agriculture	Various sources: East Maui Irrigation System & West Maui Ditch System	East Maui Irrigation System & West Maui Ditch System
12	Hawaiʻi, South Kohala	Parker Ranch, Inc.	56,771.8	Cattle ranching	Kohākōhau, Alakahi and Waikoloa Streams	Not Stated in 'Decisions and Orders'

Note: ** various 'Decisions and Orders,' State of Hawaiʻi, Land Use Commission, circa 2018.

2.6 CWRM SYSTEM ALIGNMENT MAP

The CWRM map is the sixth or seventh map (depending on the occurrence of IAL in the system) of the map series (Appendix A). The CWRM system alignment consists of the active and inactive portions of the irrigation system as designated by CWRM. The CWRM system alignment is overlaid onto the 2014-2015 land use(second map in series). The CWRM data is shown for informational purposes only and has not been verified by HDOA.

CHAPTER 3
2018 AGRICULTURAL WATER SYSTEMS

Agriculture is the most healthful, most useful, and most noble employment of man.
George Washington

The systems studied in 2018 are considered important to the agricultural economies on each island and to the designated IAL. These systems have various owners, including ARMD, ADC, and private entities. In total, 13 systems were inventoried in 2018 with the intention of completing the master inventory of the agricultural water systems, initiated by the 2004 AWUDP, as required in HRS Chapter 174C-31(e).

This chapter will provide descriptions of and pertinent information for each irrigation system. The analysis of each system will include a determination of the rehabilitation potential and proposed projects for the CIP. The sections will describe the agricultural water systems by island: 3.1 - Kauaʻi; 3.2 - Oʻahu; and 3.3 - Hawaiʻi.

3.1 KAUAʻI COUNTY IRRIGATION SYSTEMS

The following systems were studied in Kauaʻi County, and their locations are shown in Exhibit 9.

- Kīlauea Sugar Company (Kaloko to Kalihiwai):
    - Kaloko Irrigation;
    - Puʻu Ka Ele and Morita Reservoir;
    - Stone Dam; and
    - Kalihiwai.
- Anahola Ditches.
- Upper and Lower Līhuʻe Ditches and a portion of the Waiahi-ʻIliʻiliʻula Ditch.
- Upper and Lower Haʻikū Ditches.
- Waiʻahi-Kuʻia Aqueduct, portion of the Waiahi-ʻIliʻiliʻula Ditch, and Kōloa & Wilcox Ditches.
- Olokele Ditch.

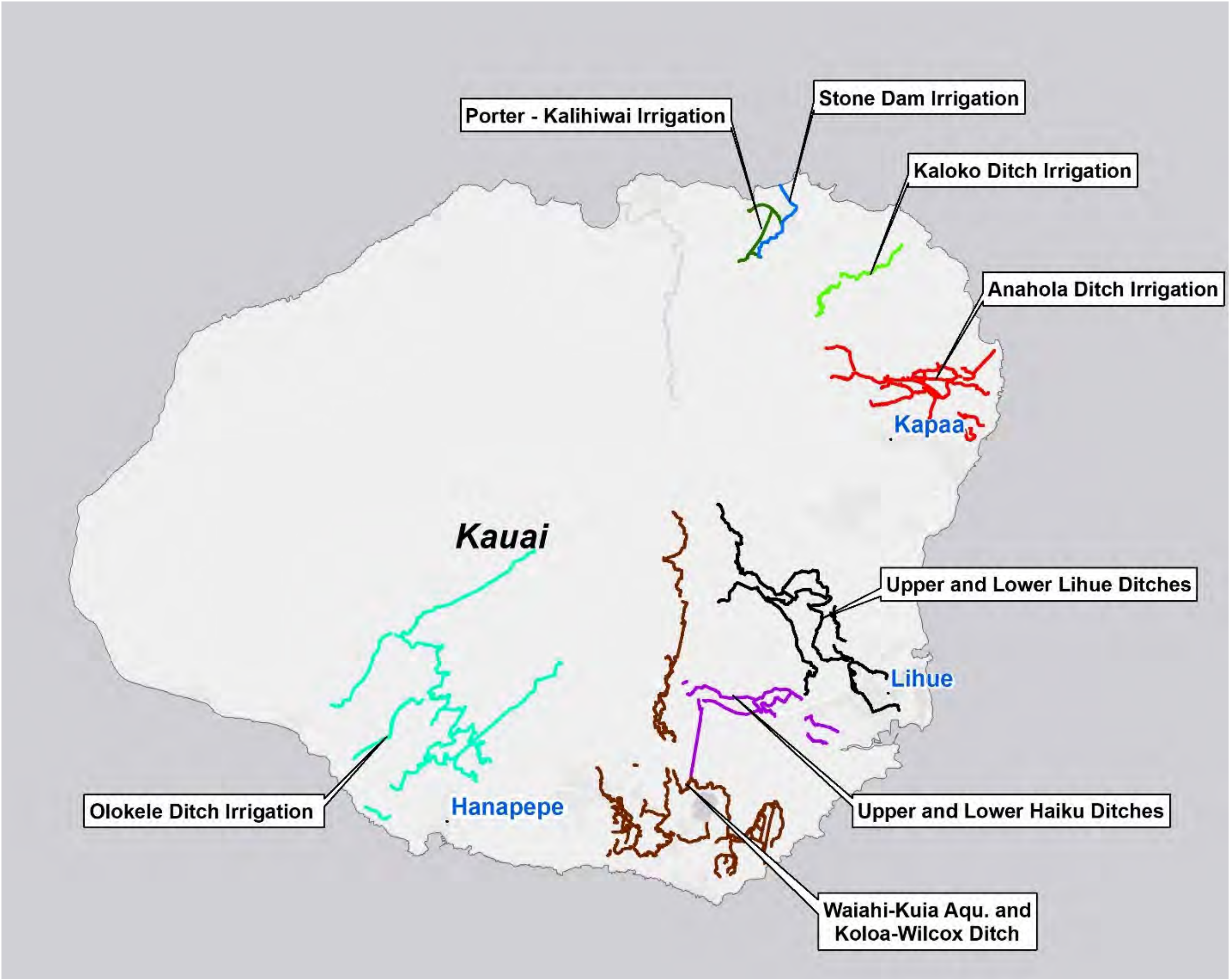

Exhibit 9. Water Systems Inventoried on Kauaʻi

3.1.1 KĪLAUEA SUGAR COMPANY (KALOKO TO KALIHIWAI)

Beginning in 1880, Kīlauea Sugar Company, Ltd. owned and developed irrigation systems from Kaloko to Kalihiwai. According to Wilcox[8], this irrigation system was comprised of a network of small ditch systems, with a total storage capacity of over 730 million gallons (MG). This system was able to irrigate over 3,000 acres of sugar cane, stretching over six (6) miles.

Currently, there are two (2) active rainfall stations in the area: one at Koloko Reservoir and the other in Kīlauea. The Koloko Reservoir station is at an

[8] Wilcox, Carol, *Sugar Water, Hawaiʻi's Plantation Ditches,* Honolulu, University of Hawaiʻi Press, 1996.

elevation of 735 feet, showing a mean annual rainfall of 83.69 inches. The Kīlauea Station is at an elevation of 315 feet, showing a mean annual rainfall of 63.64 inches.

Upon the closure of Kīlauea Sugar Company, Ltd. in 1971, the company's land assets were subdivided and sold to various entities. The new landowners inherited the irrigation system components associated with their specific properties. Therefore, the small ditch systems no longer function as a network, and the sugar company's irrigation system has been subdivided into four major standalone subsystems: 1) Kaloko Ditch, 2) Puʻu Ka Ele-Morita Reservoir; 3) Stone Dam; and 4) Kalihiwai.

3.1.1.1 Kaloko Irrigation Subsystem

Ownership and service area information for the Kaloko Irrigation Subsystem is presented in Table 4. General system information is presented in Table 5. On March 14, 2006, the Kaloko Dam failed, resulting in a breach that impacted the residential area below the dam. The incident led to legal action against various parties, and the capacity of the Kaloko Reservoir was decreased to 48 MG. Table 6 presents land use within the service area. The system maps are shown on Maps 2 to 7:

- Map 2 - Alignments and System Components;
- Map 3 - 2014-2015 Land Use;
- Map 4 - ALISH 1977;
- Map 5 - Land Capability Non-Irrigated Conditions;
- Map 6 - Land Capability Irrigated Conditions, and
- Map 7 – CWRM System Alignments and 2014-2015 Land Use.

Assessment of Needs. As a condition assessment was not completed, the CIP was not developed. However, in June 2009, a study was completed by Sustainable Resources Group International, Inc. for the County of Kauaʻi, Office of Economic Development, titled *Kīlauea Irrigation Water Engineering Design and Monitoring Study.* The study determined that the system is currently in use and should be rehabilitated and maintained for its users. The study states:

> *The existing systems have deficiencies with respect to the ditch network and mechanical components, as well as regulatory, legal,*

and institutional issues that, unless resolved, place the continued use of the systems in jeopardy.

However[,] *it is our conclusion that these deficiencies can be overcome, and with some improvements to both the infrastructure and operations, the systems can continue to function into the foreseeable future …*

… the most hydrologic and economically feasible alternative is to continue using the existing KICO and Ka Loko systems, including Ka Loko Ditch, Dam and Reservoir.

Table 4
Kaloko Irrigation Subsystem
System Ownership and Service Area

Description	Information
Owners	Mary N. Lucas Trust (803 acres), Pflueger Partners (110 acres), Circensa (71 acres)
Source	Pu‘u Ka Ele Stream Kaluaa Stream (Moloa‘a Forest Reserve)
Estimated Current Water Use (annual average)	0.098 MGD
Estimated Service Area	1,862 acres
Farms Served	Kīlauea Farm Subdivision – 28 Farm lots Mary Lucas Trust – grazing
Important Agricultural Lands	None

Table 5
Kaloko Irrigation Subsystem
General System Information

Description	**Information**	
System Length (feet) / status	15,450 (Unverified)	
Intake	Kaloko Ditch	Moloa‘a Ditch
Source (type)	Pu‘u Ka Ele Stream (Surface Water)	Kaluaa Stream (Surface Water)
Hydrologic Unit	Kīlauea	Kīlauea
Intake Status	Active	Active
Reservoirs	Kaloko	Waiakalua
Capacity (acre-feet / MG)	1,400/456.2	184/60
Status	Active, capacity is reduced 147 acre-feet (47.9 MG)	Active
Visual inspection undertaken	No	
Irrigation system condition	Condition assessment was not performed	
Rehabilitation Potential	Fair, requires resolution of regulatory, legal, and institutional issues	
Rehabilitation Cost / CIP	To be determined by system owner	

Reference: Sustainable Resources Group International, Inc., "*Kīlauea Irrigation Water Engineering Design and Monitoring Study*," County of Kaua‘i, Office of Economic Development, Final Report, June 2009.

Table 6
Kaloko Irrigation Subsystem
Land Uses within the Service Area

Cultivation	**Area** (acres)
Field Crops	0
Other Crops	60.7
Grazing	945.4

3.1.1.2 Puʻu Ka Ele and Morita Reservoir Irrigation Subsystem

Ownership and service area information for the Puʻu Ka Ele and Morita Reservoir Irrigation Subsystem is presented in Table 7. General information about the system is presented in Table 8. The Jurassic Kāhili Ranch was created by purchasing 2,300 acres from the Mary N. Lucas family in 2003, and it is currently used for ranching, maintaining over 200 head of cattle. Discussions with Jurassic Kāhili Ranch personnel[9] indicate that the entire system is inactive (not in use or demolished), including both the Puʻu Ka Ele and Morita Reservoir.

Assessment of Needs. As the system is not in use and, in fact, some portions of it have been demolished, the Puʻu Ka Ele and Morita Reservoir Irrigation Subsystem should not be rehabilitated. Therefore, the locations and identification of the system components were not mapped and maybe non-existent.

Table 7
Puʻu Ka Ele and Morita Reservoir Irrigation Subsystem
System Ownership and Service Area

Description	Information
Owners	Jurassic Kāhili Ranch
Source	Inactive and Unverified (1,2)
Estimated Current Water Use (annual average)	None
Estimated Service Area	0 acres
Farms Served	Jurassic Kāhili Ranch
Important Agricultural Lands	None

Note: 1. Telephone communication
2. In 2019, CWRM verified the inactive status of the primary stream diversion and ditch for this system.

[9] Personal communication.

Table 8
Pu‘u Ka Ele and Morita Reservoir Irrigation Subsystem
General System Information

Description	Information
System Length (feet) / status	Unverified as portions have been demolished (demolished)
Intake	Unverified
Source	Unverified
Hydrologic Unit	Unverified
Intake Status	Unverified
Reservoirs	None
Visual inspection undertaken	No
Irrigation system condition	Inactive, portions of the system have been destroyed
Rehabilitation Potential	Not recommended
Rehabilitation Cost / CIP	To be determined by owner

3.1.1.3 Stone Dam Irrigation Subsystem

Ownership and service area information for the Stone Dam Irrigation Subsystem is presented in Table 9. General system information is presented in Table 10. The Stone Dam was constructed by John Ross and E.P. Adams in 1880. Land use areas within the service area are presented in Table 11. The system maps are shown on Maps 8 to 13:

- Map 8 - Alignments and System Components;
- Map 9 - 2014-2015 Land Use;
- Map 10 - ALISH 1977;
- Map 11 - Land Capability Non-Irrigated Conditions;
- Map 12 - Land Capability Irrigated Conditions, and
- Map 13 – CWRM System Alignments and 2014-2015 Land Use.

Table 9
Stone Dam Irrigation Subsystem
System Ownership and Service Area

Description	Information
Owner(s)	Bridgewater Irrigation (System Manager)
Source	Pohakuhono and Hālaulani streams
Estimated Current Water Use (annual average)	Unverified
Estimated Service Area	130 acres
Farms Served	Unverified Provides backup water to the Kalihiwai agricultural water subsystem
Important Agricultural Lands	None

Table 10
Stone Dam Irrigation Subsystem
General System Information

Description	Information
System Length (feet) / status	7,286 (Active)
Intake Source Hydrologic Unit Intake Status	Stone Dam Pohakuhono and Hālaulani streams Kīlauea Active
Reservoir	Stone Dam (capacity unknown)
Visual inspection undertaken	Publicly accessible portions only
Irrigation system condition	Active
Rehabilitation Potential	Good
Rehabilitation Cost / CIP	To be determined by system owner

Table 11
Stone Dam Irrigation Subsystem
Land Uses within the Service Area

Cultivation	**Area** (acres)
Field Crops	0
Other Crops	50.6
Grazing	7.5

Assessment of Needs. The publicly accessible portions of the irrigation system were visually observed, but an interview and formal permission for access was not obtained. As a condition assessment was not completed, the CIP was not developed. The system is currently being used, and the publicly visible portions are in good condition. The Stone Dam Irrigation Subsystem provides backup irrigation water to the Kalihiwai Irrigation Subsystem through a pipeline connection.

3.1.1.4 Kalihiwai Irrigation Subsystem

Ownership and service area information for the Kalihiwai Irrigation Subsystem is presented in Table 12. General system information is presented in Table 13. Kalihiwai Reservoir was constructed in 1920 to provide a reliable water source for the sugar industry. Table 14 presents the land use area within the service area. The system maps are shown on Maps 14 to 19:

- Map 14 - Alignments and System Components;
- Map 15 - 2014-2015 Land Use;
- Map 16 - ALISH 1977;
- Map 17 - Land Capability Non-Irrigated Conditions;
- Map 18 - Land Capability Irrigated Conditions; and
- Map 19 – CWRM System Alignments and 2014=2015 Land Use.

Assessment of Needs. The Kalihiwai Irrigation Subsystem was surveyed in 2014 and found to be in relatively good condition. Porter Irrigation provided permission and information for the Kalihiwai Irrigation Subsystem and coordinated the inventory survey with various private landowners in the area. The upper (mauka) section above the reservoir is a 4,000-foot-long ditch and tunnel system that runs through private lands. There are easements or negotiated access points to maintain the ditch on these private lands. The lower portion of the system, downstream of the Kalihiwai Reservoir, consists of a six (6)-inch pipeline and valves that have been recently installed for irrigation and fire protection.

Table 12
Kalihiwai Irrigation Subsystem
System Ownership and Service Area

Description	Information
Owners	Various owners Kalihiwai Reservoir – Kalihiwai Ridge Community Associations Porter Irrigation System (System Manager)
Source	Pohakuhonu Stream
Estimated Current Water Use (annual average)	100,000 gpd During plantation era – estimated at 10 MGD
Estimated Service Area	794 acres
Farms Area Served Potential Farming	200 acres – mahogany trees 150 acres – community farms Potential increase if water available
Important Agricultural Lands	None

Table 13
Kalihiwai Irrigation Subsystem
General System Information

Description	**Information**	
System Length (feet) / status	17,380 (Active)	
Intake	Kalihiwai Intake 1	Kalihiwai Mauka Intake
Source	Pohakuhonu Stream	Pohakuhonu Stream
Hydrologic Unit	Kīlauea	Kīlauea
Intake Status	Active	Inactive
Reservoirs	Kalihiwai Reservoir	
Capacity (acre-feet / MG)	141 / 46	
Status	Active	
Visual inspection undertaken	Yes	
Irrigation system condition	Poor to Good – see Table 15	
Rehabilitation Potential	Good	
Rehabilitation Cost / CIP	See Table 16	

Table 14
Kalihiwai Irrigation Subsystem
Land Uses within the Service Area

Cultivation	**Area** (acres)
Field Crops	184.2
Other Crops	189.0
Grazing	9.8

Table 15
Kalihiwai Irrigation Subsystem
Distribution System Condition

Distribution System	Length (feet)	Comments
Ditches Good Condition	700	
Fair Condition	1,900	Clearing invasive plant species growth
Poor Condition	3,700	Unusable due to heavy invasive species growth
Tunnels		
Good Condition	0	
Fair Condition	1,100	Potential tree root intrusion and/or partial sediment blockage
Poor Condition	700	Collapsed tunnel due to tree root intrusion

The significant issue is deterioration of the ditches and tunnels due to age and excessive overgrowth, including invasive species. Exhibits 10 and 11 show examples of the excessive overgrowth in a portion of the ditch. The ditch walls and tunnels are collapsing, creating partial or full blockages in the portions of the system, thus reducing water flow to the agricultural users.

The Kalihiwai Ridge Community Association regularly maintains the reservoir and has funded several studies on Kalihiwai Reservoir, including:

- *Simulation of Kalihiwai Reservoir Dam-Break Flooding*, 2006; and
- *Kalihiwai Reservoir Bathymetry Mapping Study* in 2007.

A bathymetric study for the reservoir was performed in 2007 by AquaTechnex, LLC. To determine its storage capacity. The study concluded that the 2007 surface area is 20.78 acres, with a storage capacity of 46.0 MG or 141.2 acre-feet. This volume is much less than previously reported: 90.6 MG or 278 acre-feet.

According to Porter Irrigation staff, there are plans to increase the cultivated area for diversified agricultural use, which will increase water demand. Also, there is a minimum water level established for the Kalihiwai Reservoir due to the use of the water by native water birds, as well as for recreational use by community association members.

Another potential agricultural water demand on this system is from the County of Kauaʻi, Kīlauea Agricultural Park. Kīlauea Agricultural Park is across Kūhiō Highway from the Stone Dam and Kalihiwai Irrigation Subsystems. The County has been in informal discussions (circa 2014) with the Porter and Bridgewater Irrigation companies to supply agricultural water to Kīlauea Agricultural Park. The Park was designed to have three (3) wells, each with a 100-gallon-per-minute capacity, and a 300,000-gallon water storage tank.

Kīlauea Agricultural Park has 75 acres of land set aside for agriculture. This land is subdivided into 14 farm lots, ranging from 2.66 acres to 6.93 acres. The anticipated agricultural water demand for 54 acres, at an average use of 6,600 gpd/acre, is equal to pumping approximately 360,000 gpd (250 gallons per minute). The remaining parcels are used for parking, gardens, green waste, and a drainage detention pond.

Proposed Capital Improvement Projects. Based on the condition survey of Kalihiwai Irrigation Subsystem and information gathered on its various components, the following improvements are proposed. As the water supply issue for Kīlauea Agricultural Park remains undecided, no connection from the Kalihiwai system was included in the CIP. Table 16 presents the proposed CIP, estimated (planning level) costs, and phasing for the proposed improvements.

- Re-establish and reconstruct the upper (mauka) intake from Pohakuhonu Stream to increase water capacity for future agricultural use. The project would entail the reconstruction of the intake, as well as reopening and reconstruction of approximately 3,700 feet of ditch.

Exhibit 10. Overgrowth in upper portion of Kalihiwai Ditch

Exhibit 11. Overgrowth in upper portion of Kalihiwai Ditch

- Until recently (circa 2013), there was limited ditch maintenance being performed on the system, due to the lack of maintenance easements and agreements. Unfortunately, this decades-long neglect has allowed plants and invasive species to grow and caused severe damage to the ditch and tunnels. This project requires major clearing of approximately 4,400 feet of ditch segments and tunnels, focusing on clearing overgrowth, replanting of non-invasive species, and rehabilitation/reconstruction.

Table 16
Kalihiwai Irrigation Subsystem
Proposed Capital Improvement Projects

Project Description	**ESTIMATED COST** (2018 dollars)
	Short-term
Re-establish upper intake	$110,000
Clear ditch sections from overgrowth and rehabilitate ditches and tunnels	$110,000
Establish Kīlauea Agricultural Park water source	To be determined

3.1.2 ANAHOLA DITCH

Ownership and service area information for the Anahola Irrigation System is presented in Table 17. General system information is presented in Table 18. The Anahola Ditch was constructed in the early 1900s by the Makee Sugar Company. By 1933, Līhuʻe Plantation had become the sole owner of Makee Sugar Company and Anahola Irrigation System. At that time, the ditch diverted water from two locations in Anahola Stream. In 2000, Līhuʻe Plantation ended sugar operations, and certain properties were transferred to the State of Hawaiʻi. The remaining properties were sold to private owners.

Management and control of the state-owned portion was given to the State of Hawai‘i, Department of Hawaiian Home Lands (DHHL). The ditch alignment sits on both state- and privately owned lands. Due to the different owners, the ditch system was discontinued at the boundary between the two.

Historical USGS records show that average flow during low stream flow months is 3.9 MGD for Anahola Stream. During high-flow months, the average flow is 6.5 MGD. For the lower Anahola Ditch, USGS records show an average flow ranging from 0.8 MGD to 2.1 MGD between the low- and high-flow months. Rainfall stations in the Anahola region are currently inactive, with no records after 2000. The station at Kaneha Reservoir had an elevation of 845 feet and a mean annual rainfall of 96.49 inches.

Table 17
Anahola Irrigation System
System Ownership and Service Area

Description	Information
Owners	State of Hawai‘i, DHHL Private owner
Source	Anahola Stream
Estimated Current Water Use (annual average)	610,000 gpd(1) During plantation sugar cane era – estimated at 9 MGD
Estimated Service Area	DHHL – 2,345 acres Private owner – 3,725 acres
Farms Area Served Potential Farming	DHHL - 560 acres Private owner – unverified
Important Agricultural Lands	None

Note: 1) Commission on Water Resource Management

Table 18
Anahola Irrigation System
General System Information

Description	Information	
System Length (feet) / status	7,908 (Active) 36,499 (Inactive) 60,247 (Unverified)	
Reservoirs	DHHL – See Table 21 Private owner – See Table 22	
Intake	Upper Anahola Intake	Lower Anahola Intake
Source	Anahola Stream	Anahola Stream
Hydrologic Unit	Anahola	Anahola
Intake Status	Active	Inactive
Visual inspection undertaken	Yes	
Irrigation system condition	Upper Anahola Ditch – See Tables 23 and 24 Lower Anahola Ditch - Poor Private owner system not surveyed	
Rehabilitation Potential	Upper Anahola Ditch – Good Lower Anahola Ditch – Poor Private owner – To be determined by owner	
Rehabilitation Cost / CIP	DHHL Portion - See Table 25 Private owner – To be determined by owner	

Table 19 presents the land use areas within the DHHL service area, and Table 20 presents the land use areas within the private system. The system maps are shown on Maps 20 to 25:

- Map 20 - Alignments and System Components;
- Map 21 - 2014-2015 Land Use;
- Map 22 - ALISH 1977;
- Map 23 - Land Capability Non-Irrigated Conditions;
- Map 24 - Land Capability Irrigated Conditions; and
- Map 25 – CWRM System Alignments and 2014-2015 Land Use.

Table 19
Anahola Irrigation System
Land Uses within the Service Area
DHHL Portion

Cultivation	**Area** (acres)
Field Crops	0
Other Crops	248.2
Grazing	309.2

Table 20
Anahola Irrigation System
Land Uses within the Service Area
Private Landowner Portion

Cultivation	**Area** (acres)
Field Crops	106.9
Other Crops	160.9
Grazing	1,729.9

Table 21
Anahola Irrigation System
Reservoir Capacity
DHHL Portion

Reservoir	DLNR[1] Capacity		Capacity[2]		Current Status
	Acre-feet	MG	Acre-feet	MG	
Kaneha	420.0	136.9	--	--	Active
Kanehu #1	105.0	34.2	79.8	26.0	Active
Kanehu #2	146.0	47.6	46.0	15.0	Inactive
Kanehu #3	--	--	--		Active
Upper Anahola	110.0	35.8	82.9	27.0	Active
Lower Anahola	115.0	37.5	153.4	50.0	Active

Notes: 1) DLNR, Dam inventory online database http://dams.hawaii.gov
2) Nishida Souza, Jean, et.al. "*Kealia Agricultural Water System Study on State Owned Lands*," 1996. As referenced in LYON (2014).

Table 22
Anahola Irrigation System
Reservoir Capacity
Private Landowner Portion

Reservoir	Capacity[1]		Current Status
	Acre-feet	MG	
Hala‘ula	Unverified		Active
Mimino	70	22.8	Active

Notes: 1) DLNR, Dam inventory online data base. http://dams.hawaii.gov

Assessment of Needs. This assessment of needs only pertains to the DHHL portion of the system, based on a survey conducted in 2015. The condition assessment of the privately owned system was not completed, and the CIP was not developed.

In 2015, only the Upper Anahola Ditch diversion was active, flowing into the Kaneha Reservoir. The condition survey of the DHHL portion rated the intake for the Upper Anahola Ditch to be in fair condition (Exhibit 12). The remainder of the Upper Ditch is disconnected due to split ownership and is in poor condition (Exhibit 13). In 2019, CWRM re-verified that the Upper Analoha Ditch tunnel collapsed and is no longer functional. The Kealia stream diversion and ditch continues to operate, contributing water to the Kaneha Reservoir.

The Lower Anahola intake and transmission ditch from Anahola Stream is in even worse condition and may not be feasible for rehabilitation (Exhibits 14 and 15). The single intake on the Upper Anahola Ditch may provide adequate water supply for DHHL needs at this time. A summary of the system's condition is presented in Tables 23 and 24.

In addition, DHHL commissioned two studies on the Anahola Ditch system. In 1996, DHHL completed a limited survey: *Keālia Agricultural Water System Study on State Owned Lands.*[10] The 1996 study included the management and operation of the four regulated dams: 1) Keālia Field 1, 2) Keālia Field 2, 3) Upper Anahola, and 4) Lower Anahola. The second study, *Limited Archaeological & Historical Survey, Anahola Reservoirs Improvement Project*, was performed by Lyon in 2014. The study recommended that the Keālia Field #2 Reservoir and the Lower Anahola Reservoir be decommissioned. The study also recommended the following improvements to the reservoirs:

- Keālia Field #1 Reservoir
    - Reduce lower reservoir capacity to less than 16 MG;
    - Reconstruct existing outlet, including the inlet structure, tunnel, and outlet structure;
    - Partially reconstruct reservoir embankment to provide structural integrity, including adding a rip-rap rock facing on upstream and downstream slopes of the embankment, as well as to the spillway, to prevent erosion;
    - Construct a rip-rap splash pad for the outlet structure; and
    - Construct a maintenance road on the downstream toe of the embankment for ease of access.

[10] Nishida Souza, Jean, et.al. *Kealia Agricultural Water System Study on State Owned Lands*, 1996. As referenced in Lyon (2014).

Table 23
Anahola Irrigation System
Distribution System Components

Distribution System	**Length** (feet)	**Comments**
Ditches		
Active	45	
Inactive	50,556	Majority of the ditches are in poor condition
Unverified	60,437	Private property
Tunnels		
Active	7,863	DHHL property
Inactive	2,919	Majority of the inactive components are on private property
Unverified	11,965	Private property
Flumes		
Active	0	
Inactive	418	Poor condition
Unverified	0	
Pipelines		
Active	0	
Inactive	0	
Unverified	1,276	Private property
Siphons		
Active	0	
Inactive	0	
Unverified	1,148	Private property

Table 24
Anahola Irrigation System
Distribution System Condition
DHHL and Active Only

Item	Length (feet)
Ditches	
Good Condition	45
Fair Condition	0
Poor Condition	0
Tunnels	
Good Condition	7,863
Fair Condition	0
Poor Condition	0

Exhibit 12. Upper Anahola Intake – Fair Condition

Exhibit 13. Upper Anahola Ditch - Poor Condition

Exhibit 14. Lower Anahola Ditch – Tunnel with root intrusion

Exhibit 15. Lower Anahola Ditch - Fair Condition

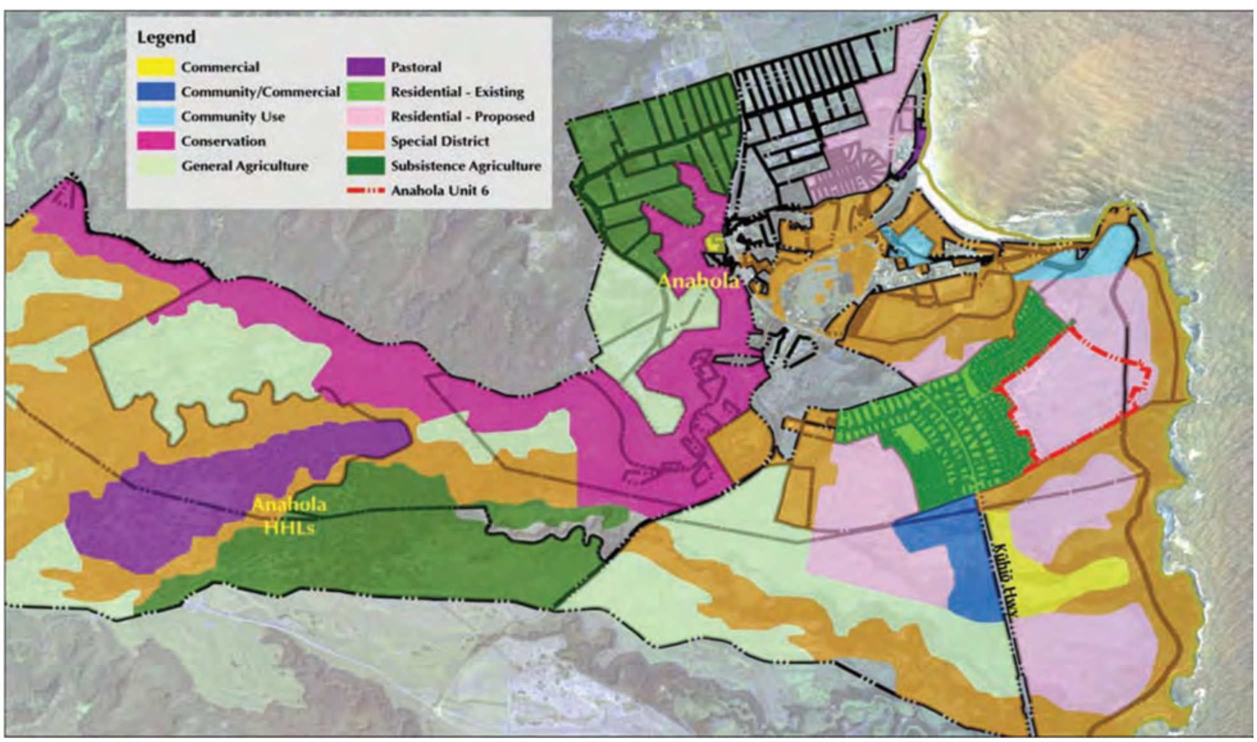

Exhibit 16. DHHL Anahola Regional Plan

- Upper Anahola Reservoir;
  - Reduce lower capacity to less than 16 MG;
  - Reconstruct existing outlet, including the inlet structure, tunnel, and outlet structure;
  - Partially reconstruct reservoir embankment to provide structural integrity, including a rip-rap rock facing on upstream and downstream slopes of the embankment, as well as to the spillway, to prevent erosion;
  - Construct a rip-rap splash pad for the outlet structure; and
  - Construct a maintenance road on the downstream toe of the embankment for ease of access.

In 2010, DHHL prepared a Regional Plan for 4,228 acres in Anahola and Kamalomaloʻo, finding that most lands in Anahola remain undeveloped. The DHHL Regional Plan is based on the concept of “homestead communities.” DHHL defines a homestead community as a *Hawaiian community being developed into perpetuity*. Based on the 2010 Plan, DHHL envisions the Anahola area housing a mixture of cultural, homestead, agriculture, pastoral (grazing), income-generating, and public land uses. Exhibit 16 presents that DHHL plan for the Anahola area.

The 2010 Regional Plan provides the following specific agricultural land uses and acreage:

- Subsistence Agriculture - 103 new 2-acre lots on 292 acres;
- Pastoral (grazing) - (14) 10-acre lots on 148 acres; and
- General Agriculture - 1,108 acres.

The “General Agriculture” areas provide farmers with acreage to develop commercially viable farming operations. These areas are typically flat to gentle rolling hills with good soil. The “Subsistence Agriculture” areas allocate acreage to families who want to supplement their food supply or incomes with farming.

The area has moderate rainfall, and DHHL has plans to develop a water system within the Anahola Agricultural Subdivision. DHHL would like to redevelop the existing irrigation ditch system to provide water to the General Agriculture areas, with the potential to develop hydroelectric power generation plant(s).

Proposed Capital Improvement Projects. Based on the condition assessment of system components and information gathered, a CIP is proposed. Because the original system has been severed, a new pipeline and distribution system should be built to reconnect the tunnel near Kaneha Reservoir to the upper Anahola Reservoir. The proposed CIP program and costs are presented in Table 25 and include the following:

- Rehabilitation/reconstruction of the upper Anahola Stream intake, as well as the tunnel from intake to a new distribution connection point near Kaneha Reservoir;
- Design and construction of a new distribution system from the new connection point near Kaneha Reservoir to the upper Anahola Reservoir. The new distribution system will provide water throughout the DHHL land area for grazing and crop irrigation and should connect to the Kanehu reservoirs. The system will be approximately 7,700 feet in length;
- Planning, design, and construction to rehabilitate upper and lower Anahola reservoirs;
- Planning and design for additional storage, as the existing reservoir capacities were significantly reduced to meet dam and reservoir regulations; and
- Provide funds to study the feasibility of reopening the lower Anahola Ditch irrigation system. This system has the potential to provide a significant amount of water for agricultural uses but is in poor condition.

Table 25
Anahola Irrigation System
Proposed Capital Improvement Projects
DHHL Portion Only

Project Description	**Estimated Cost** (2018 dollars)
	Short-term
Redevelop Upper Anahola Intake and intake tunnel	$550,000
Design and construct new distribution pipeline from intake tunnel to Upper Anahola Reservoir	$8,250,000
Plan, design, and construct rehabilitation of Upper and Lower Anahola Reservoirs	$3,300,000
Plan and create preliminary design for additional storage capacity	$1,100,000
Additional design/construction	To be determined
Study feasibility to open lower Anahola Irrigation system	$400,000

3.1.3 UPPER AND LOWER LĪHUʻE DITCH

Ownership and service area information for the Upper and Lower Līhuʻe Ditch Irrigation System is presented in Table 26. General system information is presented in Table 27.[11]

Initial development of the system was started in 1856 by William Hyde Rice, and continuously expanded until 1937. The Kapahi Tunnel and the Makaleha system were built between 1922 and 1926. In 1926, the Waiahi-ʻIliʻiliʻula-North Wailua ditches were built. By 1931, it is estimated that approximately 79 percent of the Plantation's 6,712 acres was irrigated by gravity flow. The average water demand was estimated at 82 MGD. At that time, the three largest reservoirs were Wailua at 242 million gallons; Upper Kapahi at 30 million gallons; and Lower Kapahi at 25 million gallons. There were two (2) active rainfall stations in the area: one at Puhi, and the other at Līhuʻe Airport.

[11] CWRM may possess additional information on the status of these irrigation systems.

The station at Puhi has an elevation of 330 feet, with a mean annual rainfall of 56.63 inches. The Līhuʻe Airport station has an elevation of 103 feet, with a mean annual rainfall of 39.24 inches.

In 2019, CWRM determined the following:

- Waitā Reservoir diverts from Kuia Stream and is used via pipes to lessees of Grove Farm Company, Inc.; and
- The Lihue Ditch originates from the South Fork Wailua River.

The land use areas within the service area are presented in Table 28. The service area includes IAL, which is served from both the Līhuʻe and Haʻikū irrigation systems. The total area of the IAL is approximately 11,206 acres, and the agricultural uses of these IAL includes diversified agriculture, biomass production for renewable energy and cattle ranching. Irrigation water will be provided by rainfall and water from both the Līhuʻe and Haʻikū Ditch Systems. System maps are shown on Maps 26 to 32.

- Map 26 - Alignments and System Components;Map 27 - 2014-2015 Land Use;
- Map 28 - ALISH 1977;
- Map 29 - Land Capability Non-Irrigated Conditions; and
- Map 30 - Land Capability Irrigated Conditions;
- Map 31 - Important Agricultural Lands; and
- Map 32 – CWRM System Alignments and 2014-2015 Land Use.

Table 26
Upper and Lower Līhuʻe Ditch System
System Ownership and Service Area

Description	Information
Owners	Grove Farms Company Līhuʻe Plantation (System Manager)
Source	Waiahi Stream, Hanamāʻulu Stream and Nāwiliwili Stream
Estimated Current Water Use (annual average)	: 10 MGD[1] (
Estimated Service Area	8,048 acres
Farms Served	2,473 acres (estimated) Various crops
Important Agricultural Lands	11,206 acres (Līhuʻe and Haʻikū Ditch Systems)

Note: 1. Water Use data from CWRM.

Table 27
Upper and Lower Līhuʻe Ditch System
General System Information

Description	Information		
System Length (feet) / status	75,243 (Unverified)		
Intakes	Intake #27	Intake #45	Stream Diversion
Source (type)	Waiahi Stream (Surface Water)	Hanamāʻulu Stream (Surface Water)	Hanamāʻulu Stream (Surface Water)
Hydrologic Unit	Hanamāʻulu	Hanamāʻulu	Hanamāʻulu
Intake Status	Active	Unverified	Unverified

Table 27 (continued)
Upper and Lower Līhuʻe Ditch System
General System Information

Description	Information			
Intakes (continued)	Pipe and Pump	Stream Diversion	Pipe and Pump	
Source (type)	Hanamāʻulu Stream (Surface Water)	Nāwiliwili Stream (Surface Water)	Unknown	
Hydrologic Unit	Hamamāʻulu	Hamamāʻulu	Hamamāʻulu	
Intake Status	Unverified	Unverified	Unverified	
Reservoirs	Kapaia [1]	Aii [1]	Pukakai	Demello
Capacity[1] (acre-feet / MG)	1,114 / 363	68 /22	Unverified	Unverified
Status	Active	Active	Unverified	Active
Visual inspection undertaken	No			
Irrigation system condition	Condition assessment was not performed			
Rehabilitation Potential	Good (Grove Farm Company)			
Rehabilitation Cost / CIP	To be determined by system owner			

Notes: 1) DLNR, Dam inventory online database. http://dams.hawaii.gov

Table 28
Upper and Lower Līhu‘e Ditch System
Land Uses within the Service Area

Cultivation	**Area** (acres)
Field Crops	229.1
Other Crops	608.0
Grazing	1,635.6

Assessment of Needs. As a condition assessment was not completed, the CIP was not developed. The private owner is maintaining the system and performing improvements.

3.1.4 UPPER AND LOWER HA‘IKŪ DITCH

Ownership and service area information for the Upper and Lower Ha‘ikū Ditch Irrigation System is presented in Table 29. General system information is presented in Table 30. The ditch system is privately owned and a subsystem of the Līhu‘e Irrigation System.

The Upper and Lower Ha‘ikū Ditch System is managed by Līhu‘e Plantation. The development of the system started in 1906, with the development of the Kamo‘oloa Water Lead. Between 1914 and 1917, Grove Farm built the "Upper Ha‘ikū Ditch" on the slopes of Kilohana. The Lower Ha‘ikū Ditch was constructed between 1928 to 1948, replacing and realigning the original main ditch with concrete-lined ditches and tunnels. The only active rainfall station in the area is the Halenānaho rainfall station, which sits at an elevation of 490 feet, with a mean annual rainfall of 70.94 inches.

The land use areas within the service area are presented in Table 31. The service area includes IAL, which is served by both the Līhu‘e and Ha‘ikū irrigation systems. The total area of the IAL is approximately 11,206 acres, and the agricultural uses of these IAL lands include biomass production for renewable energy and cattle ranching. Irrigation water will be provided by rainfall and water from both the Līhu‘e and Ha‘ikū Ditch Systems. The system maps are shown on Maps 33 to 39 with:

- Map 33 - Alignments and System Components;
- Map 34 - 2014-2015 Land Use;
- Map 35 - ALISH 1977;
- Map 36 - Land Capability Non-Irrigated Conditions;
- Map 37 - Land Capability Irrigated Conditions; and
- Map 38 - Important Agricultural Lands; and
- Map 39 – CWRM System Alignments and 2014 – 2015 Land Use.

Assessment of Needs. As a condition assessment was not completed, the capital improvement program was not developed. The private owner is managing and maintaining the system.

Table 29
Upper and Lower Haʻikū Ditch System
System Ownership and Service Area

Description	Information
Owners	Grove Farms Company Līhuʻe Plantation (System Manager)
Source	See Table 32
Estimated Current Water Use (annual average)	Unknown
Estimated Service Area	8,050 acres
Farms Served	2,938.6 acres
Important Agricultural Lands	11,206 acres (Līhuʻe and Haʻikū Ditch Systems)

Table 30
Upper and Lower Haʻikū Ditch System
General System Information

Description	Information	
System Length (feet) / status	63,599 (unverifed)	
Intakes	See Table 32	
Reservoirs	Halenānahu	Papuaa
Capacity (acre-feet[1] / MG)	460 / 149.9	921 / 300.1
Status	Active	Active
Visual inspection undertaken	No	
Irrigation system condition	Condition assessment was not performed	
Rehabilitation Potential	Good (Grove Farm Company)	
Rehabilitation Cost / CIP	To be determined by system owner	

Notes: 1) DLNR, Dam inventory online database. http://dams.hawaii.gov

Table 31
Upper and Lower Haʻikū Ditch System
Land Uses within the Service Area

Cultivation	Area (acres)
Field Crops	205.4
Other Crops	591.4
Grazing	2,141.8

Table 32
Upper and Lower Ha‘ikū Ditch System
Intake Description

Intake Type	Stream	Hydrologic Unit	Status
Stream Diversion (pump)	Pū‘ali	Hamamā‘ulu	Used as needed
Stream Diversion	Pū‘ali	Hamamā‘ulu	Active
Stream Diversion	Pū‘ali	Hamamā‘ulu	Active
Stream Diversion	Halehaka	Hamamā‘ulu	Occasional
Stream Diversion (pump)	Ho‘inakāunalehua	Hamamā‘ulu	Unverified
Stream Diversion	Papakōlea	Hamamā‘ulu	Unverified
Stream Diversion	Unknown	Hamamā‘ulu	Unverified
Stream Diversion	Unknown	Hamamā‘ulu	Unverified
Stream Diversion	Unknown (Kula)	Hamamā‘ulu	Unverified
Spring	Not applicable	Hamamā‘ulu	Unverified
Stream Diversion	Kula	Hamamā‘ulu	Unverified
Stream Diversion	Unknown	Hamamā‘ulu	Unverified
Stream Diversion	Kamoola	Hamamā‘ulu	Active
Stream Diversion	Unnamed	Hamamā‘ulu	Unverified
Stream Diversion	Unnamed	Hamamā‘ulu	Unverified
Stream Diversion	Kamoola	Hamamā‘ulu	Unverified
Stream Diversion	Paohia	Hamamā‘ulu	Unverified
Stream Diversion	Paohia	Hamamā‘ulu	Unverified
Stream Diversion	Ku‘ia	Hamamā‘ulu	Unverified
Stream Diversion	Papakōlea	Hamamā‘ulu	Unverified
Stream Diversion	Ku‘ia	Hamamā‘ulu	Active
Stream Diversion	Kamoola	Hamamā‘ulu	Active
Stream Diversion	Paohia	Hamamā‘ulu	Unverified
Stream Diversion	Unknown	Hamamā‘ulu	Unverified
Stream Diversion	Unnamed	Hamamā‘ulu	Unverified
Stream Diversion	Unnamed	Hamamā‘ulu	Unverified

Note: In 2019, CWRM determined that the Upper and Lower Ha‘ikū ditches originates from Kamo‘oloa Stream and the system is largely abandoned.

3.1.5 WAIAHI-KUʻIA AQUEDUCT AND KŌLOA & WILCOX DITCHES

Ownership and service area information for the Waiahi-Kuʻia Aqueduct and Kōloa & Wilcox Ditch Irrigation System is presented in two portions. System information for the portion owned by Grove Farm Company and the Eric A. Knudsen Trust is presented in Table 33, and the portion owned by Alexander & Baldwin (A&B), known as the Lāwaʻi area, is presented in Table 34. General information for the Grove Farm Company and E. A. Knudsen Trust portion is presented in Table 35, and for the Lāwaʻi area in Table 36.

Kōloa Plantation, established in 1835 by Ladd & Co., is known as Hawaiʻi's first sugar plantation. In 1848, Grove Farm Company bought Ladd & Co. at an auction and later sold the plantation to McBryde Sugar Company. In 1899, McBryde Sugar Company incorporated with McBryde Estate and ʻEleʻele Plantation. The incorporation transferred ownership and management of the Lāwaʻi and Kōloa portion of the system to the McBryde Sugar Company. In 1910, A&B became an agent, or shareholder, in McBryde Sugar Company, and later A&B bought out the remaining partners. In 1948, Kōloa Plantation, along with its mill, was acquired by Grove Farm.

The first segment of Wilcox Ditch was probably dug during the drought year of 1869. In 1885, Wilcox Ditch was extended to deliver water to an additional 200 acres of sugar cane. The estimated capacity of the Wilcox Ditch was eight (8) MGD, with an estimated average daily flow of about four (4) MGD. Kōloa Plantation completed the construction of the Waita Reservoir in 1931, with a 2.3 billion gallon storage capacity.

From 1908 to 1909, there was the "McBryde-Kōloa War" over the water rights to ʻŌmaʻo Stream, between Kōloa Plantation Company and McBryde Sugar Company. McBryde Sugar Company claimed to own the rights to the water in ʻŌmaʻo Stream and stopped the water running to Kōloa Plantation Company, a longtime user of the ʻŌmaʻo Stream's water. During the "war," dams were removed/destroyed and rebuilt. Guards were posted to protect the rebuilt dams.

USGS records show that the estimated average flow through the Waiahi-Kuʻia system during low-flow months was 1.6 MGD and during high-flow months was 7.8 MGD. The same records show the estimated average flow through the Kōloa-Wilcox system was 7.1 MGD during low-flow months and 18.1 MGD during high-flow months. There are five rainfall stations active in the area: Kōloa Mauka, Kōloa, Māhāʻulepū, East Lāwaʻi and Kukuiʻula. Table 37 presents the elevation and mean annual rainfall of these stations.

The large water storage capacity available at Waita Reservoir allowed Kōloa Plantation to irrigate over 70 percent of its fields with water from the Kuia-Waita Tunnel. The water for the Kōloa Reservoir was supplied through the modest Wilcox Ditch. In 1914, Līhuʻe Plantation built the Waiahi-Kuʻia Aqueduct, also known as the Kōloa Ditch.[12] This allowed water transmission from Waiahi and Kuʻia streams over Grove Farm lands into Waita Reservoir, via the Wilcox Ditch.

The Kōloa-Wilcox Ditch is 3.3 miles long, with the following major components: 14,685 feet of tunnels, with the longest tunnel having a length of 5,845 feet; 467 feet of flumes; and 2,320 feet of ditches. The design capacity was estimated to be 100 MGD, but the actual average daily flow was approximately 65 MGD.

The service area includes IAL, owned by Māhāʻulepū Farm LLC. The total area of the IAL is approximately 1,533 acres, and the agricultural uses include taro, seed corn, and forage crops for cattle ranching. Anticipated water use presented in the associated IAL Petition and Decision and Order is 2.4 MGD. Land use acreage within the service area is presented in Table 38. The system maps are shown on Maps 40 to 46, as follows:

- Map 40 - Alignments and System Components;
- Map 40A - Alignments and System Components Detailed View;
- Map 41 - 2014-2015 Land Use;
- Map 42 - ALISH 1977;
- Map 43 - Land Capability Non-Irrigated Conditions;
- Map 44 - Land Capability Irrigated Conditions;
- Map 45 - Important Agricultural Lands, and
- Map 46 – CRWM System Alignments and 2014-2015 Land Use.

[12] In 2019, CWRM determined that the Waiahi-Kuia Aqueduct has been abandoned and portions of the Koloa and Wilcox ditches continue to be operated.

Table 33
Waiahi-Kuʻia Aqueduct and Kōloa & Wilcox Ditch Systems
System Ownership and Service Area
(without the Lāwaʻi Portion)

Description	Information
Owners	Grove Farm Company Eric A. Knudsen Trust
Source	Various streams and tunnels
Estimated Current Water Use (annual average)	McBryde area only, see Table 39
Estimated Service Area	11,787 acres
Farms Served	Unverified
Important Agricultural Lands	None

Table 34
Waiahi-Kuʻia Aqueduct and Kōloa & Wilcox Ditch Systems
System Ownership and Service Area
(Lāwaʻi Portion)

Description	Information
Owners	Alexander and Baldwin, Inc.
Source	Nalohia Stream
Estimated Current Water Use (annual average)	Unverified
Estimated Service Area	11,787 acres
Farms Served	2,939 acres (estimated)
Important Agricultural Lands	Yes

Table 35
Waiahi-Kuʻia Aqueduct and Kōloa & Wilcox Ditch Systems
General System Information
(without the Lāwaʻi Portion)

Description	Information			
System Length (feet) / status	54,598 (Active) 27,875 (Inactive) 394,199 (Unverified)			
Intakes	See Table 40			
Reservoirs	ʻŌmaʻo	Papuaa	Waita[13]	Mauka
Capacity (acre-feet)(2) / MG	194 / 63	921 / 300	9,900 / 3,226	345 / 112
Status	Active	Active	Active	Active
Reservoirs	Puu O Hewa	Piwai	Pia Mill	
Capacity (acre-feet)(1) / MG	115 / 385	261 / 85	39 / 13	
Status	Active	Active	Active	
Visual inspection undertaken	No			
Irrigation system condition	Condition assessment was not performed			
Rehabilitation Potential	Good (Grove Farm Company and Eric A. Knudsen Trust)			
Rehabilitation Cost / CIP	To be determined by system owner			

Notes: 1) DLNR, Dam inventory online database. http://dams.hawaii.gov

[13] In 2019, CWRM determined that Waita Reservoir is a separate system, management, and ownership from ʻŌmaʻo, Piwai, Puu O Hewa, Pia Mill and Mauka reservoirs. Papuaa Reservoir is managed to supply the Upper Haʻikū Ditch.

Table 36
Waiahi-Kuʻia Aqueduct and Kōloa & Wilcox Ditch Systems
General System Information
(Lāwaʻi Portion)

Description	Information			
System Length (feet) / status	22,762 (Active) 32,073 (Inactive)			
Intakes Source (type) Hydrologic Unit Intake Status	Intake Lawai Stream (Surface Water) Kōloa Active			
Reservoirs	Hanini	Huinawai	Aepoalua	Aepo
Capacity (acre-feet[1] / MG)	Unknown	196 / 64	131 / 43	457 / 149
Status	Active	Active	Active [2]	Active [3]
Reservoirs	Aepoekolu	Aepoeha	Manuhonuhonu	
Capacity[1] (acre-feet / MG)	152 / 50	670 / 218	49 / 16	
Status	Active [4]	Active	Active [4]	
Reservoirs	Kaupale	Kūmano		
Capacity[1] (acre-feet / MG)	240 / 78	175 / 57		
Status	Active [4]	Active [2]		
Visual inspection undertaken	Yes			
Irrigation system condition	Good, See Tables 41 and 42			
Rehabilitation Potential	Good			
Rehabilitation Cost / CIP	See Table 43			

Notes: 1) DLNR, Dam inventory online database. http://dams.hawaii.gov
2) Aepoalua Reservoir used as a stormwater collection basin.
3) Aepo Reservoir also used for emergency purposes.
4) To be decommissioned as of 2014.
5) CWRM may possess additional information on the status of these irrigation systems.

Table 37
Waiahi-Kuʻia Aqueduct and Kōloa & Wilcox Ditch Systems
Rainfall Summary

Station	**Elevation** (feet)	**Mean Annual Rainfall** (inches)
Kōloa Mauka	640	96.31
Kōloa	240	56.78
Māhāʻulepū	80	44.13
East Lāwaʻi	440	54.60
Kukuʻiula	105	42.09

Table 38
Waiahi-Kuʻia Aqueduct and Kōloa & Wilcox Ditch Systems
Land Uses within the Service Area

Cultivation	**Area** (acres)
Field Crops	889.2
Other Crops	1,501.4
Grazing	2,871.0

Table 39
Waiahi-Kuʻia Aqueduct and Kōloa & Wilcox Ditch Systems
Reported Flows for McBryde Resources

Gage Name	**Mean** (MGD)	**Minimum** (MGD)	**Maximum** (MGD)
Alexander	5.92	0	8.52
Wainiha Powerhouse Plant	75.24	0	446.10
Lāwaʻi	0.73	0	1.91

Reference: CWRM (2017).

Table 40
Waiahi-Kuʻia Aqueduct and Kōloa & Wilcox Ditch Systems
Intake Description
(Without the Lāwaʻi Portion)

Intake Type	Stream	Hydrologic Unit	Status
Stream Diversion	Palikea	Kōloa	Unverified
Stream Diversion	Waiahi	Kōloa	Active
Stream Diversion	ʻIliʻiliʻula	Kōloa	Active
Stream Diversion	ʻIliʻiliʻula	Kōloa	Active
Stream Diversion	Waikoko	Kōloa	Active
Stream Diversion	Wailua	Kōloa	Unverified
Stream Diversion	Waiahi	Kōloa	Active
Stream Diversion	ʻIliʻiliʻula	Kōloa	Active
Stream Diversion	ʻIliʻiliʻula	Kōloa	Active
Stream Diversion	Waiahi	Kōloa	Active
Stream Diversion	Waiaka	Kōloa	Active
Stream Diversion	Waiahi	Kōloa	Active
Tunnel	Not applicable	Kōloa	Unverified
Tunnel	Not applicable	Kōloa	Unverified
Stream Diversion	Unknown	Unknown	Unverified
Stream Diversion	Kuʻia	Kōloa	Unverified
Stream Diversion	Kamoola	Kōloa	Unverified
Stream Diversion	Kamoola	Kōloa	Unverified
Stream Diversion	Paohia	Kōloa	Unverified
Stream Diversion	Paohia	Kōloa	Unverified
Stream Diversion	Kuʻia	Kōloa	Unverified
Stream Diversion	Kuʻia	Kōloa	Active
Stream Diversion	Kamoola	Kōloa	Active
Stream Diversion	Paohia	Unknown	Unverified
Stream Diversion	Unknown	Unknown	Unverified
Stream Diversion	Paeleele	Kōloa	Unverified
Stream Diversion	ʻŌmaʻo	Unknown	Active
Stream Diversion	ʻŌmaʻo	Unnamed	Active

Table 40 (continued)
Waiahi-Kuʻia Aqueduct and Kōloa & Wilcox Ditch Systems
Intake Description
(Without the Lāwaʻi Portion)

Intake Type	Stream	Hydrologic Unit	Status
Stream Diversion	Poeleele	Unknown	Active
Spring	Hakaka spring	Kōloa	Unverified
Stream Diversion	Waihohonu	Kōloa	Unverified
Spring	Not applicable	Kōloa	Unverified
Stream Diversion	Unnamed	Kōloa	Unverified
Stream Diversion	Waihohonu	Kōloa	Unverified
Stream Diversion	Unnamed	Kōloa	Unverified
Stream Diversion	Waihohonu	Kōloa	Unverified

Assessment of Needs. As a condition assessment was not completed for the non-A&B portion of the system, a capital improvement program was not developed. A private owner is managing and maintaining that portion of the system.

This assessment of needs for the A&B (Lāwaʻi) portion of the system and survey was conducted in 2014. The system is currently in use, in good condition, and being maintained by A&B. Tables 41 and 42 show the system components and their respective status.

The "original" A&B portion of the system that is north (mauka) of Huinawai reservoir was observed and is in good condition. Exhibits 17 and 18 show examples of the condition of the Lāwaʻi system. The irrigation system south (makai) of Huinawai reservoir was replaced by two pipelines: one with an 18-inch diameter, and the other with a 12-inch diameter. The 18-inch pipeline provides water to the coffee fields above (mauka) A&B's Kukuʻiula Development, while the 12-inch pipeline services A&B's Agriculture Park. The approximate alignment of the two pipelines are shown in Map 34. The Agriculture Park has an area of 220 acres, with 20 tenant lots ranging from 10 to 20 acres. The tenants cultivate a variety of commodities, from nursery plants to truck crops (mixed produce). In the areas used for cattle ranching, the water is provided on an as-needed basis and pumped from the nearest reservoir.

Table 41
Waiahi-Kuʻia Aqueduct and Kōloa & Wilcox Ditch System
Distribution System Components
(Lāwaʻi Portion Only)

Distribution System	**Length** (feet)	**Comments**
Ditches		
Active	4,881	
Inactive	28,356	Replaced with a pipeline system that follows parts of the ditch
Tunnels		
Active	1,713	
Inactive	3,430	Replaced with pipeline system
Siphons		
Active	0	
Inactive	287	Replaced with pipeline system
Pipelines		
Active	16,168	Estimated length
Inactive	0	

Table 42
Waiahi-Kuʻia Aqueduct and Kōloa & Wilcox Ditch System
Distribution System Condition
(Lāwaʻi Portion and Active Only)

Distribution System	**Length** (feet)	**Comments**
Ditches		
Good Condition	4,881	North of Huinawai Reservoir only
Fair Condition	0	
Poor Condition	0	
Tunnels		
Good Condition	1,713	North of Huinawai Reservoir only
Fair Condition	0	
Poor Condition	0	
Pipelines		
Good Condition	16,168	
Fair Condition	0	
Poor Condition	0	

Exhibit 17. Lāwaʻi Portion - Lined Ditch Section

Exhibit 18. Lāwaʻi Portion - Tunnel Entrance

Proposed Capital Improvement Projects. Based on the condition survey and discussions with A&B staff, the following two projects are proposed. Table 43 presents the proposed CIP, estimated costs (planning level), and phase for development.

- The ditch north of Kaumualiʻi Highway (Highway 50) is impacted by invasive species overgrowth. This overgrowth requires continuous (daily) maintenance, resulting in staff and repair costs to mitigate bank erosion, flow blockages, and reduced flow. The invasive species overgrowth needs to be cleared and the area re-planted to minimize the impact on the irrigation ditch and provide erosion control. The approximate area to be cleared and re-planted is one (1) acre and is on sloped terrain.

- The outlet from Huinawai Reservoir has a leak and requires renovation. The renovation may require a portion of the dam to be reconstructed to provide a long-term solution to the problem.

Table 43
Waiahi-Kuʻia Aqueduct and Kōloa & Wilcox Ditch System
Proposed Capital Improvement Projects
(Lāwaʻi Portion Only)

Project Description	**ESTIMATED COST** (2018 dollars)
	Short-term
Invasive species removal and revegetation (Planning, design, and construction)	$800,000
Renovation of dam at outlet	
Planning and design	$550,000
Construction	To be determined

Note: Construction cost to be determined after design is completed.

3.1.6 OLOKELE DITCH

Ownership and service area information for the Olokele Ditch Irrigation System is presented in Table 44. General system information is presented in Table 45. There is one rainfall station in the area: the Makeweli rainfall station at an elevation of 140 feet, with a mean annual rainfall of 22.24 inches.

The Olokele Ditch was opened in 1904 as part of the expansion plans for Makaweli Plantation. The Olokele irrigation system marked the first time that long tunnels were used instead of open ditches, under the design and direction of Michael M. O'Shaughnessy, who was considered one of the world's foremost irrigation engineers. This undertaking was estimated to cost $500,000. The successful development of water diversion for Makaweli Plantation (later known as Olokele Sugar Company) led to the “Hanapēpē Case.”[14] The “Hanapēpē Case” resulted in a landmark 1973 Supreme Court decision, now known as the McBryde decision.

The land use areas within the service area are presented in Table 46. The IAL area is approximately 20,888 acres and will be used primarily for cattle ranching. The system maps are shown on Maps 47 to 53, as follows:

- Map 47 - Alignments and System Components;
- Map 48 - 2014-2015 Land Use;
- Map 49 - ALISH 1977;
- Map 50 - Land Capability Non-Irrigated Conditions;
- Map 51 - Land Capability Irrigated Conditions;
- Map 52 - Important Agricultural Lands; and
- Map 53 – CWRM System Alignments and 2014-2015 Land Use.

Assessment of Needs. As a condition assessment was not completed, the CIP was not developed. However, telephone conversations with the owner’s representatives indicate that the owners are maintaining the ditch system and there are adequate water resources for farmers.

[14] Lawsuit filed by McBryde Sugar Company against Gay and Robinson regarding downstream water users.

Table 44
Olokele Ditch System
System Ownership and Service Area

Description	Information
Owners	Gay and Robinson
Source	Various streams, see Table 47
Estimated Current Water Use (annual average)	Historical – 66 MGD
Estimated Service Area	15,730 acres
Farms Served	Unverified
Important Agricultural Lands	20,888 acres

Table 45
Olokele Ditch System
General System Information

Description	Information
System Length (feet)/status	201,136 (unverified)
Intakes	See Table 47
Reservoirs	See Table 48
Visual inspection undertaken	No
Irrigation system condition	Condition assessment was not performed
Rehabilitation Potential	Good, as system is active
Rehabilitation Cost / CIP	To be determined by system owner

Note: CWRM may possess additional information on the status of these irrigation systems

Table 46
Olokele Ditch System
Land Uses within the Service Area

Cultivation	**Area** (acres)
Field Crops	7,472.4
Other Crops	933.6
Grazing	1,384.8

Table 47
Olokele Ditch System
Intake Description

Intake Type	**Stream**	**Hydrologic Unit**	**Status**
Stream Diversion	Waikai	Makaweli	Unverified
Stream Diversion	Hanonui	Makaweli	Unverified
Stream Diversion	Paliemo	Makaweli	Unverified
Stream Diversion	Manawaiopuna	Makaweli	Unverified
Stream Diversion	Lana	Makaweli	Unverified
Stream Diversion	Kala	Makaweli	Unverified
Stream Diversion	Maku	Makaweli	Unverified
Stream Diversion	Kunalele	Makaweli	Unverified
Stream Diversion	Hikilei	Makaweli	Unverified
Stream Diversion	Kunalele	Makaweli	Unverified
Stream Diversion	Mahaikona	Makaweli	Unverified
Stream Diversion	Kalopopo	Makaweli	Unverified
Stream Diversion	Kaluawai	Makaweli	Unverified
Stream Diversion	Waiānuenue	Makaweli	Unverified
Stream Diversion	Kalopopo	Makaweli	Unverified
Stream Diversion	Olokele	Makaweli	Unverified

Table 48
Olokele Ditch System
Reservoir Capacity

Reservoir	Capacity(1)		Current Status
	Acre-feet	MG	
Waikaia	--	--	Unverified
Po‘opueo	--	--	Unverified
Waikoloi	147	47.9	Active
Pu‘ulani	--	--	Unverified
Kuhumu	--	--	Unverified
Waikai	--	--	Unverified
Kaawanui	110	35.8	Active
Kalaeloa	--	--	Unverified
Waikaia	58	18.9	Active
‘A‘aka	--	--	Unverified
Kepani	85	27.7	Active

Notes: 1) DLNR, Dam inventory online database. http://dams.hawaii.gov

3.2 O‘AHU IRRIGATION SYSTEMS

The following systems were studied on O‘ahu, in the City and County of Honolulu, and their locations are shown in Exhibit 19.

- O‘ahu Ditch (Wahiawā, Helemano, Tanada, and Ito).
- Opaeula and Kamananui.
- Kahuku Irrigation System.
- Galbraith Lands Irrigation System.

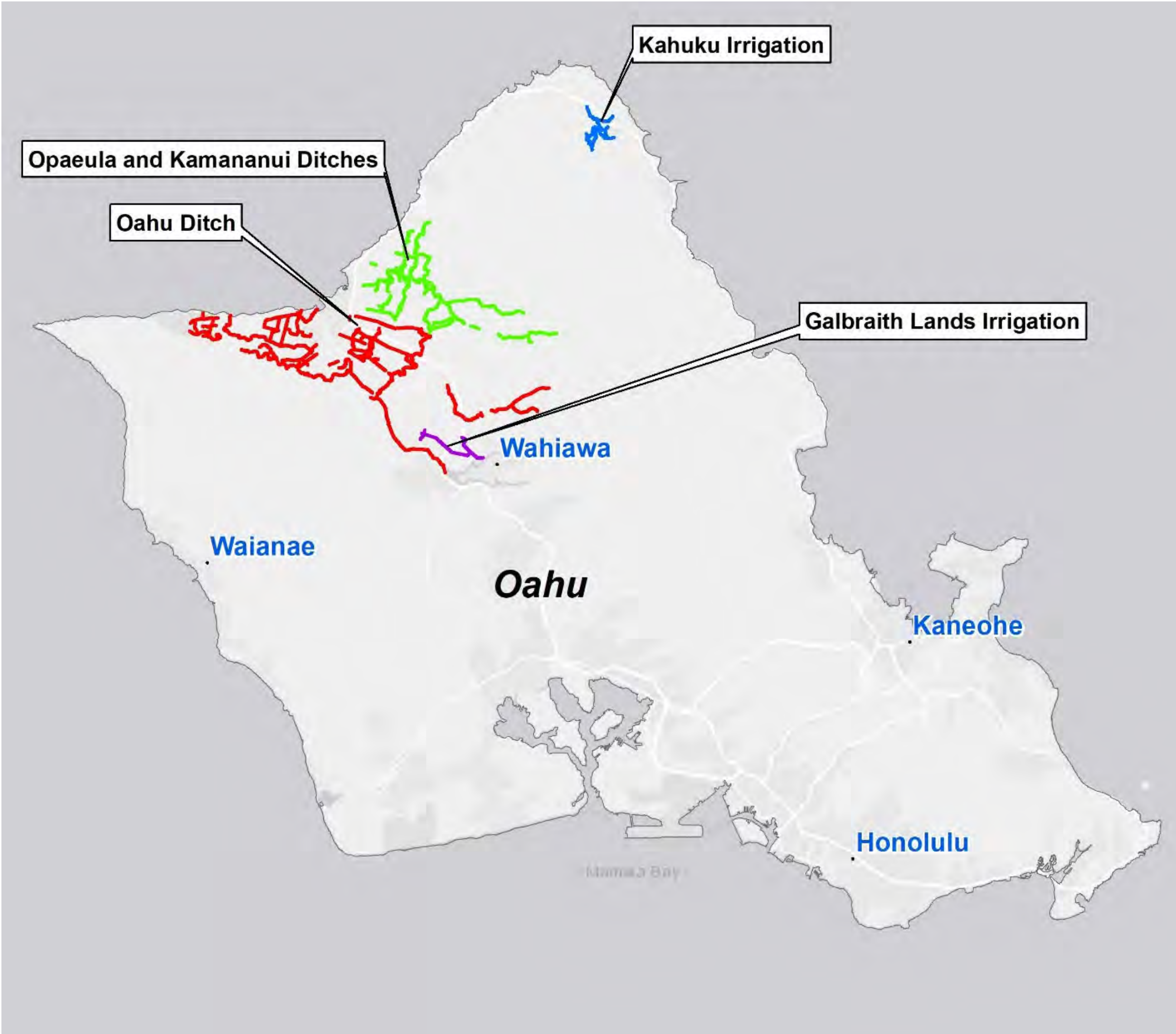

Exhibit 19. Water Systems Inventoried on O‘ahu

3.2.1 O‘AHU (MAUKA DITCH TUNNEL), WAHIAWĀ, HELEMANO, TANADA, AND ITO DITCHES

Ownership and service area information for the O‘ahu (Mauka Ditch Tunnel), Wahiawā, Helemano, Tanada, and Ito Ditch Irrigation Systems is presented in Table 49. General system information is presented in Table 50.

The irrigation network was developed by Waialua Sugar Company[15] and was comprised of seven (7) major systems: O‘ahu (Mauka Ditch Tunnel), Wahiawā, Helemano, Tanada, Opaeula, Kamananui, and Ito Ditch. While

[15] Waialua Sugar Company was a subsidiary of Dole Food Co., Inc.

Waialua Sugar Company was operating, these ditch systems were interconnected and had the flexibility to meet water demands of the production areas.

Upon the closure of Waialua Sugar Company, the system was separated into two different owners: 1) Dole Company and 2) Kamehameha Schools Bishop Estates (KSBE). This section will discuss the Oʻahu Ditch (Dole) system, which includes Oʻahu (Mauka Ditch Tunnel), Wahiawā, Helemano, Tanada, and Ito Ditches. Four (4) surface-water collection systems (Wahiawā, Helemano, Opaeula, and Kamananui) were built between 1900 and 1906. The exact dates of construction for the Helemano and Poamoho Ditch sections are not known, but reports indicate that these ditches were completed circa 1902-1904. The Tanada Ditch was designed for larger flows, but records indicate that the average flow was approximately three (3) MGD. The Ito Ditch was built sometime after 1911. In 2019, CWRM stated that Castle and Cooke Homes Hawaiʻi, Inc. operates the Helemano and Tanada Ditch.

Historical USGS data states that the estimated average flow in the Oʻahu System during low-flow months is 2.3 MGD, rising to 3.0 MGD during high-flow months. Historical USGS data states that the estimated average flow in the Wahiawā System during low-flow months is 6.5 MGD, increasing to 12.3 MGD during high-flow months. The Upper Wahiawā rainfall station has an elevation of 1,115 feet and a mean annual rainfall of 59.60 inches.

Since 1927, Lake Wilson has received treated effluent from the City and County of Honolulu through the Wahiawā Wastewater Treatment Plant (WWTP). In addition, the system receives treated effluent from the U.S. Army Schofield Barracks WWTP downstream of Lake Wilson.
Within the Oʻahu Ditch irrigation system service area, there are 679.432 acres of IAL, with 242.085 acres in Waialua, 205.593 acres in Whitmore, and 231.754 acres in Mililani South. The IAL will be used for cultivating diversified crops such as pineapple, plumeria, bananas, mango, star fruit, ʻaʻaliʻi, bromeliads, cacao, ʻiliahi, koa, lychee, moa, ʻōhiʻa lehua, papaya, rambutan, ti leaf, herbs, vegetables, ornamental shrubs, grass, and tuberose. Anticipated water use from the associated IAL Petition and Decision and Order is approximately 2.1 MGD. The land use areas within the service area are shown in Table 51. The Oʻahu Ditch system maps are shown on Maps 54 to 60, as follows:

- Map 54 - Alignments and System Components;
- Map 55 - 2014-2015 Land Use;
- Map 56 - ALISH 1977;
- Map 57 - Land Capability Non-Irrigated Conditions;
- Map 58 - Land Capability Irrigated Conditions;
- Map 59 - Important Agricultural Lands, and
- Map 60 – CWRM System Alignments and 2014-2015 Land Use.

Table 49
O'ahu (Mauka Ditch Tunnel), Wahiawā, Helemano, Tanada, and Ito Ditch System
System Ownership and Service Area

Description	Information
Owners	Dole Company
Source	Kaukonahua, Helemano and Paukaulia streams and springs
Estimated Current Water Use (annual average)	10 MGD Reported flows, see Table 52
Estimated Service Area	24,640 acres
Farms Served (estimated)	11,500 acres 18 commercial farms (2007)
Important Agricultural Lands	679 acres

Table 50
Oʻahu (Mauka Ditch Tunnel), Wahiawā, Helemano, Tanada, and Ito Ditch System
General System Information

Description	Information		
System Length (feet) / status	135,366 (active) 185,069 (inactive) 9,138 (unverified)		
Intake	Stream (with pump)	Stream	Spring
Source (type)	Kaukonahua (Surface Water)	Helemano (Surface Water)	Spring (Surface Water)
Hydrologic Unit	Wahiawā	Wahiawā	Wahiawā
Intake Status	Stream Diversion - Active Pump - Unverified	Active	Inactive
Intake	Spring	Stream	Spring
Source (type)	Spring Spring	Paukaulia (Surface water)	Spring Spring
Hydrologic Unit	Wahiawā	Wahiawā	Wahiawā
Intake Status	Inactive	Inactive	Inactive
Reservoirs	See Table 53		
Visual inspection undertaken	Yes		
Irrigation system condition	See Tables 54 and 55		
Rehabilitation Potential	Good		
Rehabilitation Cost / CIP (five years)	$8,360,000 (See Table 56)		

Table 51
O'ahu (Mauka Ditch Tunnel), Wahiawā, Helemano, Tanada, and Ito Ditch System
Land Uses within the Service Area

Cultivation	**Area** (acres)
Field Crops	4,601.8
Other Crops	4,313.3
Grazing	1,590.2

Table 52
O'ahu (Mauka Ditch Tunnel), Wahiawā, Helemano, Tanada, and Ito Ditch System
Reported Flows
(MGD)

Gage	**2015**			**2016**			**2017**		
	Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.	Max
Helemano	2.1	0.7	3.1	1.8	0.9	2.2	1.9	0.8	2.5
Wahiawā	5.4	3.9	8.0	9.0	5.7	11.4	7.6	5.7	9.4

Reference: CWRM (2017)

Assessment of Needs. A survey of the O'ahu Ditch system (including the other systems) provided data for the condition analysis. The system components and their assessed condition are shown in Tables 54 and 55. Exhibits 20-23 are examples of the various conditions found along O'ahu Ditch. The pipe, siphon, and tunnel lengths represent horizontal lengths; actual lengths will be longer, as dictated by terrain. Many of the inactive ditches within the O'ahu Ditch, especially in the Waialua area, are in fair condition and used to capture, store, and/or divert storm water runoff.

In 2008, the Hawai'i Department of Agriculture, Agricultural Development Corporation (ADC) published the *Wahiawā Irrigation System, Economic*

Impact Study.[16] The study focused on Waialua Sugar Company lands that were in Hale‘iwa, Waialua, Poamoho, and north of Poamoho. By 1996, near the end of sugar production at Waialua Sugar Company, approximately 10 MGD was flowing through the system to irrigate approximately 6,400 acres of agriculture land, or approximately 55 percent of the total farmable land.

Table 53
O‘ahu (Mauka Ditch Tunnel), Wahiawā, Helemano, Tanada, and Ito Ditch System
Reservoir Capacity

Reservoir	**Capacity(1)**		**Current Status**
	Acre-feet	MG	
Upper Helemano	700	228	Active
Wahiawā (Lake Wilson)	9,200	2,998	Active
Kemoo 5	63	21	Active
Kemoo 8	29	10	Active
Kemoo 2A	23	8	Active
Ranch 1	--	--	Decommissioned
Ranch 4	--	--	Decommissioned
Ranch 10A	--	--	Decommissioned
Ranch 10B	35	11	Active
Kaheaka	27	9	Active
Helemano 2A	27	9	Unverified
Helemano 6	80	26	Active
Helemano 10	--	--	Decommissioned
Helemano 11	--	--	Decommissioned
Helemano 16	65	21	Active

Notes: 1) DLNR, Dam inventory online database. http://dams.hawaii.gov/

According to the 2008 ADC study, there are 8,100 acres of agricultural land within the service area, of which 6,400 acres depend on irrigation. Of the 6,400 acres, approximately 45 percent is currently not being farmed (non-

[16] Southichack, Mana K., *Wahiawā Irrigation System, Economic Impact Study*, November 21, 2008.

arable) for various reasons, including topography, water, etc. According to the ADC study, approximately 1,715 acres of these non-arable lands could be converted to cultivation if irrigated.

Table 54
O‘ahu (Mauka Ditch Tunnel), Wahiawā, Helemano, Tanada, and Ito Ditch System
Distribution System Components

Distribution System	**Length** (feet)	**Comments**
Ditches		
Active	65,770	Inactive ditches are used to control and store storm water runoff
Inactive	152,140	
Pipelines		
Active	14,110	Estimated length
Inactive	22,060	
Flumes		
Active	750	
Inactive	250	
Siphons		
Active	5,660	Horizontal length
Inactive	2,250	
Tunnels		
Active	32,160	Estimated length
Inactive	5,840	
Canals		
Inactive	1,000	

Table 55
Oʻahu (Mauka Ditch Tunnel), Wahiawā, Helemano, Tanada, and Ito Ditch System
Distribution System Condition
(Active Components Only)

Distribution System	**Length** (feet)	**Comments**
Ditches		
Good Condition	54,520	
Fair Condition	9,760	Ditch along highway should be enclosed or replaced with pipeline
Poor Condition	1,490	
Pipelines		
Good Condition	13,970	
Fair Condition	120	Visual inspection for leaks
Poor Condition	10	
Siphons		
Good Condition	1,300	
Fair - Poor Condition	4,360	Leaking and aging
Tunnels		
Good Condition	32,160	Portions have minor root intrusion, which may cause damage in the future
Fair Condition	0	
Poor Condition	0	

Exhibit 20. O‘ahu Ditch - Damaged siphon

Exhibit 21. O‘ahu Ditch - Poor condition

Exhibit 22. Oʻahu Ditch - Good condition

Exhibit 23. Oʻahu Ditch - Ditch collapse

Proposed Capital Improvement Projects. Based on the 2014 assessment of Oʻahu Ditch (Dole portion), which includes the Oʻahu, Helemano, Wahiawā, Tanada, and Ito ditches, and information gathered from stakeholders, a CIP is proposed. The following projects are proposed, and estimated costs and construction phasing are presented in Table 56.

- Repair ditch damaged by age and/or plant and animal intrusion. Approximately 11,230 feet of ditch needs repair.
- Install pipelines in ditches adjacent to highways, roadways, and near public access driveways to reduce blockage caused by embankment collapse or rubbish accumulation. Some embankments near ditches may require retaining walls to be stabilized. Approximately 700 feet of ditch should be replaced with pipelines.
- Rehabilitate or replace leaking and aged siphons. The use of slip-lining or cured-in-place technologies to rehabilitate the existing siphons should be considered. There are five (5) leaking siphons with a total horizontal length of 4,360 feet.
- Perform a bathymetry study on Helemano Reservoir. As the system has been operating for over a century, the sediment buildup in the reservoir has reduced its storage capacity. Therefore, a bathymetry study is recommended to determine the reduced capacity and to analyze the feasibility of having the reservoir dredged to increase storage capacity.

Table 56
Oʻahu (Mauka Ditch Tunnel), Wahiawā, Helemano, Tanada, and Ito Ditch System
Proposed Capital Improvement Projects

Project Description	ESTIMATED COST (2018 dollars)
	Short-Term
Repair ditches	$2,100,000
Install pipelines	
Investigation	$500,000
Design and Construction	To be determined
Rehabilitate siphons	$5,700,000
Bathymetry study	$60,000

3.2.2 OPAEULA AND KAMANANUI SYSTEMS

This section discusses the KSBE System, comprising the Opaeula and Kamananui ditch systems. Ownership and service area information for the Opaeula and Kamananui irrigation systems is presented in Table 57. General system information is presented in Table 58. This system was once connected to the other Oʻahu ditch systems during the operation of Waialua Sugar Company.

There are two (2) rainfall stations for this area. The Opaeula rainfall station is located at an elevation of 1,060 feet and has a mean annual rainfall of 56.82 inches. The Pūpūkea Road rainfall station is located at an elevation of 1,160 feet and has a mean annual rainfall of 75.44 inches.

Within the KSBE irrigation system (Opaeula and Kamananui) service area, there are 9,171 acres of IAL, with 6,488.497 acres in the Kamananui service area and 2,683 acres in the Opaeula service area. The IAL lands contain approximately 722 acres planted with diversified agriculture such as corn, banana, taro, papaya, mango, and lettuce; 297 acres used for livestock; and one (1) acre planted with koa as a windbreak. The land above the 600-foot elevation is occupied by 30 wind turbines. Table 59 presents the land use areas within the service area. In 2019, CWRM re-verified that Kamehameha Schools operates a diversion on ‘Opae‘ula and Kawai‘iki streams as part of the ‘Opae‘ula Ditch, a diversion on Kawainui Stream as part of the Kawainui Ditch, and a diversion on Punalu‘u Stream as part of the Punalu‘u Ditch.

The overall system is shown on Maps 61 to 67:

- Map 61 - Alignments and System Components;
- Map 62 - 2014-2015 Land Use;
- Map 63 - ALISH 1977;
- Map 64 - Land Capability Non-Irrigated Conditions;
- Map 65 - Land Capability Irrigated Conditions;
- Map 66 - Important Agricultural Land, and
- Map 67 – CWRM System Alignments and 2014-2015 Land Use.

Table 57
Opaeula and Kamananui Irrigation System
System Ownership and Service Area

Description	Information
Owners	Kamehameha School Bishop Estate
Source	Various streams
Estimated Current Water Use (annual average)	Unverified
Estimated Service Area	9,350 acres
Farms Served	4,500 acres
Important Agricultural Lands	9,171 acres

Table 58
Opaeula and Kamananui Irrigation System
General System Information

Description	Information
System Length (feet) / status	164,952 (unverified)
Intakes	See Table 60
Reservoirs	See Table 61
Visual inspection undertaken	No
Irrigation system condition	Working and active
Rehabilitation Potential	Good
Rehabilitation Cost / CIP	To be determined by owner

Table 59
Opaeula and Kamananui Irrigation System
Land Uses within the Service Area

Cultivation	Area (acres)
Field Crops	158.2
Other Crops	1,575.4
Grazing	2,719.2

Table 60
Opaeula and Kamananui Irrigation System
Intake Description

Intake Type	Stream	Hydrologic Unit	Status
Stream Diversion	Opaeula	North	Unverified
Stream Diversion	Kawaiiki	North	Unverified
Stream Diversion	Waimea	North	Active*
Stream Diversion	Ka‘alaea	North	Active*
Stream Diversion	Kawailoa	North	Active*
Stream Diversion	Laniākea	North	Active*
Stream Diversion	Anahulu	North	Active*
Spring	--	North	Active

Note: * Information from the KSBE IAL petition.

Table 61
Opaeula and Kamananui Irrigation System
Reservoir Capacity

Reservoir	Capacity [1]		Current Status
	Acre-feet	MG	
Opaeula 1	320	104	Active
Opaeula 2	75	24	Decommissioned
Opaeula 5	30	10	Unverified
Opaeula 8	39	13	Unverified
Opaeula 15	74	24	Unverified
Opaeula 16	85	28	Active
Kawailoa 3	33	11	Unverified
Kawailoa 7	63	21	Unverified
Kawailoa 8	11	4	Unverified
Kawailoa 9	27	9	Unverified
Kawailoa 11	20	7	Unverified
Kawailoa 14	63	21	Unverified
Kawailoa 15	23	8	Unverified
Kawailoa 18	44	14	Unverified

Notes: 1) DLNR, Dam inventory online database. http://dams.hawaii.gov/

Assessment of Needs. As a condition assessment was not completed, a capital improvement program was not developed. The Opaeula and Kamananui System (KSBE System) is privately owned and currently active. Based on discussions with system users, the system is active and has a water management system in place to schedule irrigation times for farmers. Future uses include diversified agriculture and wind and photovoltaic energy farms.

3.2.3 KAHUKU IRRIGATION SYSTEM

Ownership and service area information for Kahuku Irrigation System is presented in Table 62. General system information is presented in Table 63. The system was developed and managed by HDOA-ARMD within the Kahuku Agricultural Park, Kahuku, Oʻahu. The system is an underground pipeline system. In addition, discussions with HDOA-ARMD staff provided insight to issues, flows, and land use.

There is one rainfall station in the area: the Kiʻi-Kahuku (Pump 5) rainfall station at an elevation of 40 feet, with a mean annual rainfall of 43.97 inches. Table 64 presents the land use acreages within the service area. The system maps are shown on Maps 68 to 72, as follows:

- Map 68 - Alignments and System Components;
- Map 69 - 2014-2015 Land Use;
- Map 70 - ALISH 1977;
- Map 71 - Land Capability Non-Irrigated Conditions; and
- Map 72 - Land Capability Irrigated Conditions.

Table 62
Kahuku Irrigation System
System Ownership and Service Area

Description	Information
Owners	State of Hawaiʻi HDOA–ARMD (System Manager)
Source:	Groundwater
Estimated Current Water Use (annual average)	6,000 gpd/acre for nursery use (planned) 4,000 gpd/acre for truck farms (planned)
Estimated Service Area	225 acres
Farms Served	24 farms
Important Agricultural Lands	None

Table 63
Kahuku Irrigation System
General System Information

Description	Information
System Length (feet)/Status	12,000 (active)
Intake Source (type) Hydrologic Unit Intake Status	Wells Groundwater Koʻolauloa Active
Reservoirs Capacity Status	Water tank 0.10 million gallons Active
Visual inspection undertaken	Yes
Irrigation system condition	Good, see Table 65
Rehabilitation Potential	Good
Rehabilitation Cost / CIP (five years)	$4,370,000 See Table 66

Table 64
Kahuku Irrigation System
Land Uses within the Service Area

Cultivation	Area (acres)
Field Crops	0.0
Other Crops	197.8
Grazing	0.0

Assessment of Needs. Visual inspection of the system identified the pump house as a potential project, but there were no visible and known leaks in the distribution system. The pump house is deteriorating due to environmental conditions in the area. A summary of the inspection is presented in Table 65, and Exhibits 24 and 25 show the pumps and water tank, respectively.

Kahuku Agricultural Park is located west of Kahuku town and adjacent to the land used by Kahuku Farmers Association. The Kahuku Irrigation System supplies water to 24 agriculture lots covering approximately 225 acres. Of the 225 acres, there are approximately 160 acres of relatively flat lands (slopes < 10 percent) that were designated for truck farming. The remaining acreage is poorer land, with varying slopes, some greater than 10 percent, is designated for nursery operations. As nursery operations cultivate potted plants, these operations are more suited to the varying slopes and not limited by soil type.

In the 1990s, HDOA-ARMD constructed an irrigation system consisting of approximately 12,000 feet of pipe, wells, pumps and pump house, and a water tank. The pumps and wells are located near the 20-foot elevation, with the water pumped up to the water tank for storage, providing gravity flow to the farms.

Table 65
Kahuku Irrigation System
Distribution System Condition

Distribution System	**Length** (approx. feet)	**Comments**
Pipeline		
Good Condition	12,000	Constructed circa 1990
Fair Condition	0	
Poor Condition	0	

Exhibit 24. Kahuku Irrigation System - Pumps and Wells

Exhibit 25. Kahuku Irrigation System - Water Tank

Proposed Capital Improvement Projects. Based on the assessment of the system and information gathered on the condition of various components, the following proposed CIP list was developed. Table 66 presents the proposed CIP list, estimated costs (planning level) and phase for development.

- Install a SCADA system to monitor water flow.
- Miscellaneous upgrades.
- Replace the pump house structure due to corrosion.
- Investigate and repair roadway.
- Investigate and repair sinkhole.

Table 66
Kahuku Irrigation System
Proposed Capital Improvement Projects

Project Description	**ESTIMATED COST** (2018 dollars)
	Short-Term
Install SCADA (ongoing)	$850,000
Miscellaneous upgrades (ongoing)	$3,000,000
Pump house renovation	$300,000
Investigate and repair roadway	$110,000
Investigate and repair sinkhole	$110,000

3.2.4 GALBRAITH LANDS IRRIGATION SYSTEM

Ownership and service area information for the Galbraith Lands Irrigation System is presented in Table 67. General information about the system is presented in Table 68.

The George Galbraith Trust (GGT) lands cover approximately 2,100 acres of agricultural land in Central O‘ahu. In the past, these lands were used for pineapple production by Del Monte Fresh Produce and Dole Food Co. Del

Monte Fresh Produce operations shut down in 2008, and approximately 1,200 acres of GGT lands were put up for sale. The GGT lands used by Del Monte Fresh Produce were acquired by ADC. The acquisition is part of ADC's overall agricultural development plan for the Wahiawā area.

Table 67
Galbraith Lands Irrigation System
System Ownership and Service Area

Description	Information
Owners	State of Hawai'i ADC (System Manager)
Source	Groundwater
Estimated Current Water Use (annual average)	Farms are currently being developed
Estimated Service Area	1,021 acres
Farms Served	1,000 acres (estimated)
Important Agricultural Lands	None

Therefore, the overall areas acquired by the State of Hawai'i that are being developed for diversified agriculture are shown on Map 73. The current irrigation system may not be able to service the entire area; therefore, the service area is just a subset of the entire area. The service area also includes parcels owned by the Office of Hawaiian Affairs.

The Galbraith Lands Irrigation System (GLIS) initially consisted of the former Del Monte's Well Number 5 and a distribution system of 2 to 3 miles of 12-inch water mains with risers. The GLIS originally irrigated pineapple fields. The ADC will be improving the system to meet the irrigation needs of diversified agriculture.

Table 69 presents the land use areas within the service area. The overall system maps are shown on Maps 74 to 78, as follows:

- Map 74 - Alignments and System Components;

- Map 75 - 2014-2015 Land Use;
- Map 76 - ALISH 1977;
- Map 77 - Land Capability Non-Irrigated Conditions, and;
- Map 78 - Land Capability Irrigated Conditions.

Table 68
Galbraith Lands Irrigation System
General System Information

Description	Information	
System Length (feet) / status	9,925 (active) 3,164 (unverified)	
Intake Source (type) Hydrologic Unit Intake Status	Well Groundwater Groundwater Wahiawā Active	
Reservoirs Capacity Status	Reservoir 1 9.2 acre-feet (estimated) Design/ Construction	Reservoir 2 30.7 acre-feet (estimated) Design/ Construction
Visual inspection undertaken	Yes	
Irrigation system condition	Fair, see Table 70	
Rehabilitation Potential	Good	
Rehabilitation Cost / CIP (five years)	$17,000,000 See Table 71	

Table 69
Galbraith Lands Irrigation System
Land Uses within the Service Area

Cultivation	Area (acres)
Field Crops	0.0
Other Crops	1,081.8
Grazing	0.0

Assessment of Needs. The system is currently running, and the well pump was renovated in 2013. A list of the system components and their condition is presented in Table 70. The distribution system was constructed by Del Monte, and there were no visible leaks during the condition survey. ADC plans to construct two (2) new reservoirs for agricultural uses, and a tenant will be constructing a private reservoir. The proposed ADC reservoirs are planned to have three (3) million gallons and ten (10) million gallons of storage capacity.

ADC's short-term agricultural development plan includes the acquisition of 1,200 acres of agriculture land from Dole Food Co. In addition, there is a plan to increase irrigation water supply by using water from the Wahiawā Wastewater Treatment Plant (WWTP) and Lake Wilson. As part of the plan, storage and overflow contingences will be provided. The Wahiawā WWTP effluent has a recycle rating of R1, and Lake Wilson water has a recycle rating of R2. When the discharge of recycled water is discontinued at Lake Wilson, water use will become unrestricted.

The ADC development plan envisions the growing, processing, and distribution of agricultural commodities while accommodating food safety rules and regulations related to certain crops. Its focus is to lease land to farmers that cultivate food crops. As part of the ADC development plan, ADC acquired land from Dole Food Co. and acquired the old Tamura's warehouse in Wahiawā.

Table 70
Galbraith Lands Irrigation System
Distribution System Condition

Distribution System	Length (feet)	Comments
Pipelines		
Good Condition	0	
Fair Condition	10,000	To be replaced
Poor Condition	0	

Proposed Capital Improvement Projects. Based on the assessment of the system and information gathered on the condition of various components, the following proposed CIP list was developed. Table 71 presents the proposed CIP, estimated costs (planning level), and development phase.

- Design and construct a three (3) million-gallon reservoir for water storage.
- Design and construct a ten (10) million-gallon reservoir for water storage.
- Construct new water distribution system from the reservoirs to supply water to the farms. The estimated length of the system is 10,500 linear feet.
- Construct a facility and distribution system to use recycled water from the Wahiawā WWTP.

Table 71
Galbraith Lands Irrigation System
Proposed Capital Improvement Projects

Project Description	**ESTIMATED COST** (2018 dollars)
	Short-term
Three (3) million-gallon reservoir	$1,700,000
Ten (10) million-gallon reservoir	$5,300,000
Distribution Pipeline	$10,000,000
Irrigation from Wahiawā WWTP	
Planning	To be determined
Design and construction	To be determined

3.3 HAWAI‘I COUNTY IRRIGATION SYSTEMS

The following systems were studied in Hawai‘i County, and their locations are shown in Exhibit 26.

- Ka‘ū Agribusiness Irrigation System
- Kohala Ditch
- Kehena Ditch

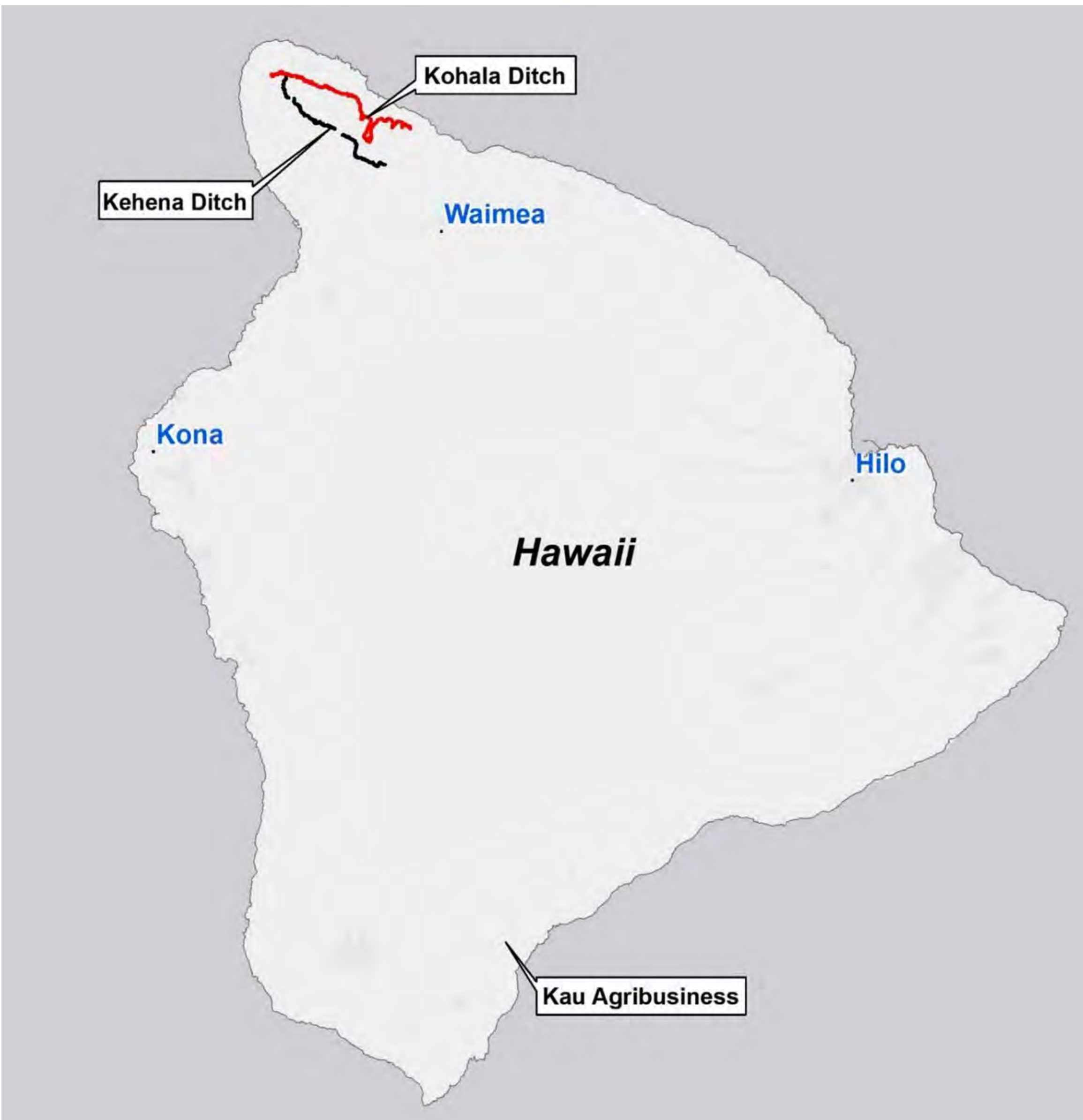

Exhibit 26. Water Systems Inventoried on Hawai‘i

3.3.1 KAʻŪ AGRIBUSINESS IRRIGATION SYSTEM

Ownership and service area information for the Kaʻū Agribusiness Irrigation Subsystem is presented in Table 72. The Kaʻū Irrigation System was developed to support sugar production for Hawaiian Agricultural Company. By 1919, the plantation had constructed approximately 35 miles of flumes to transport sugar cane stalks to the mill. The water was suppled from 16 tunnels in mountain areas. Five (5) tunnels were constructed in the 1920s: Kaumaikeohu, Mudflow, Noguchi, Heio, and Weda, with total length of 3,308 feet. In the 1940s, the water supply was supplemented by drilling wells. The distribution system has a total length of approximately seven (7) miles.

Table 72
Kaʻū Agribusiness Irrigation System
System Ownership and Service Area

Description	Information
Owners	Various private owners (transitioning to State of Hawaiʻi ownership)
Source	Various sources
Estimated Current Water Use (annual average)	Unverified
Estimated Service Area	71,702 acres
Farms Served	Unverified
Important Agricultural Lands	None

A total of seven (7) working water systems remain from the former plantation in the Kaʻū area. The source locations are shown on Map 69, with the approximate total extent of the service area. There are three (3) rainfall stations in the area. The Pāhala Mauka 21.3 rainfall station is at an elevation of 1,090 feet and has a mean annual rainfall of 52.44 inches. The Pāhala rainfall station is at an elevation of 875 feet and has a mean annual rainfall of 39.61 inches. The Kamāʻoa Puʻuʻeo rainfall station is at an elevation of 1,040 feet and has a mean annual rainfall of 34.52 inches.

The primary crops in the area are coffee, biofuels, cattle, and truck farming, especially in the Wood Valley area. The overall system is shown on Maps 79 to 84, as follows:

- Map 79 - Alignments and System Components;
- Map 80 - 2014-2015 Land Use;
- Map 81 - ALISH 1977;
- Map 82 - Land Capability Non-Irrigated Conditions;
- Map 83 - Land Capability Irrigated Conditions, and
- Map 84 – CWRM System Alignments and 2014-2015 Land Use.

Assessment of Needs. As a condition assessment was not completed, a CIP was not developed. The existing system is currently being used by various agricultural users, and ADC has not completed an assessment of needs.

3.3.2 KOHALA DITCH

Ownership and service area information for the Kohala Ditch Irrigation System is presented in Table 73. General information of the system is presented in Table 74.

The system sits in the North Kohala District of Hawaiʻi Island (the Big Island), from within the Kohala Mountains through Hawi, and was developed by the Kohala Ditch Company. The Kohala Ditch Company, established in 1904, was one of two (2) companies formed to supply water to sugar plantations on the northern portion of the Big Island. The other was Hāmākua Ditch Company, established around 1906, to build the Upper and Lower Hāmākua ditches.

The Kohala Ditch Company obtained a license from the Territory of Hawaiʻi in 1904 for a period of fifty years to "enter upon, confine, conserve, collect, impound, and divert all the running natural surface waters on the *Kohala Hāmākua Watershed*."

Table 73
Kohala Ditch System
System Ownership and Service Area

Description	Information
Owners	Kamehameha Schools Bishop Estate
Source	Various streams and springs
Estimated Current Water Use (annual average)	50 MGD (estimated)
Estimated Service Area	17,000 acres
Farms Served	Unverified
Important Agricultural Lands	None

Table 74
Kohala Ditch System
General System Information

Description	Information		
System Length (feet) / status	124,025 (unverified)		
Intakes	See Table 76		
Reservoirs (1)	Hawi No. 5	Hawi No. 3	Puakea
Capacity (acre-feet(2) / MG)	55 / 17.9	--	Unverified
Status	Active	Decommissioned	Unverified
Visual inspection undertaken	No		
Irrigation system condition	Active		
Rehabilitation Potential	Good		
Rehabilitation Cost/CIP	To be determined by owner		

Note: 1) Not all reservoirs are accounted for, as visual survey was not performed
2) DLNR Dam Inventory System database. http://dams.hawaii.gov

The Kohala Ditch supplied water to plantations including Union Mill, Kohala Sugar, Niuliʻi Plantation, Hawi Sugar, and Hālawa Plantation. At the time, the entire ditch was about 23 miles long, with 57 tunnels traversing about 16 miles, the longest being 2,500 feet. The system has approximately six (6) miles of open ditch and 23 miles of flumes. The ditch was lined primarily with stone or cement to Hawi and unlined beyond Hawi. The tunnels are cement lined, and the flumes are seven (7) feet wide and six (6) feet deep.

The Honokāne section was opened in 1906 to provide water to the following plantations: Kohala, Niuliʻi, Hālawa, Kohala, Hawi, and Union. The ʻĀwini section was finished in 1907 and served Puʻukea Plantation. On average, the ditch delivered 22 to 30 MGD.[17] The literature reports minimum flow as low as 3.5 MGD. The designed capacity was originally 70 MGD, but later reduced to 50 MGD when the original flumes were replaced with smaller ones. There is one (1) rainfall station, the Kohala Mission rainfall station, located at an elevation of 535 feet with a mean annual rainfall of 71.50 inches.

The land use areas within the service area are shown in Table 75. The overall system is shown on Maps 85 to 90, as follows:

- Map 85 - Alignments and System Components;
- Map 86 - 2014-2015 Land Use;
- Map 87 - ALISH 1977;
- Map 88 - Land Capability Non-Irrigated Conditions;
- Map 89 - Land Capability Irrigated Conditions; and
- Map 90 – CWRM System Alignments and 2014-2015 Land Use.

Table 75
Kohala Ditch System
Land Uses within the Service Area

Cultivation	**Area** (acres)
Field Crops	0.0
Other Crops	1,071.9
Grazing	4,823.8

[17] Wilcox, Carol, *Sugar water, Hawaiʻi's Plantation Ditches*, Honolulu, University of Hawaiʻi Press, 1996.

Table 76
Kohala Ditch System
Intake Description

Intake Type	Stream	Hydrologic Unit	Status[1]
Stream Diversion	Hapahapai	Kohala	Unverified
Stream Diversion	Waiakauaua	Kohala	Unverified
Stream Diversion	Waiakauaua	Kohala	Unverified
Spring	Not applicable	Kohala	Unverified
Stream Diversion	Hālawa	Kohala	Unverified
Stream Diversion	Hālawa	Kohala	Unverified
Stream Diversion	Waiaohia	Kohala	Unverified
Stream Diversion	Waipuhi	Kohala	Unverified
Stream Diversion	Waipunalau	Kohala	Unverified
Stream Diversion	Pakolea	Kohala	Unverified
Stream Diversion	‘A‘amakāō	Kohala	Unverified
Stream Diversion	Niuli‘i	Kohala	Unverified
Stream Diversion	Waikani	Kohala	Unverified
Stream Diversion	Waikani	Kohala	Unverified
Stream Diversion	Waikani	Kohala	Unverified
Stream Diversion	Niuli‘i	Kohala	Unverified
Stream Diversion	Waikani	Kohala	Unverified
Stream Diversion	Niuli‘i	Kohala	Unverified
Stream Diversion	Niuli‘i	Kohala	Unverified
Stream Diversion	Niuli‘i	Kohala	Unverified
Stream Diversion	Waikama	Kohala	Unverified
Stream Diversion	Waikama	Kohala	Unverified
Stream Diversion	Waikama	Kohala	Unverified
Stream Diversion	Waikama	Kohala	Unverified
Stream Diversion	Waikaina	Kohala	Unverified
Stream Diversion	Waikama	Kohala	Unverified
Stream Diversion	Waikama	Kohala	Unverified
Stream Diversion	Waikama	Kohala	Unverified
Stream Diversion	Waiakala‘e	Kohala	Unverified
Stream Diversion	Waiakala‘e	Kohala	Unverified
Spring	Not applicable	Kohala	Unverified
Stream Diversion	Honokāne	Kohala	Unverified
Stream Diversion	Honokāne	Kohala	Unverified

Note: 1) CWRM may have additional and updated data.

Assessment of Needs. As a condition assessment was not completed, a CIP was not developed. The system is active and managed and maintained by a private owner.

3.3.3 KEHENA DITCH

Ownership and service area information for the Kehena Ditch Irrigation System is presented in Table 77. General information about the system is presented in Table 78.

Circa 1970, the County of Hawaiʻi planned to use Kehena Ditch as a drinking water source for the South Kohala area. This ambitious plan to transport water to the Kawaihae area was abandoned around 1974 due to the enactment of the Safe Drinking Water Act.[18] During construction, a portion of the Kehena Ditch was partially demolished and replaced by a pipeline, which is currently active. Two current users, Kahua and Ponoholo Ranches, have installed new pipelines from the pipeline terminus to supply water to their respective ranching operations.

Historical USGS records indicate an average daily flow of six (6) MGD, with a maximum flow of 14 MGD, and an estimated average flow during low-flow months as 4.2 MGD, rising to 9.7 MGD during high-flow months. The owners stated that there was substantial water loss in the distribution network, especially from the unlined ditch segments.

There are two (2) rainfall stations in the area: one located at the Kahua Ranch Headquarters and the other at the Middle Pen. The Kahua Ranch Headquarters station is located at an elevation of 3,269 feet, with a mean annual rainfall of 69.39 inches. The Middle Pen station is located at an elevation of 1,380 feet and has a mean annual rainfall of 15.64 inches.

The land use areas within the service area are presented in Table 79. The system maps are shown on Maps 91 to 96, as follows:

- Map 91 - Alignments and System Components;

[18] The Safe Drinking Water Act increased regulation on the use of surface water for drinking water.

- Map 92 - 2014-2015 Land Use;
- Map 93 - ALISH 1977;
- Map 94 - Land Capability Non-Irrigated Conditions;
- Map 95 - Land Capability Irrigated Conditions; and
- Map 96.- CWRM System Alignments and 2014-2015 Land Use.

Table 77
Kehena Ditch System
System Ownership and Service Area

Description	Information
Owners	State of Hawaiʻi, Kahua Ranch and Ponoholo Ranch Maintained by ranchers served by the system
Source	Various streams
Estimated Current Water Use	Less than 1 MGD (low flow estimate)
Estimated Potential Service Area	19,235 acres
Farms Served	Three (3) ranches
Important Agricultural Lands	None

Table 78
Kehena Ditch System
General System Information

Description	Information	
System Length (feet)/Status	42,566 (active) 32,011 (inactive) 1,545 (unverified)	
Intakes	Various, see Table 80	
Reservoirs	Pūnāwai	Kehena
Capacity (acre-feet / MG)	30 / 10	57 / 19
Status	Active	Decommissioned
Reservoirs	Puuokumau	Unnamed
Capacity (acre-feet / MG)	Unverified	15 / 5
Status	Decommissioned	Active
Visual inspection undertaken	Yes	
Irrigation system condition	See Tables 81 and 82	
Rehabilitation Potential	Good	
Rehabilitation Cost / CIP (five years)	$7,250,000 See Table 83	

Table 79
Kehena Ditch System
Land Uses within the Service Area

Cultivation	Area (acres)
Field Crops	0.0
Other Crops	6.7
Grazing	9,178.2

Table 80
Kehena Ditch System
Intake Description

Intake Type	Stream	Hydrologic Unit	Status
Stream Diversion	Unverified	Kohala	Unverified
Stream Diversion	Unnamed	Kohala	Unverified
Stream Diversion	Unnamed	Kohala	Unverified
Stream Diversion	Unnamed	Kohala	Unverified
Stream Diversion	Honokāne	Kohala	Active
Stream Diversion	Unnamed	Kohala	Unverified
Stream Diversion	Unnamed	Kohala	Unverified

Assessment of Needs. The visual walkthrough of the system was performed in 2015. Although the system currently serves two private ranchers, other potential agricultural water users may be identified. The ranches' demand for water is increasing with consumer demand for grass-fed beef. Therefore, it is necessary to increase the acreage of grass pastures to maintain the grass-fed label for these cattle. The water required for these grass-fed pastures is supplied by both rainfall and the Kehena Ditch Irrigation System.

Parker Ranch uses the lower portion of the original Kehena Ditch, from its south boundary to Kehena Reservoir. The ranch has installed two (2) smaller water storage systems as well. The ditch section beyond Parker Ranch lands, heading north toward Hawi, is not in use and in poor condition. Exhibits 27 and 28 show representative photos of the ditch.

The Kehena system water supply is highly variable and susceptible to low rainfall conditions. During dry periods, the water flow is reduced to less than one (1) MGD. As low rainfall occurs frequently, additional water storage is required, and other water sources should be developed. The distribution system components and their conditions are presented in Tables 81 and 82.

Exhibit 27. Kehena Ditch Irrigation System

Exhibit 28. Kehena Ditch Irrigation System -
Ditch (left) & Flow Structure (right)

Table 81
Kehena Ditch System
Distribution System Components

Distribution System	Length (feet)
Ditches	
Active	37,566
Inactive	32,820
Tunnels	
Active	10,526
Inactive	737
Flumes	
Active	114
Inactive	0
Pipelines	
Active	152
Inactive	0

Table 82
Kehena Ditch System
Distribution System Condition
(Active Components Only)

Distribution System	**Length** (feet)
Ditches	
Good Condition	37,326
Fair Condition	225
Poor Condition	15
Tunnels	
Good Condition	10,526
Fair Condition	0
Poor Condition	0
Flumes	
Good Condition	0
Fair Condition	0
Poor Condition	114
Pipelines	
Good Condition	152
Fair Condition	0
Poor Condition	0

Proposed Capital Improvement Projects. As grass-fed beef demand is increasing, there is a need to provide more irrigated pasture lands. The amount of water required for growing irrigated pastures is estimated to be approximately 9,000 gpd/acre but will vary due to soil conditions, wind, etc. To accommodate this growth, there is a need for additional water sources, as well as additional storage (reservoir) capacity. Other landowners in the Kohala and Kawaihae areas would benefit from the development of additional water systems for agricultural use.

The condition survey found certain portions of the distribution and collection system in need of significant repair. The higher elevation intakes were not accessible at the time, but they could provide additional water when operating properly. The following is a list of proposed improvements and project phasing. There are two phases: 1) to improve water supply to current users; and 2) to expand the user base. Based on the assessment of the system and information gathered on the condition of various components, the following proposed CIP list was developed (see Table 83). In addition, the ditch and catwalks should be renovated.

- Short-term (1-5 years)
  - Complete miscellaneous repairs of the flume, catwalks, etc.
  - Plan for additional water storage and complete preliminary design. Compliance with the regulatory process will be required.
  - Complete design of additional water sources and water storage, with construction to follow.

Table 83
Kehena Ditch System
Proposed Capital Improvement Projects

Project Description	**ESTIMATED COST** (2018 dollars)
	Short-term
Ditch, tunnel, trail, and catwalk renovation and maintenance; flume renovation and other miscellaneous improvements	$200,000
Develop additional water storage and intakes	
Planning and design	$6,600,000
Construction	To be determined
Develop additional water sources for Kehena users and surrounding landowners	
Planning	$450,000
Design and construction	To be determined

CHAPTER 4
UPDATE OF 2004 IRRIGATION SYSTEMS

Nobody is qualified to become a statesman who is entirely ignorant of the problem of wheat.

Socrates

The 2004 AWUDP studied 13 irrigation systems, including both public and private water systems. This study aims to update system component information; provide maps of system components, land use, and soil characteristics; identify IAL in the service area; provide the status of the 2004 CIP; and present the current CIP.

A summary of CIP from 2004 to 2014 for the irrigation systems studied in 2004 is presented in Table 84. The systems studied in the 2004 AWUDP are listed below and shown in Exhibit 29.

Kauaʻi County
- East Kauaʻi Irrigation System
- Kekaha Ditch Irrigation System
- Kōkeʻe Ditch Irrigation System
- Kauaʻi Coffee Irrigation System

Maui County
- Maui Land and Pineapple/Pioneer Mill Irrigation System
- East Maui Irrigation System
- West Maui Irrigation System
- Upcountry Maui Irrigation System
- Molokaʻi Irrigation System

Oʻahu (City and County of Honolulu)
- Waiāhole Ditch Irrigation System
- Waimānalo Irrigation System

Hawaiʻi County
- Lower Hāmākua Ditch Irrigation System
- Waimea Irrigation System

Table 84
Summary of 2004 Capital Improvement Program

Irrigation System	**Manager/ Owner**	**2004 CIP** (000s)	**Estimated Service Area** (100 acres)		**Cultivated Area** (100 ac.)**	**Grazing Area** (100 ac.)**
				ALISH		
KAUAʻI						
East Kauaʻi	East Kauaʻi Water Users' Cooperative (Disbanded)/ADC	$10,387	59.2*	55.1*	15.3	43.8
Kauaʻi Coffee	McBryde Company (A&B)	n/a	46.6*	43.7*	39.0	4.9
Kekaha Ditch	Kekaha Agriculture Association/ADC	$6,790	65.7*	64.5*	65.2	--
Kōkeʻe Ditch	Kekaha Agriculture Association/ADC	$1,712	--	--	--	--
OʻAHU						
Waiāhole Ditch	ADC	$10,668	62.7*	57.3*	40.0	--
Waimānalo	HDOA	$5,492	15.8*	15.2*	8.1	1.1
MAUI						
Molokaʻi	HDOA	$16,776	98.9*	77.8*	26.7	6.8
Upcountry Maui	HDOA	$9,274	17.2*	10.3*	4.0	2.5
East Maui	East Maui Irrigation Co. Ltd.	n/a	--	--	--	--
West Maui	Wailuku Agribusiness Co/Alexander & Baldwin	n/a	64.3*	63.0*	63.2	--
Maui Land and Pineapple/Pioneer Mill	Maui Land and Pineapple	$8,912	--	--	---	--
HAWAIʻI						
Lower Hāmākua Ditch	HDOA	$9,586	46.6*	39.5*	3.1	36.7
Waimea	HDOA	$20,963	19.9	12.4*	7.4	5.7

Note: * HDOA-ARMD, "*Agricultural Water Use and Development Plan*," 2004.
** data from HDOA-ARMD, Geographical Information System.

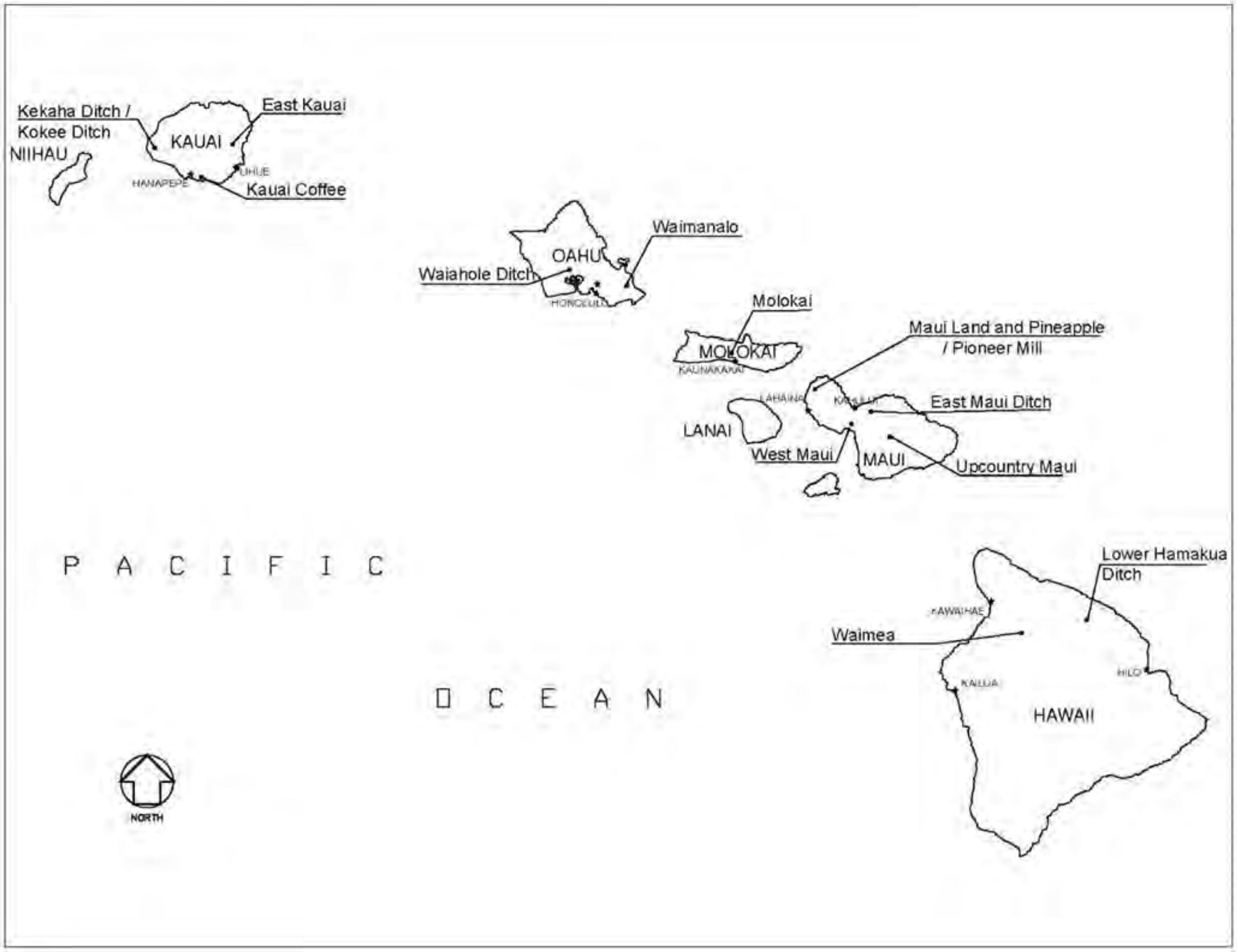

Exhibit 29. Agricultural Water Systems Studied in the 2004 AWUDP

The sections of this Chapter are organized to present the water irrigation systems by management agencies. Therefore, Section 4.1 updates the water systems owned and managed by HDOA-ARMD, Section 4.2 updates the water systems managed by or in partnership with ADC, and Section 4.3 updates the water systems owned and managed by private entities.

The base maps of the irrigation system maps are derived from information provided by HDOA (circa 2007):

- Alignments and System Components;
- Statewide Agricultural Land Use Baseline 2015 (Melrose et al.);
- ALISH 1977;

- Land Capability Non-Irrigated Conditions;
- Land Capability Irrigated Conditions; and
- IAL, if appropriate.

4.1 HAWAI‘I DEPARTMENT OF AGRICULTURE SYSTEMS

The following HDOA-ARMD systems were inventoried in the 2004 AWUDP and have been updated based on discussions with HDOA-ARMD.

- Waimānalo Irrigation System, O‘ahu.
- Moloka‘i Irrigation System, Moloka‘i.
- Upcountry Maui Irrigation System, Maui.
- Waimea Irrigation System, Hawai‘i.
- Lower Hāmākua Ditch, Hawai‘i.

4.1.1 WAIMĀNALO IRRIGATION SYSTEM

The Waimānalo Irrigation System (WIS) has a service area of 1,174 acres[19] and is in the Waimānalo sub-aquifer of the Windward aquifer. In 2003, the system served 60 acres. The system intakes water from Maunawili, ‘Ainoni and Makawao streams. The USGS gage station that measures source intake is no longer operational.

The system has undergone significant changes since 2004. The system is still fed by the existing Waimānalo ditch, but it has a new storage system, pipeline, and metered distribution network for its customers. The old reservoirs were decommissioned, and a new 60 MG (184 acre-feet) reservoir was constructed above (mauka) the Waimānalo agricultural area.

There are three (3) rainfall stations in the area: the Maunawili station, which is near the source, and two stations within the Waimānalo farm area. The Maunawili station is at an elevation of 417 feet, with a mean annual rainfall of 73.18 inches. The first station within the farm area is Waimānalo Experiment station, at an elevation of 60 feet, with a mean annual rainfall of 42.10 inches.

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[19] Hawai‘i Department of Agriculture, Agricultural Resource Management Division, Irrigations Systems website, April 29, 2015, http://hdoa.hawaii.gov/arm/irrigation-systems/.

The second is the Waimānalo Nonokio station, located at an elevation of 66 feet, with a mean annual rainfall of 44.94 inches.

The irrigation system is approximately 15 miles long and transports 150.0 million gallons per year. The forecast average water demand is estimated to be 5.3 MGD. Thus, this system is forecast to exceed current capacity. Additional improvements will be needed to meet forecast demand. The development timeframe is unknown at this time and will depend on agricultural use in the service area.

The system maps are shown on Maps 97 to 102, as follows:

- Map 97 - Alignments and System Components;
- Map 98 - Statewide Agricultural Land Use Baseline 2015 (Melrose et al.);
- Map 99 - ALISH 1977;
- Map 100 - Land Capability Non-Irrigated Conditions;
- Map 101 - Land Capability Irrigated Conditions; and
- Map 102 – CWRM System Alignment and Statewide Agricultural Land Use Baseline 2015.

Table 85 presents the status of the CIP program that was developed in the 2004 AWUDP. Table 86 provides a list of CIP projects performed from 2004 to 2014 and their status. As most of the system has already been upgraded, the remaining components need to be upgraded or renovated. Therefore, the proposed CIP for the Waimānalo Irrigation System are listed below and summarized in Table 87.

- Construct a new office building, renovate baseyard, and install safety features. In addition, conduct miscellaneous improvements in the system, such as restoring access roads; renovating ditch with HDPE pipe; and repairing or replacing gates, fencing, grates, etc.
- Design a replacement pipeline for portions of remaining ditch to reduce system water losses and maintenance costs. Construction costs will be determined after design.
- Tayli Reservoir Improvements.
- Flow measurement and metering.

Table 85
Waimānalo Irrigation System
2004 Capital Improvement Projects

No.	Item	Improvements	Status
1	Land	Land treatment	Deferred
2	Maunawili source	Improve water collection system	Completed
3	Reservoir	Install irrigation pipeline system	Completed
4	Ditch	Install irrigation pipeline system	Completed
5	Ditch	Modify old irrigation ditch	Ongoing
6	Sewage	Construct sewage effluent pumps, pipeline system, and storage reservoir	Deferred
7	Waste management	Install solid waste collection sites	Deferred
8	Reservoirs	Restore three (3) abandoned reservoirs (reservoirs are not in use or decommissioned)	Deleted

Note: Deferred project – Past project recommendation. Reevaluation required for applicability, necessity, and feasibility. Defer to new CIP projects.

Table 86
Waimānalo Irrigation System
2004-2014 Capital Improvement Projects

No.	Item	Improvements	Status
1	Land	DLNR land transfer	Ongoing
2	Distribution	Pipeline stabilization	Completed
3	Distribution	Extend pipeline (Wong Ditch)	Completed
4	Safety	Miscellaneous safety improvements	Completed
5	Baseyard	Renovations at HDOA baseyard	Ongoing
6	Ditch	Miscellaneous ditch repairs	Completed
7	Source	Install Emergency Pump Well No. 1	Completed

Table 87
Waimānalo Irrigation System
2018 Capital Improvement Projects

Project Description	ESTIMATED COST (2018 dollars)	
	Phase I	Phase II
Renovation of baseyard and miscellaneous improvements	$3,500,000	
Replace remaining ditch portion with pipeline		
Design		$1,000,000
Construction		To be determined
Tayli Reservoir Improvements	$1,300,000	
Flow measurement and metering	To be determined	

4.1.2 MOLOKA‘I IRRIGATION SYSTEM

The Moloka‘I Irrigation System (MIS) is in the Waikolu sub-aquifer of the Northeast aquifer. The Moloka‘i Irrigation System services lands in the Manawainui, Hoolehua and Kualapu‘u sub-aquifers of the Moloka‘i Central aquifer. The system intakes water from Waikolu Stream and has one of the largest reservoirs (Kualapu‘u Reservoir) in the state, with a storage capacity of 1,656.0 million gallons (5,082 acre-feet). The system serves agricultural lands, including Department of Hawaiian Home Lands properties.

The closest active rainfall station in this area is the Waikolu rainfall station, located in the mountains at an elevation of 3,550 feet, with a mean annual rainfall of 102.64 inches. According to the Rainfall Atlas of Hawai’i, there is an inactive rainfall station at the Moloka‘i Airport, at an elevation of 445 feet, with a mean annual rainfall of 22.7 inches (data collected 1939-2004). There is also an inactive rainfall station (Field 305) near Kualapu‘u Reservoir, at an elevation of 875 feet, with a mean annual rainfall of 27.92 inches (data collected between 1948-1983).

The service area for MIS is approximately 9,730 acres. The system is 25 miles long and transports 1.2 billion gallons per year. The forecast average water demand is estimated to be 11.2 MGD. Thus, this system is forecast to exceed current capacity. Additional improvements will be needed to meet forecast demand. The development timeframe is unknown at this time and will depend on agricultural use in the service area.

The system maps are shown on Maps 103 to 108, as follows:

- Map 103–- Alignments and System Components;
- Map 104–- Statewide Agricultural Land Use Baseline 2015 (Melrose et al);
- Map 105–- ALISH 1977;
- Map 106–- Land Capability Non-Irrigated Conditions;
- Map 107–- Land Capability Irrigated Conditions, and
- Map 108 – CWRM System Alignments and Statewide Agricultural Land Use Baseline 2015.

Table 88 presents the status of the CIP program that was developed in the 2004 AWUDP. Table 89 provides a list of CIP projects performed from 2004 to 2014 and their status. The proposed CIP for the Molokaʻi Irrigation System is summarized in Table 90.

Table 88
Moloka'i Irrigation System
2004 Capital Improvement Projects

No.	Item	Improvements	Status
1	Kawela Stream Diversion	Raise existing diversion dam height by two (2) feet	Deferred
2	Activated Unused Well	• Install new well casing • Tap into and extend power line to well site • Install submersible turbine pump and motor • Construct inlet and junction boxes • Install connecting pipeline from well to transmission pipeline	Deferred
3	Waihānau Stream Diversion	• Install new telemetry system • Construct new inlet box • Install pipeline with junction box to connect onto existing pipeline	Deferred
4	Telemetry System	• Install new telemetry system • Connect all syste''s facilities to central control station at office building • Install instruments, computer programs, and appurtenant works • Connect to power sources or install portable power sources	Ongoing

Note: Deferred project – Past project recommendation. Reevaluation required for applicability, necessity, and feasibility. Defer to new CIP projects.

Table 89
Moloka'i Irrigation System
2004-2014 Capital Improvement Projects

No.	Item	Improvements	Status
1	Distribution	Planning for reservoir improvements	Ongoing
2	Distribution	Installation of hydroelectric system	Deferred
3	Distribution	Concrete flume repair	Ongoing
4	Safety	Miscellaneous safety improvements	Ongoing
5	Baseyard	Renovations at HDOA baseyard	Ongoing
6	Ditch	Miscellaneous ditch repairs	Completed
7	Source	Install Emergency Pump Well No. 1	Completed

Table 90
Moloka'i Irrigation System
2018 Capital Improvement Projects

Project Description	ESTIMATED COST (2018 dollars)
	Phase I
Baseyard renovation and miscellaneous improvements, Waikolu safety, Waikolu cable, irrigation system, safety assessment, miscellaneous improvements, and SCADA	$5,400,000
Dam improvements to access bridge, walkway, East Portal, and grate	$3,760,000
Flow measurement and metering	To be determined

4.1.3 UPCOUNTRY MAUI IRRIGATION SYSTEM

The Upcountry Maui Irrigation System has a potential service area of approximately 1,500 acres in the Maui Central aquifer. Only portions of the system have been constructed, and a water source has not been secured. The system will eventually serve the agricultural lands in the Upper Kula area and Department of Hawaiian Home Lands Kēōkea area.

There are two (2) rainfall stations in the area: the Olinda rainfall station, at an elevation of 4,125 feet; and the Kula Experiment Station, at an elevation of 3,050 feet. The Olinda rainfall data has a mean annual rainfall of 66.95 inches, and the Kula Experiment Station has a mean annual rainfall of 24.43 inches.

The service area and alignment for the Upcountry Maui Irrigation System were mapped in 2007 for HDOA-ARMD. The forecast average water demand is estimated to be 3.6 MGD. The system maps are shown on Maps 109 to 114 as follows:

- Map 109 - Alignments and System Components;
- Map 110 - Statewide Agricultural Land Use Baseline 2015 (Melrose et al.);
- Map 111 - ALISH 1977;
- Map 112 - Land Capability Non-Irrigated Conditions;
- Map 113 - Land Capability Irrigated Conditions, and
- Map 114 – CWRM System Alignment and Statewide Agricultural Land Use Baseline 2015.

Table 91 presents the status of the CIP program that was developed in the 2004 AWUDP. Although most of the projects are listed as ongoing, various portions of each project have been completed,[20] as shown in Table 92.

[20] Communication with West Maui Soil & Water Conservation District, February 21, 2014.

Table 91
Upcountry Maui Irrigation System
2004 Capital Improvement Projects

No.	Improvements	Status
1	Main Pipeline • 0+00 to 165+00 • 165+00 to 257+00 • 257+00 to 286+00 • 286+00 to 323+00 • 323+00 to 387+00 • 387+00 to 495+00	Deleted
2	Lateral/Sublateral Pipeline • Olinda Road • Kimo Road • Crater Road • Pulehuiki/Kamehameiki • Kealahou • Waiakoa • Ka‘ono‘ulu • Waiohuli • Kēōkea/DHHL	Deleted
3	Gulch Crossing	Deleted
4	Access Road	Deleted

Table 92
Upcountry Maui Irrigation System
2004-2014 Capital Improvement Projects

Item	Improvements	Status
Distribution	Phases 1 to 5	Completed
Distribution	Phase 6A	Deferred
Distribution	Phase 6B and 1C	Deleted
Distribution	Phase 7	Deleted

4.1.4 WAIMEA IRRIGATION SYSTEM

The Waimea Irrigation System (WIS) has a service area of 1,985 acres and is in the Waimanu sub-aquifer of the Kohala aquifer. This system is also known as the Upper Hāmākua Ditch (UHD). The system intakes water from Kawainui, Kawaiki, Alakahi, Waimā, and Koʻiawe streams. The system serves agricultural lands in the Lālāmilo area and Department of Hawaiian Home Lands in the Puʻu Kapu, and Waimea areas. The rainfall in Lālāmilo Farm Lots is measured at Lālāmilo Field Office station, at an elevation of 2,620 feet, with a mean annual rainfall of 19.85 inches.

The length of the system is 15 miles, and it transports approximately 307.2 million gallons per year. The forecast average water demand is estimated to be 10.0 MGD. Thus, this system is forecast to exceed current capacity. Additional improvements will be needed to meet forecast demand. The development timeframe is unknown at this time and will depend on agricultural use in the service area.

The system maps are shown on Maps 115 to 120, as follows:

- Map 115 - Alignments and System Components;
- Map 116 - Statewide Agricultural Land Use Baseline 2015 (Melrose et al.);
- Map 117 - ALISH 1977;
- Map 118 - Land Capability Non-Irrigated Conditions;
- Map 119 - Land Capability Irrigated Conditions

- Map 120 – CWRM System Alignments and Statewide Agricultural Land Use Baseline 2015.

Table 93 presents the status of the CIP program that was developed in the 2004 AWUDP. Table 94 provides a listing of other CIP projects performed from 2004 to 2014 and their status. The proposed CIP for the Waimea Irrigation System is summarized in Table 95.

Table 93
Waimea Irrigation System
2004 Capital Improvement Projects

No.	Item	Improvements	Status
1	UHD Improvements	• UHD bypass pipelines • UHD to Waimea II reservoir supply pipeline	Deferred
2	Waimea II Reservoir	• Construct lined reservoir	Deferred
3	Irrigation Water Distribution System	• Lālāmilo Addition • DHHL additions • Waimea II to existing mainline	Deferred
4	Livestock Water Distribution System	• Main, Group 2, E, E-1 • Group 1 • Group 3 • Group 5 • Group 7 • Group 9	Deferred
5	Pumps	• Convert two (2) electrical pumps to diesel	Deferred
6	Telemetry System	• Install new system to control & monitor flows	Deferred

Note: Deferred project – Past project recommendation. Reevaluation required for applicability, necessity, and feasibility. Defer to new CIP projects.

Table 94
Waimea Irrigation System
2004-2014 Capital Improvement Projects

No.	Item	Improvements	Status
1	Reservoir	Dam safety improvements - Puʻu Pelehu and Puʻu Kapu	Design completed
2	Ditch	Open ditch improvements (earthquake)	Completed
3	Ditch	Alakahi	Deferred
4	Distribution	Lālāmilo Distribution Pipeline	Completed
5	Baseyard	Renovate HDOA baseyard	Pending
6	Distribution	Flume replacement	Completed
7	DHHL	Agriculture subdivision water distribution	Completed
8	Source	Koʻiawe intake design and construction	Ongoing
9	System	Hydropower plant	Canceled

Table 95
Waimea Irrigation System
2018 Capital Improvement Projects

Project Description	ESTIMATED COST (2018 dollars)	
	Phase I	Phase II
Miscellaneous improvements: • Koʻiawe Intake – install blow-off valve and slide gate • Upper Ditch lining repair (approx. 100 LF) • Waimā Intake – diversion wall repair • Kawaiki slide gate repair • Tunnel lining repair	$1,100,000	
Retrofit system with pipeline		
Design		To be determined
Construction		To be determined
Puʻu Kapu Reservoir Safety Improvements - Construction	$ 5,600,000**	
Flow measurement and metering	To be determined	

Note: ** Combined construction cost with Pauuilo Reservoir (Lower Hāmākua Ditch System)

4.1.5 LOWER HĀMĀKUA DITCH

The Lower Hāmākua Ditch (LHD) has a service area of 4,214 acres and is in the Waimanu sub-aquifer of the Kohala aquifer. The system intakes water from Kawainui, Alakahi, Koʻiawe, and Waimā streams, and has a length of approximately 26 miles. The rainfall station within the Honokaʻa-Paauilo area is the Honokaʻa Town station, at an elevation of 1,070 feet, with a mean annual rainfall of 89.99 inches. The forecast average water demand is estimated to be 12.5 MGD. The system maps are shown on Maps 121 to 126, as follows:

- Map 121 – Alignments and System Components;
- Map 122 – Statewide Agricultural Land Use Baseline 2015 (Melrose et al.);
- Map 123 – ALISH within 1977;
- Map 124 – Land Capability Non-Irrigated Conditions;
- Map 125 – Land Capability Irrigated Conditions;
- Map 126 – CWRM System Alignments and Statewide Agricultural Land Use Baseline 2015.

Table 96 presents the status of the CIP developed in the 2004 AWUDP. Table 97 provides a listing of other CIP performed from 2004 to 2014 and their status. The proposed CIP for the Lower Hāmākua Irrigation System is summarized in Table 98.

Table 96
Lower Hāmākua Ditch System
2004 Capital Improvement Projects

No.	Item	Improvements	Status
1	Land	Conservation assistance	Deferred
2	Land	Technical assistance	Deferred
3	Land	Waipiʻo Valley assistance	Deferred
4	Ditch	Repair flume	Ongoing
5	Ditch	Remove sediment	Ongoing
6	Ditch	Repair concrete lining	Ongoing
7	Intake	Modify intakes	Completed
8	System	Install lateral system	Deferred
9	Ditch	Install exclusion fencing	Ongoing
10	Intake	Install SCADA system	Deferred
11	Intake	Reactivate Waimā Intake	Deferred

Note: Deferred projects are being reevaluated for applicability and cost, and for compliance with current policies, rules, and regulations.

Table 97
Lower Hāmākua Ditch System
2004-2014 Capital Improvement Projects

Item	Improvements	Status
Dam/ Reservoir	Pauuilo dam and reservoir safety improvements	Construction ongoing
Source	Alakahi Intake reconstruction	Completed
Distribution	Replace old plantation irrigation system	Ongoing
System	Miscellaneous system improvements	Construction ongoing
Baseyard	HDOA Baseyard renovation (see Waimea)	Pending
Source	Koʻiawe reconstruction	Pending
Source	Alakahi reconstruction	Completed
Distribution	Ditch lining stabilization and repair – Phase I	Completed

Table 98
Lower Hāmākua Ditch System
2018 Capital Improvement Projects

Project Description	**ESTIMATED COST** (2018 dollars)	
	Phase I	**Phase II**
Baseyard renovation and miscellaneous improvements (see Waimea)	To be determined	
Ditch lining stabilization and repairing – Phase II		$1,100,000
Agricultural Park meters	$275,000	
Exclusion fencing	$275,000	
Retrofit with pipeline		
Design		$1,400,000
Construction		To be determined
Pauuilo Reservoir Safety Improvements	$5,600,000**	
Flow measurement and metering	To be determined	

** Combined construction cost with Pu‘u Kapu Reservoir (Waimea Irrigation System)

4.2 HAWAIʻI AGRIBUSINESS DEVELOPMENT CORPORATION / PARTNERSHIP SYSTEMS

The following systems were described in the 2004 AWUDP and are managed by ADC or in partnership with private organizations:

- Kekaha Ditch Irrigation System, Kauaʻi;
- Kōkeʻe Ditch Irrigation System, Kauaʻi;
- East Kauaʻi Irrigation System, Kauaʻi; and
- Waiāhole Ditch Irrigation System, Oʻahu.

4.2.1 KEKAHA DITCH IRRIGATION SYSTEM

The Kekaha Ditch Irrigation System (KEDIS) services approximately 6,570 acres of agricultural land. The water source for KEDIS is the Kekaha sub-aquifer in the Waimea aquifer. The system intakes water from Waimea River. There is a gage on the KEDIS system; flow data is summarized in Table 99. The overall mean flow at Kekaha Ditch gauge is 29.3 MGD, with minimum flow of 0.0 MGD and maximum flow of 49.4 MGD. Historical data from USGS showed a gauge at Camp 1 had an average flow of 33.6 MGD during low-flow months and an average flow of 40.7 MGD during high-flow months.

The Waimea rainfall station has an elevation of 20 feet and shows a mean annual rainfall of 20.1 inches. Additionally, the Niu Ridge Station, at an elevation of 1,250 feet, was operational until 2000. Data shows a mean annual rainfall of 26.09 inches.

The KEDIS system maps are shown on Maps 127 to 132, as follows:

- Map 127 - Alignments and System Components;
- Map 128 - Statewide Agricultural Land Use Baseline 2015 (Melrose et al.);
- Map 129 - ALISH 1977;
- Map 130 - Land Capability Non-Irrigated Conditions;
- Map 131 - Land Capability Irrigated Conditions; and
- Map 132 – CWRM System Alignments and Statewide Agricultural Land Use Baseline 2015.

Table 99
Kekaha Ditch Irrigation System
Reported Flows

Gage Location	**Reported Monthly Average Flows at Gage Locations [1]** (MGD)											
	2012 (11 months)		**2013**		**2014**		**2015**		**2016**		**2017** (7 months)	
	low	**high**	**low**	**high**	**low**	**high**	**low**	**high**	**low**	**high**	**low**	**high**
Waimea Hydro	14.1	40.8	14.8	26.7	13.0	24.1	0.0	45.7	12.0	15.0	10.3	13.6

Note: 1) Data reports are from Commission on Water Resource Management and could contain estimates and incomplete records. The exact location of measurements may not be reported.

Since the 2004 AWUDP, the KEDIS has not undergone any major modifications to the system or alignment, other than those improvements identified in the 2004 CIP. The status of the 2004 CIP is shown in Table 100, and the projects which were completed from 2004 to 2014 are shown in Table 101. The proposed CIP for the Kekaha Ditch Irrigation System is summarized in Table 102. One of the ongoing projects for this system is the renovation of the 14 reservoirs between Waiwa and Polihale. This project is expected to take approximately three (3) years, with a cost between $5 million to $8 million.

In 2013, there was a petition filed to amend the instream flow standards for Waimea River, and in 2017, CWRM approved the terms of the settlement. Pursuant to the settlement, KEDIS can only receive diverted water after instream flows are met at the various Waimea River diversions. The development of the system will be reassessed due to this settlement.

Table 100
Kekaha Ditch Irrigation System
2004 Capital Improvement Projects

No.	Item	Improvements	Status (2014)
1	Waipao Gulch Pipe Crossing	Demolish pipe; install pipe supports and 42-inch HDPE siphons	Completed
2	Equipment Access Road(s)	Clear and grub, install pavement (1,000 foot)	Completed
3	Koaiʻe Stream Intake	Install automatic bar screen/cleaner and control gate; install power source, equipment shelter, and concrete apron	Completed
4	Waihuiu Stream Intake	Install automatic bar screen/cleaner and control gate; install power source, equipment shelter, and concrete apron	Completed
5	Black Pipe Siphon Inlet	Install Concrete Rock Masonry (CRM) lining and 20-LF 26 in. HDPE slip-lining; replace intake	Completed
6	Various Control Gate	Retrofit control gates with new valves and channel structures; add metering; redesign flow controls at Waimea forebay tunnel, Waimea Heights-Menehune Ditch lateral, Pali flumes, Obake bridge, and Menehune Ditch junction box	Completed
7	Pali Flume	Replace two sections of Pali flumes (80-120 feet) with bypass tunnel	Completed
8	Reservoirs	Clean, grade, and install HDPE lining on 14 reservoirs between Waiwa and Polihale	In progress.

Table 101
Kekaha Ditch Irrigation System
2004-2014 Capital Improvement Projects

Item	Improvements	Status (2014)
Maintenance	Damages to system and roadways due to heavy rainfall events	Completed
Distribution	Halemanu stave pipe replaced with HDPE pipeline	Completed
Distribution	Black Pipe Siphon Inlet renovated	Completed
Distribution	Control gates, various improvements	Completed
System	Phase 6B and 1C security gates were installed at the main entrances	Completed

Table 102
Kekaha Ditch Irrigation System
2018 Capital Improvement Projects

Project Description	ESTIMATED COST (2018 dollars)
	Phase I
System Maintenance	$11,000,000

4.2.2 KŌKE‘E DITCH IRRIGATION SYSTEM

The Kōke‘e Ditch Irrigation System (KODIS) has an intake below Alaka‘i Swamp and other intakes on Waiakoali, Kawaikōī, Kauaikinana and Kōke‘e streams, which lie in the Kekaha sub-aquifer of the Waimea aquifer. There is a gage on the KODIS system, and flow data is summarized in Table 103. The overall mean flow at the Kōke‘e Ditch-Pu‘ulua reservoir gage is 12.4 MGD, with a minimum flow of 0.0 MGD and a maximum flow of 36.7 MGD.

Historical data from USGS shows that a gage near Waimea has an estimated average flow of 8.4 MGD during low-flow months and 22.6 MGD during high-flow months. There are no active rainfall stations in the area, but the Puehu

Ridge station has records until 2000. The station is at an elevation of 1,660 feet, and data shows a mean annual rainfall of 27.71 inches.

Due to the 2017 settlement with CWRM for Kekaha Ditch, the development of the system needs to be reassessed. Like Kekaha Ditch, normal maintenance and operations will be ongoing. Table 104 presents the status of the CIP program that was developed in the 2004 AWUDP.

In 2021 a Draft Environmental Assessment was published for the *West* Kaua'i Energy Project under HRS 343.[21] The proposed project is an integrated renewable energy and irrigation project. The proposed project would

- divert water for energy production and irrigation from Waiakoali, Kawaikaoi, Kauaikinana, and Kokee stream diversions of the Kokee Ditch Irrigation System;
- utilize and rehabilitate the existing Kokee Irrigation System and the Puu Lua, Puu Opae, and Mana Reservoirs; and
- Construct new stream and ditch gages, pressurized pipelines, hydroelectric facilities, photovoltaic solar array and battery, substations, and buried powerlines.

[21] SSFM International, Inc., West Kaua'i Energy Project, Draft Environmental Assessment, Prepared for Kaua'I Island Utility Cooperative and AES West Kauai Energy Project, LLC., July 2021.

Table 103
Kōke‘e Ditch Irrigation System
Reported Flows

Gage Location	Reported Monthly Average Flows at Gage Locations [1] (MGD)											
	2012 (11 months)		2013		2014		2015		2016		2017 (7 months)	
	low	high	low	high	low	high	low	high	low	high	low	high
Pu‘ulua Reservoir	0.0	10.0	1.0	9.0	1.0	2.0	1.0	3.0	2.0	2.0	1.0	2.0

Note: 1) Reports are from Commission on Water Resource Management and could contain estimates and incomplete records. The exact location of measurements may not be reported.

Table 104
Kōke‘e Ditch Irrigation System
2004 Capital Improvement Projects

No	Item	Improvements	Status (2014)
1	Kawaikōī Flume	Demolish flume; install wooden trestle, 48-inch semi-circular corrugated metal pipe (CMP), HDPE lining; conduct structural study	Completed
2	Pu‘u Lua Reservoir	Site work; install HDPE lining on dam, pipe burst/24-inches HDPE, discharge pipe; install 24-inch globe valve, flow meter, and appurtenances	In progress with DLNR
3	Pu‘u Moe Ditch Divide	Site work; install new divide, Parshall flumes, flow meters, and appurtenances	Pending due to settlement

4.2.3 EAST KAUA‘I IRRIGATION SYSTEM

The East Kaua‘i Irrigation System (EKIS) services approximately 5,920 acres of agricultural lands. The water source for the EKIS is the Wailua sub-aquifer of the Līhu‘e aquifer. In 2019, the East Kauai Water Users’ Cooperative, which formerly maintained the system, was disbanded.

Historical USGS records for water flow in the system are shown on Table 105. The Kapahi rainfall station has an elevation of 520 feet, with a mean annual rainfall of 89.06 inches. The system maps are shown on Maps 133 to 138, as follows:

- Map 133 - Alignments and System Components;
- Map 134 - Statewide Agricultural Land Use Baseline 2015 (Melrose et al.);
- Map 135 - ALISH 1977;
- Map 136 - Land Capability Non-Irrigated Conditions;
- Map 137 - Land Capability Irrigated Conditions, and
- Map 138 – CWRM System Alignments and Statewide Agricultural Land Use Baseline 2015.

Table 105
East Kaua‘i Irrigation System
Historical Flow Data

Gage Location	**Estimated Mean Monthly Discharge** (Low) (MGD)	**Estimated Mean Monthly Discharge** (High) (MGD)
Hanamalu	9.7	23.9
Stable Storm	2.6	9.0
Kapani	2.9	5.4
Makaleha	2.1	5.4
Wailua	6.0	14.2
‘A‘ahoaka	0.6	1.1

The EKIS has undergone significant changes since the 2004 AWUDP, especially in water storage capacity reduction. Since 2004, the following changes to storage capacity have occurred:

- The Wailua Reservoir has been reduced in volume to meet new dam safety regulations;
- In 2013, the Hanamā‘ulu Reservoir 21 storage capacity was reduced to have the reservoir deregulated; and
- The storage capacity of the Lower ‘A‘ahoaka Reservoir has been impaired by invasive species encroachment.

In addition, although not within EKIS, the Lower Kapahi Reservoir has been decommissioned, and the Twin Reservoirs are slated to be decommissioned. The status of the CIP listed in the 2004 AWUDP is presented in Table 106.

Table 106
East Kaua‘i Irrigation System
2004 Capital Improvement Projects

No.	Item	Improvement	Status (2014)
1	Lateral 8	Demolish 100 linear feet (LF) of 30-inch CMP; install 100 LF of new 30-inch CMP; improve ditch bank; and repair lateral eight (8) siphon inlet	Completed
2	Hanamā‘ulu Flume	Demolish wooden flume and salvage; excavate unclassified backfill and buried wooden trestle; backfill earthen ditch; install new reinforced concrete flume; install concrete flume	Completed
3	Twin Reservoirs	Demolish catwalks; install new wooden catwalks and concrete platform; creosote treatment for lumber; install new control gates	Reservoir to be decommissioned
4	Upper Kapahi Reservoir	Demolish catwalk; install new wooden catwalk and concrete platform; creosote treatment for lumber; install new control gate	Completed
5	Wailua Reservoir	Demolish catwalk; install new wooden catwalk and concrete platform; creosote treatment for lumber; install new control gate; retrofit intake gate structure to main transmission line	Completed(1)
6	Hanamā‘ulu Reservoir 21	Install new control valve	Completed
7	Control Gates	Retrofit approximately 15 control, bypass, and release gates	Pending
8	Diversion Works	Renovate diversion works and inlet gates for intakes on Kapa‘a Stream, Wailua Ditch, Stable Storm Ditch, Hanamā‘ulu Ditch	Kapa‘a and Wailua completed. Hanamā‘ulu not completed
9	Stable Storm Ditch	Re-route portion of Stable Storm Ditch onto state land with pipeline; construct lined reservoir	Long-term project

Note: 1) The Wailua reservoir capacity has been reduced due to compliance issues.

A notable project in the EKIS service area (circa 2015) is the harvesting of "wild" albizia trees by the biofuel company Green Energy of Kaua'i. The energy company plans to start power production with Albizia chips while the approved forestry trees for long-term biofuel needs are planted and reaching maturity.

The improvements to the 'A'ahoaka Reservoir have been completed since 2004. EKIS is another century-old system that requires repair, renovation, and upgrading to sustain or increase water flow. EKIS currently supplies water to the existing users and has potential to expand the number of acres cultivated. To provide for the potential increase in agriculture, a greater water supply must be coupled with long-term stable water flow to the agricultural lands. Therefore, EKIS had proposed the following projects to maintain existing water flow and increase it for an additional 300-plus acres. A summary of the proposed CIP is presented in Table 107.

- Overall System
    - Renovation/retrofit of control gates at various locations.
    - Planning and design to rebuild Kapahi diversion and intake structure.
    - Renovation of the Kapahi diversion and intake structure.
    - Planning and design for renovation and rebuilding of diversions at various locations.
    - Renovation of diversions at various locations.
    - Planning, design, and construction to renovate and replace control gates at various locations.
    - Reconnaissance survey to provide bathymetry data and storage capacity in reservoirs.

- Kapaʻa Section
  - The access road for the main transmission line, Wailua Ditch to North Fork, needs to renovate approximately two (2) miles with 50-foot roadways, including swales and shoulders. Vegetation needs to be cleared on either side of the roadway, approximately 25 feet deep, to prevent incursion, remove blockage from falling trees and branches, and allow the road to dry after rainfall.

  - Flume 2 needs to be replaced.

  - The access road for the main transmission line (to North Fork) requires clearing and reconstruction for about one (1) mile. The access road dimensions are the same as the above.

  - The control gates on the North Fork, catwalk, and weir need to be rebuilt.

- Kālepa Section
  - Lower and Upper ʻAʻahoaka Reservoirs require significant invasive species removal, typically the overgrowth of eucalyptus (paper bark) and hau.

- Lateral 8B (off from Wainaau Road) has root intrusion through the ditch walls, as well as into the tunnel. The ditch measures four (4) feet wide by five (5) feet high, and approximately 80 feet of ditch requires repair. The root intrusion into Tunnel 2 is about 80 feet into the tunnel. Tunnel 2 is approximately 200 feet long.

- Stable Storm. Planning and design for reconstruction of the intake and for replacement and rerouting of distribution line onto state land. The intake will provide a backup for the existing water demand and a long-term supply for the future increase in cultivated area.

- Distribution system. A long-term project to construct a pipeline from Upper Kapahi Reservoir to Hauiki Road and lateral 9 to Upper Kapahi. The new pipeline will improve the longevity of the system and potentially reduce repair costs.

Table 107
East Kaua‘i Irrigation System
2018 Capital Improvement Projects

Project Description	ESTIMATED COST (2018 dollars)	
	Phase I	Phase II
Repair and renovate control gates and various diversions	$110,000	
Reconstruct Kapahi Diversion	$150,000	
Restore reservoir capacity		
Capacity analysis and bathymetric survey	$230,000	
Design and construction		To be determined
Kapa‘a access road and flume		
Design	$2,000,000	
Construction		$10,000,000
North Fork Access Road and miscellaneous improvements	$6,500,000	
Reopen Lower ‘A‘ahoaka Reservoir, clearing and dredging	$10,000,000	
Kālepa Section Lateral 8B		
Planning	$120,000	
Design and construction		To be determined
Reopen Stable Storm Ditch		
Planning	$130,000	
Design and construction		To be determined
Pipeline from Upper Kapahi Reservoir to Hauiki Road		To be determined

4.2.4 WAIĀHOLE DITCH IRRIGATION SYSTEM

The Waiāhole Ditch Irrigation System (WDIS) services approximately 6,270 acres of agricultural lands. The WDIS water comes from intake tunnels which lie in the Windward aquifer. There are no active rainfall stations within the service area, but Waiāhole rainfall station is in the source area. The Waiāhole station has an elevation of 745 feet and a mean annual rainfall of 157.06 inches. Inactive rainfall stations in the service area include O‘ahu Sugar Field station 240, which was operating in Mililani until 1983, with a mean annual rainfall of 31.42 inches; and the Kunia rainfall station 807, which was operating in Camp 84 until 1983, with a mean annual rainfall of 31.77 inches.

Within the Waiāhole irrigation system service area, there are approximately 2,013 acres in two (2) IAL parcels. One (1) IAL parcel is owned by Monsanto Company, and the other parcel is owned by Hartung Brothers Hawai‘i, LLC. The Monsanto Company IAL totals approximately 1,550 acres and will be used for seed corn and soybean production, and cattle grazing. Anticipated water use presented in the associated IAL Petition and Decision and Order is 0.56 MGD. The Hartung Brothers Hawai‘i, LLC IAL totals approximately 463 acres and will be used for seed corn and sorghum. Anticipated water use presented in the associated IAL Petition and Decision and Order is 2.158 MGD. The system maps are shown on Maps 139 to 145, as follows:

- Map 139 - Alignments and System Components;
- Map 140 - Statewide Agricultural Land Use Baseline 2015 (Melrose et al.);
- Map 141 - ALISH 1977;
- Map 142 - Land Capability Non-Irrigated Conditions;
- Map 143 - Land Capability Irrigated Conditions;
- Map 144 – Important Agricultural Lands; and
- Map 145 – CWRM System Alignment and Statewide Agricultural Land Use Baseline 2015.

The status of the CIP listed in the 2004 AWUDP is presented in Table 108, and Table 109 shows the projects completed between 2004 and 2014.

Table 108
Waiāhole Ditch Irrigation System
2004 Capital Improvement Projects

No.	Item	Improvements	Status (2014)
1	Reservoir 155	• Remove sediment • Install lining • Repair cut stone wall • Repair overflow channel • Construct sediment trap and floating debris screen at inlet • Remove trees along embankment • General site grading	Construction
2	Reservoir 225	• Remove sediment • Install lining • Replace cut stone wall • Construct sediment trap and floating debris screen at inlet • General site grading	Construction
3	Garst Seed Co. Supply Earthen Ditch	• Seal off earthen ditch connection • Reservoir lateral • Backfill earthen ditch	Completed
4	Siphon A	• Slip line with HDPE pipe • Bypass • Headwork modification	Construction
5	Siphon B	Same as Siphon A	Construction
6	Siphon C	Same as Siphon A	Construction
7	Siphon D	Same as Siphon A	Construction
8	Reservoir	Construct two (2) to three (3) lined reservoirs	Design

Table 109
Waiāhole Ditch Irrigation System
2004-2014 Capital Improvement Projects

Item	Improvements	Status (2014)
Reservoir	Designed improvements to reduce water loss in reservoirs and installed two (2) Parshall flumes to monitor flow	Completed
Reservoir	Designed Waiāhole Irrigation System Reservoir improvements	Completed
Reservoir	Installed backup pump system at Reservoir 225	Completed
Reservoir	Designed water loss improvements for Reservoirs 225 and 155	Completed
Distribution	Closed 800 feet of unlined wing ditch (not in use)	Completed
Land	Acquired land parcels in Kahana and Waiāhole	Completed
Maintenance	Installed two new culvert pipes to replace two collapsed wooden flumes due to heavy rains in December 2008	Completed
Maintenance	Dredged bypass ditch at Reservoir 155 and implemented soil erosion control measures	Completed

The Waiāhole System requires additional projects to maintain water flow to the service area. The proposed projects were determined by field visits and discussions with ADC staff. The following projects are proposed and summarized in Table 110.

- Rehabilitation of access road and security fencing. The access road to the intake tunnel near Waimā stream crossing has been washed out and eroded due to heavy rainfall events. This repair was not anticipated in the annual maintenance budget, so funds were moved from other maintenance projects to repair the access road. The erosion will continue during heavy rainfall events, and annual maintenance costs will continue to increase. The washouts are caused by the accumulation of debris and rocks, formed due to overgrowth of invasive Albizia trees and other vegetation in the primary streambed. The new island diverts water toward the road, a natural low point, causing erosion at the roadway and adjacent areas.

This project recommends the removal of vegetation and debris to re-open the natural stream channel and accommodate the stream flow. In addition, it will provide structural reinforcement for the road and bridge to minimize damage from large river flows. During the development of this project, HDOA and ADC should work with the Hawaiʻi Housing Finance and Development Corporation (HHFDC) to reinforce the McCandless pipeline crossing the stream.

In addition, the roadway requires re-grading to restore proper drainage and minimize ponding and washout potential. New security fencing and gates also are needed to prevent public access into the system.

- Pipeline Installation 1. Install 300 feet of HDPE or similar pipe to prevent storm water intrusion, and mitigate wall collapse and root intrusion into the existing ditch structure.

- Pipeline Installation 2. Install 1,000 feet of HDPE or similar pipe to mitigate illegal dumping, prevent attractive nuisance liability, and prevent ditch wall collapse.

- Pipeline Installation 3. Install approximately three (3) miles of HDPE or similar pipeline through Mililani Town to mitigate illegal dumping, and prevent attractive nuisance liability, root intrusion, and wall collapse.

- Repair and/or replace damaged ditch lining at various locations. The approximate cumulative length of the damaged sections is 1.5 miles (not contiguous sections).

- SCADA monitoring system. Install a SCADA system with solar power. The system is planned to have seven (7) stations: four (4) located on the Windward side to monitor intake water flow and three (3) located on the Leeward side to measure ditch flow.

- Retrofit portions of the irrigation system with pipelines.

Table 110
Waiāhole Ditch Irrigation System
2018 Capital Improvement Projects

Project Description	**ESTIMATED COST** (2018 dollars)	
	Phase I	**Phase II**
Security and access	$2,100,000	
Pipeline installation 1	$110,000	
Pipeline installation 2	$220,000	
Pipeline installation 3		$3,300,000
Rehabilitation of ditch structure	$1,100,000	
SCADA	$2,200,000	
Retrofit with pipeline		
Design		$1,100,000
Construction		To be determined

4.3 PRIVATE SYSTEMS STUDIED IN THE 2004 AWUDP

The 2004 AWUDP studied four (4) privately managed irrigation systems:

- Kaua‘i Coffee Irrigation system, Kaua‘i;
- East Maui Irrigation System, Maui;
- Wailuku (West Maui) Irrigation System, Maui; and
- Maui Land and Pineapple/Pioneer Mill Irrigation System, Maui.

Unfortunately, updates for these systems are not available, as the **Maui Land and Pineapple** portion of **Pioneer Mill Irrigation System** and **Kaua‘i Coffee** did not return our request to update the study by the time of publication.

Both **East Maui Irrigation System** and **Wailuku (West Maui) Irrigation System** have declined to provide updates due to ongoing legal proceedings. As of 2021, CWRM has performed field inspections of the Wailuku Irrigation System and may have additional information.

The Nā Wai ʻEhā ruling in April 2014 set interim instream flow standards (IIFS) for Waiheʻe River, Wailuku River (ʻĪao Stream), North and South Waiehu Streams, and Waikapu Stream, all of which contribute to Wailuku Irrigation System. Having set the IIFS for the Nā Wai ʻEhā streams, the Commission began the task of making allocations to specific users through the issuance of water use permits. More than 100 water use permit applications have been filed. However, allocation decisions are complicated because claims of appurtenant rights to Nā Wai ʻEhā waters are made by the scores of claimants. In preliminary proceedings related to appurtenant rights, more appurtenant rights claims were filed than had been anticipated by IIFS proceedings. To further complicate matters, HC&S announced in January 2016 that it was transitioning from sugar cane cultivation to diversified agriculture by the end of that year. Nā Wai ʻEhā appurtenant rights, water allocations, and IIFS continue to be adjudicated through contested case proceedings.

The IIFS for several streams that contribute to East Maui Irrigation System also continue to be litigated. Following contested case proceedings, the hearing officer transmitted a recommended decision to CWRM at the end of 2015. Shortly thereafter, HC&S made the transition announcement mentioned above. The IIFS contested case is being re-opened to consider this new information before CWRM renders a decision on the IIFS for these East Maui streams. Refer to Section 7.5 for additional information on the litigation.

The gage reports for the East Maui and Wailuku irrigation systems are shown on Tables 111 and 112, respectively. Both systems provide water to IAL with an anticipated water demand from the Petition and Decision and Order of 195 MGD.

Table 111
East Maui Irrigation System
Reported Flows
(Hawaiian Commercial & Sugar Company)

Gage Location	**Hist. Ave. Flow [(2)]** (MGD)	**USGS [(1)] Location Date range**	**USGS [(1)] Est. Mean Monthly Discharge** (MGD)		**Reported [(3)] Monthly Average Flows at Gage Locations** (MGD)					
					2012 (11 months)		**2013**		**2014**	
			low	**high**	**low**	**high**	**low**	**high**	**low**	**high**
(old) Hāmākua	[65]	Honopou near Huelo 1918-1965	0.8	4.2						
Spreckels (old Haʻikū)	[30]	below Kaaiea near Huelo 1918-1929	2.9	8.4						
		At Haipuaʻena	--	--	3.2	18.4	3.1	32.8	3.1	20.6
		At Wailuku	--	--	6.8	19.4	0.0	25.4	10.7	25.7
Lowrie	[45]	Honopou near Huelo 1910-1985	18.1	30.3	6.5	20.7	0.0	15.8	2.1	20.3
		At Kailua	--	--	3.6	21.4	0.0	13.3	2.3	25.4
		At Māliko	--	--	7.4	16.2	0.0	13.7	4.2	16.2
New Hāmakuā	[54]	Honopou near Huelo 1918-1985	14.9	36.8	0.9	32.3	0.0	20.5	3.3	27.6
Koʻolau	[55]	Wahinepee near Huelo por. 1922	21.3	98.2						
		At Keʻanae	--	--	20.0	79.3	0.0	86.5	18.6	64.1
		At Nāhiku	--	--	7.7	39.7	0.0	31.6	0.0	40.0
New Haʻikū	[45] 25	Honopou near Kailua 1910-1985	11.0	25.9	1.3	13.6	0.0	13.3	0.6	14.2
		At Māliko	--	--	3.9	32.5	0.0	15.6	4.2	16.7

TABLE 111 (continued)
East Maui Irrigation System
Reported Flow
(Hawaiian Commercial & Sugar Company)

Gage Location	Hist. Ave. Flow [2] (MGD)	USGS [1] Location Date range	USGS [1] Est. Mean Monthly Discharge (MGD)		Reported [3] Monthly Average Flows at Gage Locations (MGD)					
					2012 (11 months)		2013		2014	
			low	high	low	high	low	high	low	high
Kauhikoa	[71]	ʻŌpana Weir 1910-1928	9.0	22.0						
		At Māliko	--	--	2.5	32.8	0.0	22.8	3.6	28.6
Wailoa	[110]	Honopou near Huelo 1922-1987	88.5	135.1	43.5	147.0	0.0	148.3	34.2	170.9
		At ʻŌpana	--	--	44.4	151.1	0.0	150.5	50.3	171.8
Waiheʻe Ditch	--	At Field 63	--	--	7.0	18.0	0.0	20.2	5.1	18.6

Note: 1) USGS Surface – Water Monthly Statistics for the Nation (http://waterdata.usgs.gov/nwis)
2) Source: Wilcox, Carol, 1977
Hist. Ave. Flow - Historical Average Flows, based on the historical record
Cap. - Capacity (unless otherwise noted)
3) Reports are from Commission on Water Resource Management and could contain estimates and incomplete records, and exact location of measurements are not reported.

Table 112
Wailuku Water Company
Reported Flows

Gage Location	**Hist. Ave. Flow** [2] (MGD)	**USGS** [1] **Location Date Range**	**USGS** [1] **Est. Mean Monthly Discharge** (MGD)		**Reported** [3] **Monthly Average Flows at Gage Locations** (MGD)					
					2012 (partial)		**2013** (partial)		**2014** (partial)	
			low	**high**	**low**	**high**	**low**	**high**	**low**	**high**
Waiheʻe Ditch (Spreckels)	[10] 10-2	--	--	--						
Waiheʻe Canal (Ditch)	[27] 27	--	--	--						
Everett Ditch Waikapū Stream					0.0	0.0	0.0	0.0	0.0	0.0
Field #1 Waiheʻe Stream					0.0	0.0	0.0	0.0	0.0	0.0
ʻĪao-Māniania Ditch ʻĪao Stream					0.9	2.5	0.5	2.7	0.4	1.7
ʻĪao -Waikapū Ditch ʻĪao Stream					5.0	15.8	7.1	15.2	6.4	17.1
Kama Ditch ʻĪao Stream					0.0	0.0	0.0	0.0	0.0	0.0
North Waiehu Ditch Waiehu Stream					0.0	0.0	0.0	0.0	0.0	0.0
Reservoir #6 Waikapū Stream					0.0	0.0	0.0	0.0	0.0	0.0
South Waikapū Ditch-Waikapū Str.					1.0	1.4	1.2	1.6	1.2	1.8
Spreckels Ditch Waiheʻe Stream					5.2	10.5	4.3	8.4	3.5	9.5
Waiheʻe Ditch Waiehu Stream					0.0	0.0	0.0	0.0	0.0	0.0
Waiheʻe Ditch Waiheʻe Stream					12.3	23.3	10.3	22.1	10.8	31.5
Waiheʻe Ditch Waikapū Stream					1.1	18.1	0.3	2.1	0.1	1.7

Note: 1) USGS Surface – Water Monthly Statistics for the Nation (http://waterdata.usgs.gov/nwis)
2) Source: Wilcox, Carol, 1977. Hist. Ave. Flow - Historical Average Flows, based on historical records
Cap. - Capacity (unless otherwise noted)
3) Reports are from Commission on Water Resource Management and could contain estimates and incomplete records, and exact location of measurements are not reported.

4.3.1 PIONEER MILL IRRIGATION SYSTEM (HONOKĀHAU) – WEST MAUI LAND CO.

A portion of the Honokāhau Irrigation ditch (Pioneer Mill Irrigation System) belongs to West Maui Land Co. and provided insights into its agricultural land use. Water does not currently flow into the West Maui Land Co. portion of the ditch due to the decommissioning of the Wahikuli Reservoir and issues upstream of the reservoir. The gage reports for the Maui Land and Pineapple/Pioneer Mill Irrigation System are presented on Table 113. In Table 114 are the CIP projects that may have impacted the West Maui Land Co. section of the ditch and their status.

The alignment of the Honokāhau ditch through the West Maui Land Co. property is shown in Map 146. The potential service area is approximately 1,000 acres of agricultural land owned by KSBE, as well as approximately 400 acres of agricultural land owned by West Maui Land Co. The agricultural land mauka (north) of the ditch is supplied by private water companies that draw water from various surface and ground water sources. However, if the Honokāhau ditch was to reopen, the irrigation water could be used as backup water for these mauka farms that have approximately 1,200 acres of diversified agriculture. CWRM has performed field inspections of the Honolua/Honokohau Ditch operated by the Maui Land and Pineapple and/or Pioneer Mill. The CWRM data is found on Map 147.

In 2004, as the 2004 AWUDP was published, the Kaanapali Land Management Corporation (KLMC) and Pioneer Mill (and their parent entities) emerged from bankruptcy as reorganized entities. These entities continue to engage in diversified agriculture on some of their lands in West Maui. One development is the Makila Land Co., LLC, which offers a range of agricultural lot sizes and configurations for a variety of agricultural uses.[22] The Makila project encompasses 4,500 acres stretching from Honoapiʻilani Highway to the West Maui Mountains. The agricultural portion includes 19 15-acre lots, 24 five (5)-acre lots and nine (9) lots ranging between 25 to 65 acres. In the future, new developments may include agricultural lots ranging from 15 to 65 acres.

[22] http://www.westmauiland.com/index/, accessed August 2015.

Table 113
Maui Land and Pineapple/Pioneer Mill Irrigation System
Reported Flows
(including reports from West Maui Land Company)

Gage Location	**Hist. Ave. Flow**[2] (MGD)	**USGS**[1] **Location Date range**	**USGS**[1] **Est. Mean Monthly Discharge** (MGD)		**Reported**[3] **Monthly Average Flows at Gage Locations** (MGD)					
					2012 (partial)		**2013 (partial)**		**2014 (partial)**	
			low	**High**	**Low**	**high**	**low**	**high**	**low**	**High**
Honokāhau	[35] 20	At Intake nr. Honokāhau 1907-1913	19.4	22.6	--	--	--	--	0.5	19.1
Kauaʻula	4.5	nr. Lahaina 1912-1917	5.1	6.5	2.0	4.0	1.6	5.7	1.2	4.1
Olowalu	4	nr. Olowalu 1911-1967	3.8	5.5	1.0	1.6	1.1	3.6	1.4	2.1
Honolua	[50] 30-18				--	--	--	--	0.0	0.0
Honokōwai	6									
Kahoma	3				0.1	0.3	0.2	1.0	0.3	0.8
Kanahā	3.8									
Launiupoko	0.8				0.2	0.7	0.3	0.7	0.3	0.8
Ukumehame	3									
Wahikuli	[5]									
Kaluanui					--	--	--	--	0.0	0.0

Table 113 (continued)
Maui Land and Pineapple / Pioneer Mill Irrigation System
Reported Flows
(including reports from West Maui Land Company)

Gage Location	Hist. Ave. Flow [2] (MGD)	USGS [1] Location Date range	USGS[1] Est. Mean Monthly Discharge (MGD)		Reported[3] Monthly Average Flows at Gage Locations (MGD)					
					2012 (partial)		2013 (partial)		2014 (partial)	
			low	High	Low	high	low	high	low	High
Agriculture Irr.					0.2	1.2	0.3	0.8	0.0	0.4
‘Awalau 4"					0.0	0.2	0.0	0.1	0.0	0.1
DWS Māhinahina					1.0	2.2	1.6	2.1	0.0	1.7
Kā‘anapali Dev. Co.					3.5	13.0	3.4	6.2	0.0	5.9
Kapalua Water Irr.					0.9	1.7	0.9	1.5	0.0	0.6
Nāhiku Stream Pump					0.0	0.0	0.0	0.0	0.0	0.0
‘Ōpana 12"					0.0	0.7	0.0	0.4	0.0	0.4
‘Ōpana 2.5"					0.0	0.0	0.0	0.1	0.0	0.0
Troon (golf)					0.6	1.1	0.7	1.3	0.0	0.4

Note: 1) USGS Surface – Water Monthly Statistics for the Nation (http://waterdata.usgs.gov/nwis)
2) Source: Wilcox, Carol, 1977
Hist. Ave. Flow - Historical Average Flows, based on the historical record
Cap. - Capacity (unless otherwise noted)
3) Reports are from Commission on Water Resource Management and could contain estimates and incomplete records, and exact location of measurements is not reported. Reported by West Maui Land Company, Inc.

Table 114
West Maui Land Co. Portion
2004 Proposed Capital Improvement Projects

No.	Item	Description	Status
1	"New Reservoir"	Remove silt; install base course, geotextile, and HDPE lining	Not Completed
2	Wahikuli Reservoir	Dewater, remove silt; install pipe bypass, base course, geotextile and HDPE lining; Level II dam hazard assessment	Reservoir Decommissioned
3	Pump "M"	Remove pump house and pumps; install three (3) new pumps, 10-inch Ductile Iron (DI) pipe & 10-inch HDPE pipe, new building, fence and gate; reactivate electrical service	Shut Down

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CHAPTER 5
PROPOSED NEW IRRIGATION SYSTEMS

To make agriculture sustainable, the grower has got to be able to make a profit.
Sam Farr

This chapter presents suggestions for potential growth of diversified agriculture based on the proposed development of new water systems and offers studies to investigate the viability of these new water systems. As these potential (suggested) systems are preconceptual, details such as water rights, ownership, management, and construction costs have not been determined. In addition, when these new water system(s) are ripe for decision-making, the feasibility, environmental, and/or cost-benefit studies will be performed as required.

The development of these new water systems would benefit the State by expanding diversified agriculture acreage. Expanding diversified agriculture is especially pressing because Hawai'i imports approximately 98 percent of its commodities.[23] In addition, State policymakers and the community have called for sustainability and self-sufficiency, which is directly related to diversified agriculture.

During the interview process and data collection, farmers and ranchers highlighted two (2) commodity groups that have the potential to grow diversified agriculture production. These two (2) commodity groups were truck farming and grass-fed beef. The increase in production of these commodities would support the state's goals of food sustainability and, to a lesser extent, import replacement. One of the key issues that inhibits the expansion of these commodities in the proposed growing areas is the lack of water resources.

Section 5.1 provides a brief overview of areas that have the potential to increase truck farming acreage. Section 5.2 provides a brief definition of grass-fed beef and the areas for potential expansion. Section 5.3 provides a CIP to investigate the potential to develop these new systems and agriculture areas.

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[23] Laney, Leroy O., *The Impact of Hawai'i's Harbors on the Local Economy,* May 2007.

5.1 POTENTIAL TRUCK FARMING AREAS

Farmers have proposed an increase in irrigated acreage for truck farms in the Kula area of Maui, and the Lālāmilo and Kawaihae areas of Hawai‘i. The Kula and Lālāmilo areas are two (2) of the best-producing areas in the state. The suggested areas are shown on Exhibit 30.

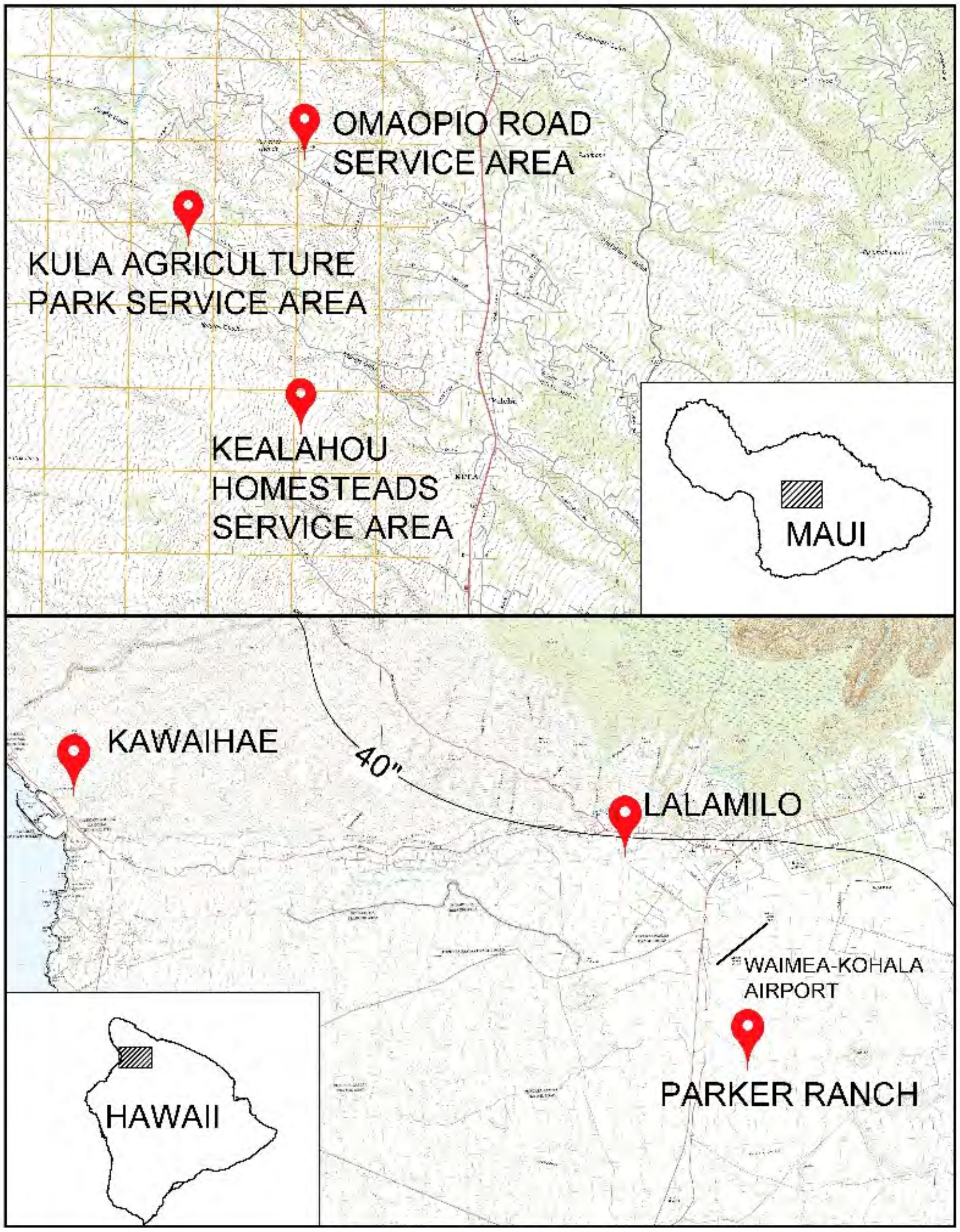

Exhibit 30. Potential Truck Farming Areas on Maui and Hawai‘i.

5.1.1 POTENTIAL KULA EXPANSION

The Kula area of Maui County has been subjected to various degrees of drought throughout its history. The *Kula Stormwater Reclamation Study* (KSWRS) was conducted by the Central Maui Soil and Water Conservation District, with technical assistance provided by the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS). The KSWRS is a set of four (4) reports: 1) an inventory and assessment of agricultural water needs, sources, and facilities; 2) a drought-mitigation resource analysis; 3) development of alternative concepts; and 4) an alternatives assessment, which included identification of economic, social, and environmental issues.

The major goals of this study were:

- An assessment of the drought-period agricultural water needs of the agricultural producers in the Lower Kula region;
- A survey of the existing and potential agricultural water supply sources and distribution facilities;
- An assessment of stormwater capture and storage potential in Kula and surrounding areas;
- A formulation of alternatives involving stormwater reclamation to reduce drought-related damage to crops and livestock, and to improve agricultural drought resiliency; and
- An evaluation of the economic, social, and environmental effects of implementing the drought-mitigation alternatives.

The KSWRS studied both the agricultural service and water supply areas. The agricultural service area covers approximately 1,338 acres of active[24] cropland or agricultural land within the area from the 1,200-foot to the 3,500-foot elevation, and from Pi‘iholo Road to Nā‘alae Road. The potential water supply area extends from Ke‘anae Gulch to Nā‘alae Gulch, running from 1,000-foot to 4,400-foot elevation. The service area includes 336 acres in the Upper Kula area and 1,002 acres in the Lower Kula area. An additional 250 acres of land near Ōma‘opio being used by Hāli‘imaile Pineapple Company has the potential to be serviced. To determine the water demand, KSWRS based the analysis

[24] Active farmland and cropland are considered lands that are currently being farmed.

on three (3) rainfall conditions — normal, drought, and severe drought — and the results are shown in Table 115.

The KSWRS forecast a 25-percent increase in crop acreage, equivalent to 335 acres, if water was available. The increase includes 84 acres in the Upper Kula area and 251 acres in the Lower Kula area. The study computed the future water demand based on rainfall conditions and the forecast increase of crop acreage. The increased acreage would require 217 million gallons per year (MG/yr) of irrigation water during normal rainfall years and 246 MG/yr of irrigation water for drought years. Table 116 summarizes the present and future agricultural acreages and water demand.

Table 115
Average Daily Irrigation Water Requirements
Kula Farms

	Upper Kula Farms			**Lower Kula Farms**		
	Normal Rainfall (Median)	**Drought**	**Severe Drought**	**Normal Rainfall (Median)**	**Drought**	**Severe Drought**
Average Daily Water Requirement (gpd/acre)	2,577	3,029	3,221	3,889	4,371	4,577
Peak Daily Water Requirement (gpd/acre)	4,093	4,294	4,416	5,711	5,930	6,063

Reference: Mink and Yuen, *Kula Stormwater Reclamation Study*, 2007

The preferred alternative included two (2) development system options as shown on Exhibit 31:

- System 1 - basic conceptual layout with a standalone reservoir; and
- System 2 - basic conceptual layout with two (2) standalone reservoirs.

The two (2) development options have the following characteristics:

- Captures excess water from the Piʻiholo Reservoir during rainy season rainfall events and other storm events;
- Utilizes existing easements and rights-of-way for the distribution system; and
- Avoids construction of storage and distribution systems in Conservation District lands.

Table 116
Present and Future Agricultural Acreages and Water Demand

DWS Systems	**Present Acres (active)**	**Normal Rainfall Water Demand** (MG/yr)	**Drought Rainfall Water Demand** (MG/yr)	**Future Acres**	**Normal Rainfall Water Demand** (MG/yr)	**Drought Rainfall Water Demand** (MG/yr)
Upper Kula	336	158.0	185.7	420	197.6	232.2
Lower Kula	1,002	711.1	799.4	1,253	888.8	999.2
Ōmaʻopio	250	--	--	--	--	--
Total Kula	1,338	869	985	1,673	1,086	1,231
Total	1,588	--	--	--	--	--

Reference: Mink and Yuen, *Kula Stormwater Reclamation Study*, 2007
Notes: DWS - Maui County Department of Water Supply
Normal rainfall year - 50 percent probability
Drought rainfall year - 80 percent probability

System 1 utilizes a large reservoir with a storage capacity between 150 MG to 300 MG on open pastureland owned by Haleakalā Ranch. This reservoir would be located between the 2,200-foot to 2,600-foot elevations.

System 2 utilizes two (2) reservoirs on Haleakalā Ranch lands: one (1) in the Kailua area and one (1) in the Pulehunui area. The Kailua reservoir would have a storage capacity between 130 MG to 150 MG and be located between the 2,500-foot and 2,600-foot elevations. The Pulehunui reservoir would have a storage capacity of 150 MG and be located between the 2,650-foot and 2,700-foot elevations.

The System 2 option would irrigate 80 acres more of diversified agricultural land than System 1. Due to the higher elevation of the System 2 reservoirs, there also is potential to irrigate an additional 2,000 acres of pastureland when compared to the System 1 option.

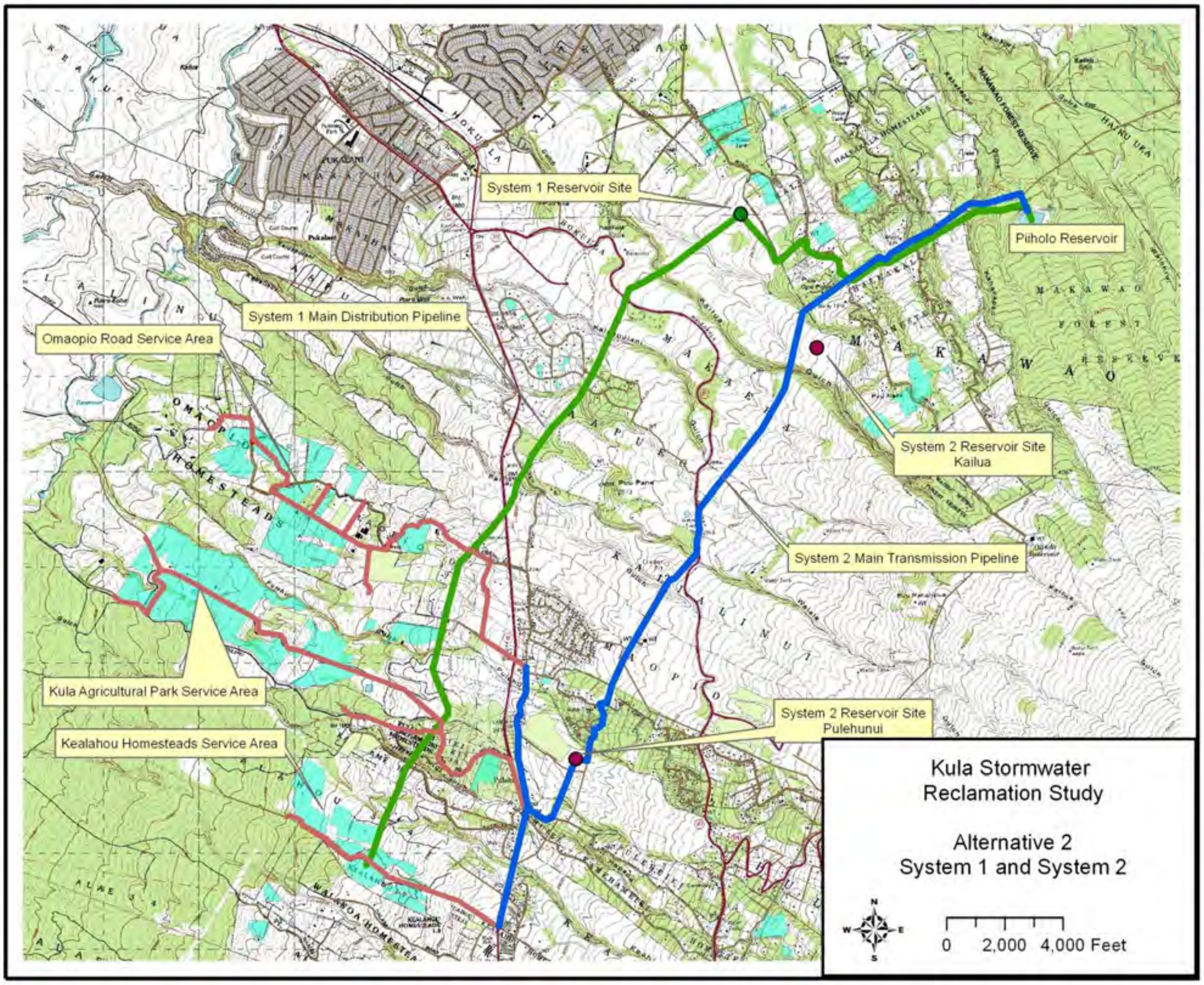

Exhibit 31. Kula System Preferred Alternatives (Mink and Yuen, *Kula Stormwater Reclamation Study*, 2007)

5.1.2 POTENTIAL - LĀLĀMILO AND WAIMEA EXPANSION

Farmers in the area would like to expand the Lālāmilo Farm lots as originally planned and/or develop certain Parker Ranch lands for diversified agriculture. Informal discussions with Parker Ranch indicated a willingness to consider using certain portions of the ranch for diversified agriculture. At that time, the area suggested by Parker Ranch for diversified agriculture is located south of Waimea-Kohala Airport.

One of the constraints for developing these areas is the supply and distribution of water. Based on the 2004 AWUDP, water demand in this area is approximately 3,400 gpd/acre. The following concepts were suggested for consideration:

- Expansion of the Upper Hāmākua (Waimea) Ditch System;
- A new reservoir and agricultural water system; and
- Conversion of the current County of Hawaiʻi Department of Water Supply potable water system to a nonpotable system, and replacement of a new potable water system with a well and reservoir system.

The first alternative would develop a new distribution system from the Upper Hāmākua Ditch System. However, current distribution of water from the Upper Hāmākua Irrigation System is limited to its existing users, and any expansion would require approval by the Board of Agriculture.

The expansion may require an increase in the water supply, distribution lines, and possibly new reservoirs. If the expansion area neighbors the existing Lālāmilo farm lots, the distribution system may connect to the existing Lālāmilo water system. If the expansion area is south of Waimea-Kohala Airport, an extension of the main transmission pipeline will be required along the Old Māmalahoa Highway.

The second alternative would be to develop a new system, including source development, water storage, and a distribution system. In the past, there was a plan to develop a new reservoir and distribution system north of Waimea town on DHHL property. However, this plan was not implemented.

The third alternative would be to convert the current Waimea potable water system to a well reservoir(s) system, providing the Hawaiʻi County of Department of Water Supply finds a suitable aquifer to develop. The existing potable water system is a surface water system and can be converted for agricultural use. The initial studies will need to find a suitable aquifer, as well as negotiations between the County of Hawaiʻi and the system developer. A previous study, the *Lālāmilo Water System, Revised Environmental Impact Statement,*[25] described a similar system.

5.2 POTENTIAL GRASS-FED BEEF AREAS

The ranchers and landowners have stated that there is an increased consumer demand for grass-fed beef, and they currently are having difficulty maintaining a consistent and high-quality supply. Interviews[26] with several commercial consumers support the need for consistent supply, taste, and quality.

The USDA certified grass-fed beef under their *Grass-fed Label* until 2016. The certification stated that animals must be fed only grass and forage for its lifetime, with continuous access to pasture during the growing period. In addition, regular grass supply will provide better consistency of taste and quality to the market. To accomplish this, the pastureland needs to have finishing and managed pastures. The finishing pastures will be used to prepare the animals for market. Many of the pasturelands need to be managed to provide the animal with continuous access to good grazing areas. Typically, grass-fed cattle will require approximately 2 acres per head, depending on the quality of the pasture and ranching technique. Most of the pastures will need to be irrigated.

The ranchers suggested the following areas for consideration to increase grass-fed beef production: North Kohala, Kawaihae, and between Puʻu Kapu to Āhualoa. The proposed areas for additional grass-fed beef pastures are shown in Exhibit 32.

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[25] State of Hawaiʻi, Department of Land and Natural Resources, *Lālāmilo Water System, South Kohala, Revised Environmental Impact Statement,* March 1980.
[26] Personal communication.

5.2.1 POTENTIAL NORTH KOHALA EXPANSION

One of the mainstays of the agricultural industry in the North Kohala district is cattle, with one of its main commodities being grass-fed beef. To increase production of grass-fed beef, there needs to be an increase in acreage for managed pastures, irrigated pastures, and general pastures. Ranchers suggest irrigating the area below the 40-inch rainfall isohyet.

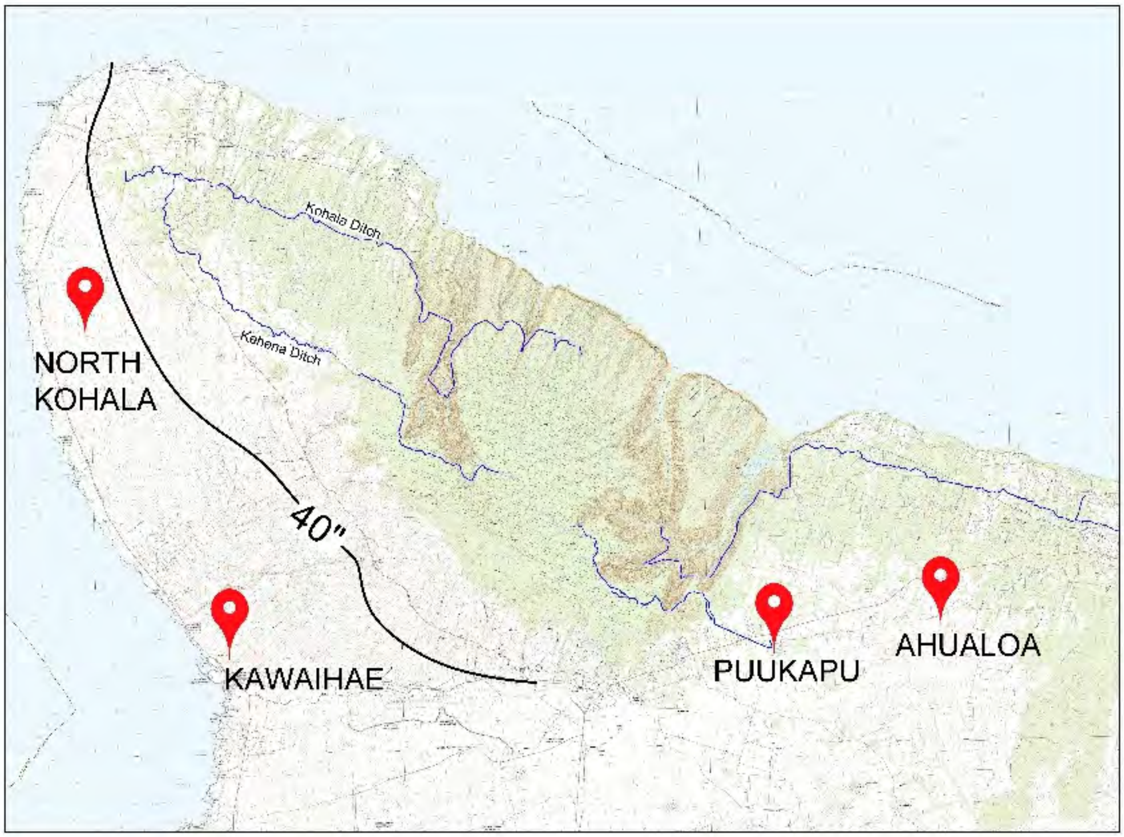

Exhibit 32. Potential Areas for Managed and Irrigated Pastures.

Notable irrigation systems in the North Kohala district are the Kohala and Kehena ditches. One of the recommendations for the rehabilitation of the Kehena Ditch system includes reopening an unused intake to increase flow into the system. Another suggestion from the ranchers to increase agricultural water supply is to transmit water from the Kohala Ditch system. It should be noted that during the plantation era, the Kehena and Kohala ditches were connected, with the Kehana Ditch system supplying water to the Kohala Ditch system.

If an increase in irrigation acreage is required, a new distribution system will be necessary. Both the new and existing distribution system should be constructed using a pipe system, as system loss for an open ditch system is significant.

5.2.2 POTENTIAL PUʻU KAPU TO ĀHUALOA EXPANSION

Ranchers suggest that the area from Puʻu Kapu to Āhualoa be developed for managed pastures and "finishing" pastures. These pastures would enable consistent, quality beef to be produced in this area. The following concepts were suggested as possible alternatives to increase the water supply to this area:

- Divert water from the Lower Hāmākua Ditch system, which will require a pump system;[27]
- Develop a new system that draws water from either the Kohala or East Mauna Kea hydrographic units; or
- Divert and increase water capacity of the Upper Hāmākua Ditch Irrigation System.[28]

5.2.3 POTENTIAL KAWAIHAE EXPANSION

The land areas east and north of Kawaihae Harbor are agricultural lands that have limited production due to lack of water. This area was historically known for sweet potato cultivation, with water being diverted by ʻauwai from a gulch that runs only intermittently today. Therefore, if water systems for other areas of South and North Kohala are being studied, these studies should include Kawaihae as part of the service area. The agricultural potential is unknown, as it is currently used for cattle grazing and historically for crop cultivation.

[27] In 2014, ACT 233 mandated the toll on water provided by the Lower Hāmākua Ditch shall not exceed 20 cents per 1,000 gallons.

[28] USGS map of the area shows a tunnel and ditch system that connected Puʻukapu Reservoir to Āhualoa.

5.3 PROPOSED CAPITAL IMPROVEMENT PROGRAM

The development plan proposes additional studies to investigate the potential of these new systems and agricultural areas. The CIP program is summarized in Table 117. The CIP proposes projects for truck farming and grass-fed beef expansion areas in Hawaiʻi. As these are suggested systems, the proposed projects are conceptual planning studies to investigate the potential of these new areas, including the stakeholders and users. If a decision is made to pursue the development of a new or expanded agricultural new water system in these area(s), then additional feasibility and planning will be performed to determine the land area, system ownership and management, land availability, water demand, water source, etc.

For the truck farming area at Kula, Maui, the CIP proposes a feasibility study to update the information in the KSWRS and also include information such as, but not limited to, water source(s), system ownership and management, and implementation options and schedule. The design and construction would be determined upon completion of the feasibility study and when funds are available.

Table 117
Estimated Costs for Potential Water System(s)
Kohala, Kula and Hāmākua Regions

Capital Improvement Project	**Estimated Cost** (2018 dollars)
Truck Farming	
Conceptual planning study Lālāmilo and Waimea expansion, including Kawaihae	$500,000
Feasibility, planning, design, construction	To be determined
Feasibility, source, ownership study Kula	$5,000,000
Planning, design, construction	To be determined
Grass-fed Beef	
Conceptual planning study North Kohala, including Kawaihae	$500,000
Feasibility, planning, design, construction	To be determined
Conceptual planning study Pu‘u Kapu to Āhualoa	$500,000
Feasibility, planning, design, construction	To be determined

CHAPTER 6
AGRICULTURAL WATER DEMAND

When the well's dry, we know the worth of water.
Benjamin Franklin

Agricultural "water demand," as defined by HDOA-ARMD, is the quantity of water supplied to farms from agricultural irrigation systems (ditches). In comparison, CWRM applies the term "water duty," which is the quantity of irrigation water required for a crop to mature. Note that neither "water duty" or "water demand" values can be used to set diversion allowances.

In this study, the term "water demand" will refer to water use as measured at the farm's boundary or water meter. From an irrigation standpoint, this demand is the "gross irrigation requirement," as it includes system losses and other non-irrigation water uses occurring within the farm area. Within the farm, non-irrigation uses include pest control strategies, cleaning of product, etc. The net irrigation requirement is the amount of water that reaches the crop. It is also referred to as the consumptive use, or the crop's water duty.

6.1 HISTORICAL PERSPECTIVE

The pre-contact population (prior to 1778 A.D.) engaged in subsistence agriculture, cultivating crops like taro and raising livestock such as pigs and dogs. The estimated pre-contact population total ranged from 200,000 to 800,000, with some estimates closer to 1 million people (Kirch 2007b).[29] According to Kirch (1982), the population probably started to decline about 100 years before contact with Westerners.

As the population increased over time, agricultural areas expanded and intensified. To meet the increase in water demand, agricultural stakeholders developed irrigation systems that included stream diversions, spring

[29] As referenced in Lagenfoged, et. al., Kirch, P.V., 2007b. ''Like Shoals of Fish'': archaeology and population in pre-contact Hawai'i. In: Kirch, P.V., Rallu, J. (Eds.), The Growth and Collapse of Pacific Island Societies: Archaeological and Demographic Perspectives. University of Hawai'i Press, Honolulu, pp. 52–69.

diversions, and ditches. The oldest known irrigation system is the Moloka‘i agricultural irrigation system, with an estimated creation date of 1200 A.D. Archaeological studies have shown that between 1200 A.D. to 1650 A.D., there was significant development of large-scale irrigation and permanent field systems (Cuddihy and Stone, 1990). Pre-contact era agricultural systems are generally categorized into four types (Kurashima and Kirch, 2011):

- irrigated pondfield;
- rain-fed dryland;
- colluvial slope cultivation; and
- aquaculture.

Irrigated pondfield agriculture supported the intensive cultivation of taro in large-scale agricultural development. Water demand for the cultivation of taro has been estimated at 280,000 liters/hectare per day.[30] This water demand was referred to as the "Hawaiian Legal Requirement" (de la Pena, 1983), or the minimum legal requirement by others. Spriggs (1984) stated that irrigated agriculture requires about half the labor of non-irrigated agriculture, or about 437.5 workdays/hectare per year.

Lagenfoged, et. al. (2009) estimated that 190 square kilometers (46,950 acres or 19,000 hectares) were cultivated using irrigated agriculture in pre-contact Hawai‘i. Based on the 19,000 hectares used for taro production and taro irrigation’s legal requirement, total statewide water demand was approximated at 1.4 billion gallons per day.[31] Based on the modeling results, the required labor input was approximately 240,000 people for all agricultural crops. Due to this large labor requirement and the intense nature of the agriculture activity, large population centers developed near these agricultural areas.

The arrival of European and American ships increased the bartering of Hawaiian agriculture commodities for imported iron and manufactured items. Typical agricultural commodities used in bartering included pigs, bananas, taro, and sweet potatoes.

[30] 280,000 liters/hectare per day is approximately 30,000 gallons/acre per day.
[31] Using today’s taro irrigation values of 260,000 gpd/acre, that 46,950 acres would be using approximately 12.2 billion gallons per day.

6.2 PAST STUDIES AND ANALYSIS

Between 1953 to 2011, it has been reported that the water demand for agriculture in Hawai‘i ranged from 1,131 to 8,035 gpd/acre. Water demand for an assortment of crops from various studies is shown in Table 118. Past studies have presented water demand and production of diversified agriculture crops from the 1930s to present.

In 1933, **Wadsworth**[32] published *A Historical Summary of Irrigation in Hawai‘i*, which documented the transition from pre-contact irrigation practices to those used for modern sugar production. Wadsworth marks the modern period of water utilization at 1878 due to economic and political developments. In the document, it is noted that immigrant laborers from Japan, particularly from Fukuoka and Kumamoto prefectures, were skilled in the dangerous work of tunneling. One of the outstanding laborers was Nitaro Kawano, who constructed 24 tunnels in the Olokele system on Kaua‘i in 1903.

In 1938, the **University of Hawai‘i, Agricultural Extension Service** prepared Land Utilization Maps, which were reprinted as MacLennan's *Sovereign Sugar, Industry and Environment in Hawai‘i,* 2014. Acreages for various land uses are summarized in Table 119. The land use study found that grazing commanded the largest land use at 2,080,000 acres, while other agricultural uses occupied 308,895 acres. For comparison purposes, the land use for 2012 from the National Agricultural Statistics Service is included in Table 120.

[32] Wadsworth, H. A., *A Historical Summary of Irrigation in Hawai‘i,* The Hawaiian Planters’ Record, Vol. XXXVII, No. 3, Third Quarter, 1933.

Table 118
Comparison of Agricultural Water Demand

Year	Water Demand (gpd/acre)	Comment
1953 (Reference 41)	5,325	Kailua and Kāneʻohe, Oʻahu
1956 (Reference 15)	1,131	Waimānalo
	2,277	Waimānalo - dry
1959 (Reference 13)	7,140 to 8,035	Sugar cane
	1,000,000	Wet crops (rice, taro, etc.)
	1,340 to 4,465	Diversified agriculture (excluding sugar cane and pineapple)
1984 (Reference 64)	6,000	Kahuku - nursery
	4,000	Kahuku - truck orchard
1995 (Reference 46)	7,722	Sugar cane
1999 (Reference 51)	4,700	Reference Crop - normal rainfall for elevations under 500 feet
	5,300	Reference Crop - low rainfall for elevations under 500 feet
	3,500	Reference Crop - normal rainfall for elevations above 500 feet
	4,200	Reference Crop - low rainfall for elevations above 500 feet
2004 AWUDP	3,400	Lālāmilo
2011 (Reference 34)	2,577	Upper Kula - average rainfall
	3,029	Upper Kula - drought
	3,221	Upper Kula - severe drought
	3,889	Lower Kula - average rainfall
	4,371	Lower Kula - drought
	4,577	Lower Kula - severe drought

Table 119
Land Use Acreages in Hawai‘i, 1937
Territorial Planning Board, Hawai‘i
(Ripperton, Coulter, Moltzau)

Utilization	Acres* per County					
	Kaua‘i	O‘ahu	Maui	Hawai‘i	Total	%
Sugar Cane	47,000	43,200	40,700	110,000	240,900	5.87
Pineapple	2,900	15,000	32,200	0	50,100	1.22
Grazing	177,000	107,000	406,000	1,390,000	2,080,000	50.72
Forest	149,000	120,000	196,000	562,000	1,027,000	25.04
Wet Crops (rice, taro, etc.)	1,170	1,275	220	285	2,950	0.07
Federal	80	36,700	17,700	145,000	199,480	4.86
Avocado	15	540	85	145	785	0.02
Banana	25	995	15	155	1,190	0.03
Field Crops	40	260	655	1,200	2,155	0.05
Other Fruit	30	128	35	135	328	0.01
Coffee	--	0	0	5,850	5,850	0.14
Nuts (macadamia)	200	72	15	530	817	0.02
Papaya	5	300	5	50	360	0.01
Vegetables	335	1,550	1,300	275	3,460	0.08
County Parks	1,900	2,880	570	675	6,025	0.15
Other	17,300	54,100	54,500	354,000	479,900	11.70
Total	397,000	384,000	750,000	2,570,000	4,101,000	

Note: *Acreage of some minor crops are estimated.

Table 120
Land Use Acreages in Hawai‘i, 2012
(USDA, National Agricultural Statistics Service)

Utilization	1,000 Acres									
	Kaua‘i		O‘ahu		Maui		Hawai‘i		TOTAL	
	1937	2012	1937	2012	1937	2012	1937	2012	1937	2012
Sugar Cane	47	<0.1	43.2	D	40.7	D	110	<0.1	240.9	D
Pineapple	2.9	<0.1	15.0	D	32.2	D	0	<0.1	50.1	D
Grazing	177	98.1	107.0	27.7	406.0	155.3	1,390.0	520.2	2080.0	801.4
Wet Crops (rice, taro, etc.)	1.2	nr	1,275.0	nr	0.2	nr	0.3	nr	nr	nr
Avocado	<0.1	D	0.5	<0.1	0.1	D	0.2	D	0.8	D
Banana	<0.1	D	1.0	D	<0.1	0.2	0.2	0.6	1.2	1.3
Field Crops	0.0	nr	0.3	nr	0.7	nr	1.2	nr	2.2	nr
Corn (grain)	nr	2.3	nr	D	nr	D	nr	0	nr	5.2
Other Fruit	<0.1	D	0.1	D	<0.1	D	0.1	D	0.3	2.8
Coffee	--	D	0	D	0	D	5.9	d	5.9	9.9
Nuts (macadamia)	0.2	<0.1	0.1	0.6	<0.1	<0.1	0.5	17.4	0.8	18.0
Papaya	<0.1	<0.1	0.3	0.2	<0.1	<0.1	<0.1	1.7	0.4	2.0
Vegetables	0.3	0.2	1.6	5.2	1.3	1.8	0.3	1.7	3.5	8.8

Note: D - Data withheld to avoid disclosure of a single farm
nr - not reported

In 1942, **Ripperton and Hosaka** published *Vegetation Zones of Hawai‘i.* The original purpose of the study was to classify and identify zones for pastureland, but instead the effort documented the diverse forms of agriculture in Hawai‘i (at the time, pasturelands were approximately one-fourth (1/4) of the state’s land area). The collected information on agricultural cultivation formed the basis of delineated cultivation zones for each island.

Based on elevation, climate, soil, and vegetation, Ripperton and Hosaka characterized five (5) zones: A, B, C, D, and E. Within zones C, D, and E, the authors created subzones delineated at certain elevation contours. The vegetation zones depicted by Ripperton and Hosaka are shown on Exhibits 33 to 35.

The five (5) zones are described as follows.

- A - This zone is typically located on the lee side of an island and ranges from sea level to an elevation of 500 feet. Where water is available, the arable parts are used for sugar production and grazing.

- B - This zone lies above Zone A, unless it extends to the shoreline. The upper elevation limit is 2,000 feet, and the average annual rainfall ranges from 20 to 40 inches.

- C - This zone extends to an elevation of 4,000 feet. There is a distinct change in vegetation; therefore, it is subdivided into two (2) subzones at the 2,500-foot elevation.

- D - This zone typically occurs on the windward side of the islands and has a minimum rainfall of 60 inches at sea level. The maximum rainfall averages can exceed 200 inches. This zone is subdivided into three (3) subzones with no distinct characteristics. The authors chose the upper limit of the lower subzone to represent the highest level of present and probable future agriculture development (circa 1940). The upper (highest) subzone is characterized by having the highest rainfall and is above the 4,000- to 5,000-foot elevation.

  Sugar cane was grown in suitable areas without irrigation. There are truck crops grown in these zones, but the wetter conditions increase the impact of insects and diseases.

- E - The zone covers the upper elevation of the islands, and is found only on Haleakalā, Mauna Kea, Mauna Loa, and Hualālai. Only a small part of this zone is suitable for agriculture, as it generally lacks deep soils and the temperature is cooler (below 60 degrees Fahrenheit). The forest reserve and other national parks occupy most of this zone.

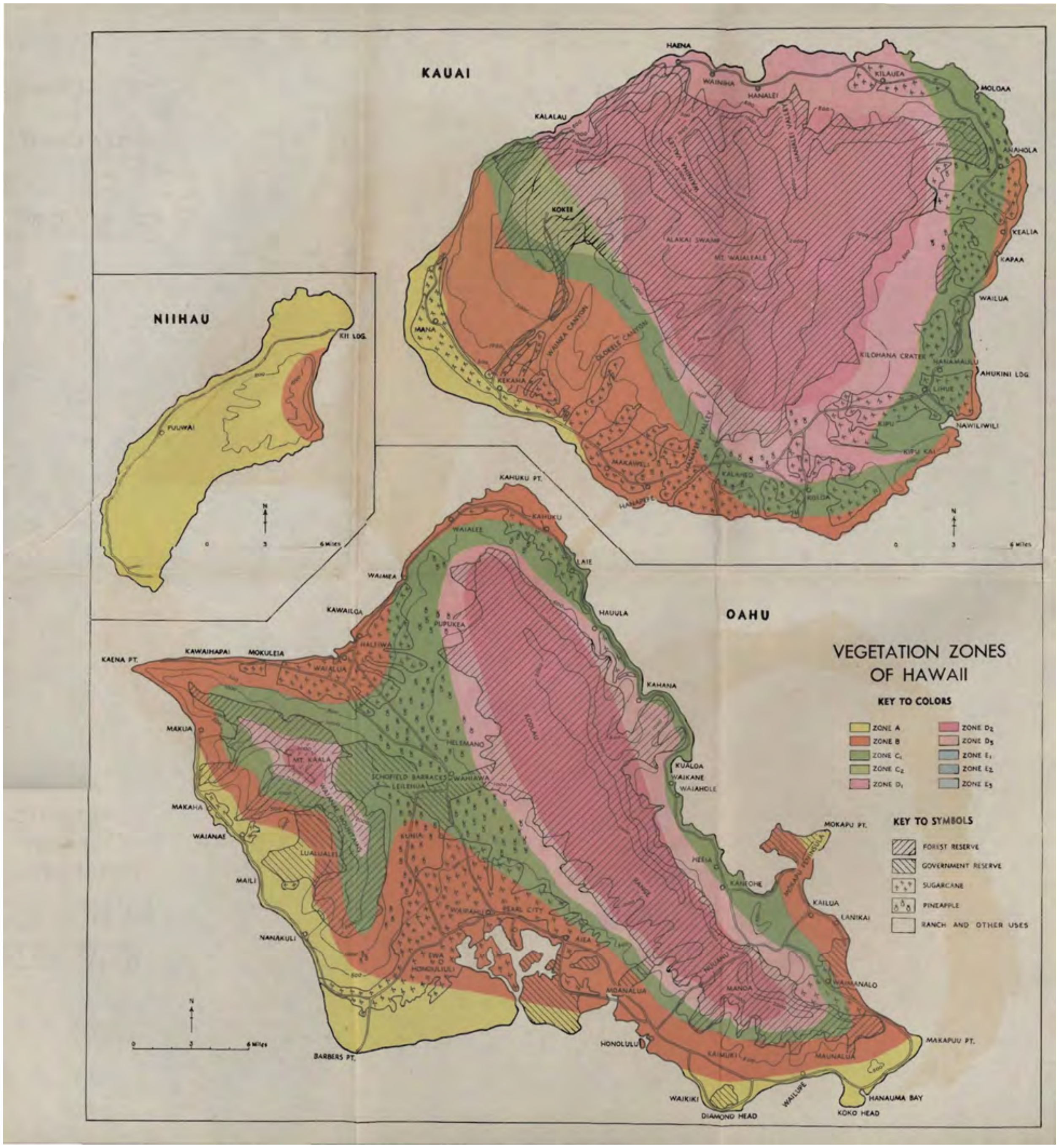

Exhibit 33 - Ripperton and Hosaka - O‘ahu, Kaua‘i and Ni‘ihau

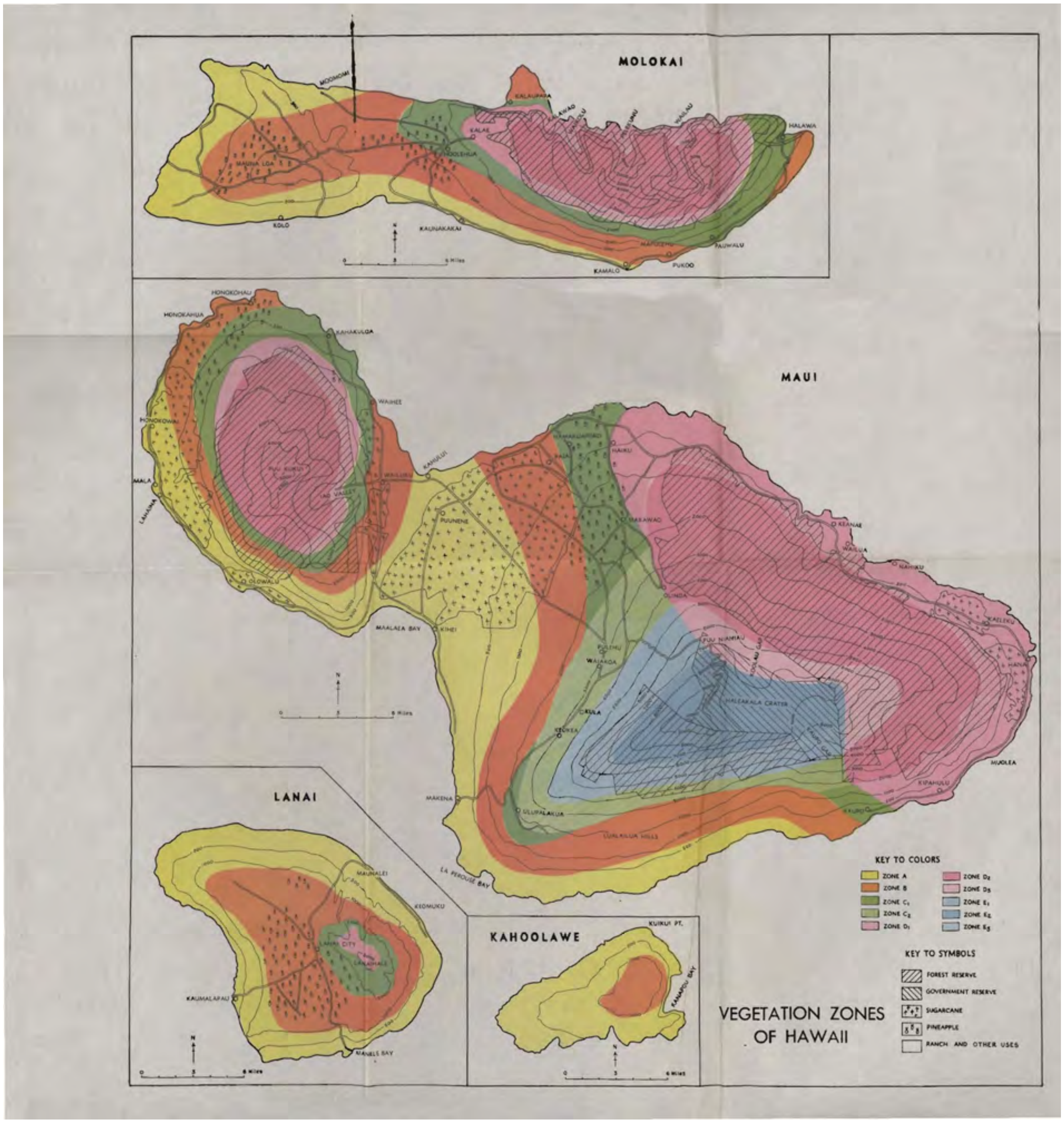

Exhibit 34 - Ripperton and Hosaka - Maui County

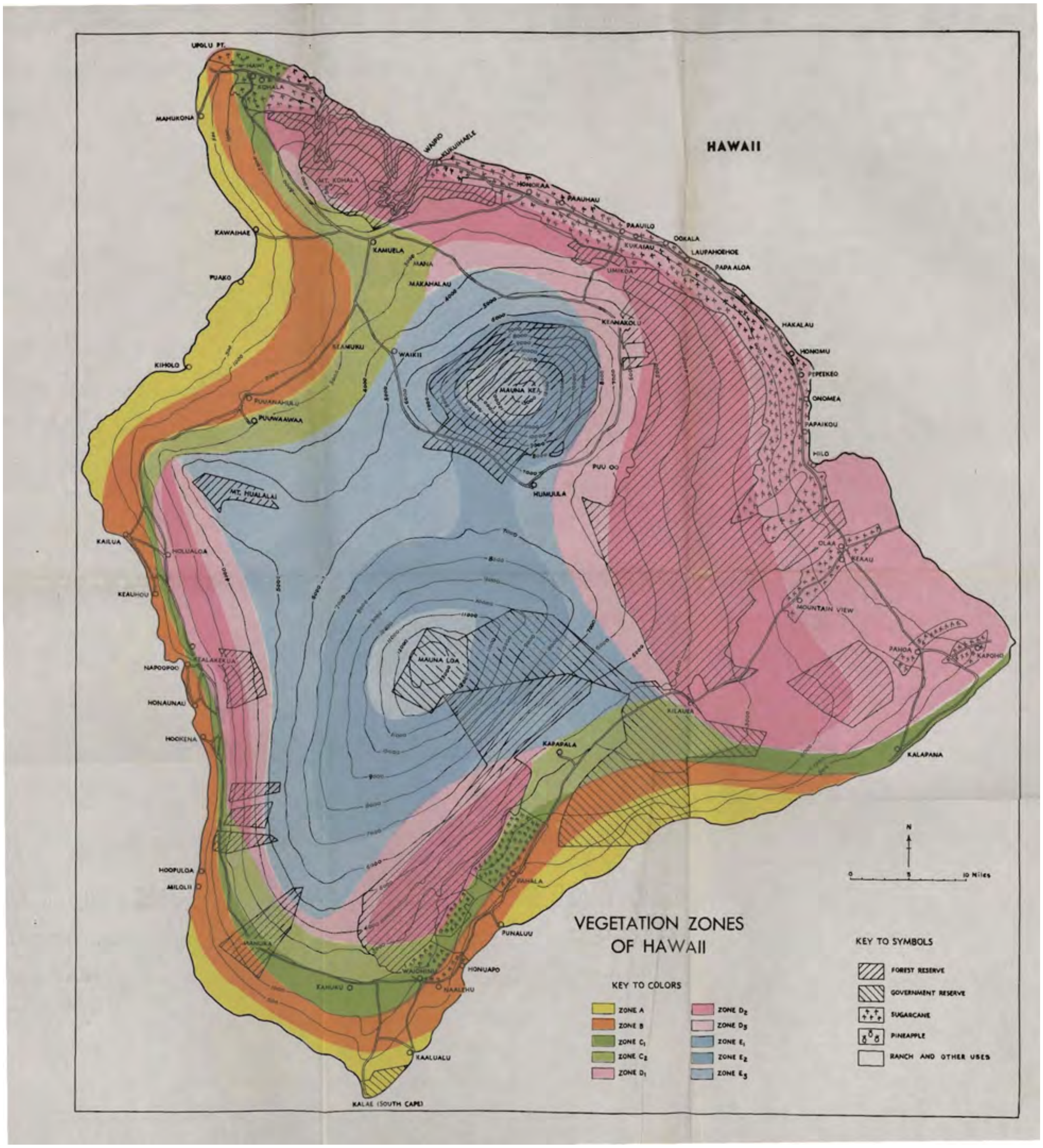

Exhibit 35 - Ripperton and Hosaka – Hawai‘i County

In 1956, the **Hawai‘i Irrigation Authority** completed an in-depth study of irrigation requirements and resources for the Waimānalo Irrigation System.[33] The study cites flow records (1924-1941) that show extreme drought flow from upper Maunawili Valley is 1.3 MGD, compared to the “dependable low flow”[34], estimated at 1.8 MGD. To provide an accurate estimate of crop water requirements, the Authority selected 14 farms that had variations in soil and rainfall conditions; diversification of crops; and different methods of cultivation and irrigation.

The analysis of the 14 farms indicated that water demand ranged from a low of 0.016 acre-inch per acre per month (15 gpd/acre) to 1.37 acre-inch per acre per month (1,240 gpd/acre). The mean was 0.64 acre-inch per acre per month (579 gpd/acre). This was based on water meter data at the farms and does not include on-farm irrigation system losses. The 14-farm analysis concluded that the best method to analyze water demand for the farm area was to use the data collected from farms spread out within the Waimānalo system. It provided representative water use that is reliable for the range of farms, climates, and soil types within the farming area.

The study concluded that three (3) water use numbers are needed to provide an estimate of water requirements for the farms in the area: 1) mean annual water, 2) maximum monthly water, and 3) maximum seasonal water. The definitions of the water requirements are provided below.

- Mean annual water requirement: To estimate pumping costs and revenues for economic studies and water rate establishment.
- Maximum monthly water requirement: To estimate irrigation requirements and determine the adequacy of the water resource. To a lesser degree, the maximum daily requirement also needs to be considered in establishing irrigation system requirements.
- Maximum seasonal water requirement: To determine the total water required, adequacy of available water resources over the “dry” summer period, and, more importantly, storage requirements for the system.

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[33] Hawai‘i Irrigation Authority, *Irrigation Requirements and Available Water Resources, Waimānalo Irrigation System,* Territory of Hawai‘i, 1956.

[34] Dependable Low Flow - defined as the lowest flow which occurs in four out of five years, except for an occasional isolated day or two.

Based on the 14-farm analysis, estimated water requirements for the Waimānalo Farm area are shown in Tables 121 to 123. The 15.2 acre-inch per acre per year computes to 1,131 gpd/acre. The 2.60 acre-inch per acre per month during the "dry season" computes to 2,277 gpd/acre.

Table 121
Estimated Irrigation Water Requirements - Average Year

	Water Demand Per Acre		Annual Total for Irrigation System
	Acre-Inches	Gallons	Gallons
Farm Diversion Requirements[1]	15.2	413,000	227,000,000
Diversion Requirements at Source[2]	43.4	1,180,000	649,000,000

Note: 1) The diversion requirements assume 50 percent of the farm area is irrigated at any given time. The diversion requirement is the water delivered to the diversion gates at farm.
2) Assumes 65 percent distribution system losses.

Table 122
Estimated Irrigation Water Requirements - Maximum Month
(based on no effective rainfall)

	Water Demand Per Acre		Maximum Month Total
	Acre-Inches	Gallons	Gallons
Farm Diversion Requirements[(1)]	3.0	81,000	53,500,000
Diversion Requirements at Source[(2)]	6.0	163,000	107,000,000

Note: 1) The diversion requirements assume 60 percent of the farm area is irrigated at any given time.
2) Assumes 50 percent distribution system losses.

Table 123
Estimated Irrigation Water Requirements - Maximum Season
(June to October)*

	Water Demand Monthly Total Per Acre		Maximum Seasonal Total
	Acre-Inches	**Gallons**	**Gallons**
Farm Diversion Requirements[1]			
2 months	3.00	82,000	98,600,000
1 month	2.60	71,000	42,700,000
2 months	2.20	60,000	72,200,000
Total	**----**	**----**	**213,500**
Mean per month	2.60	71,000	42,700
Diversion Requirements at Source[2]			
2 months	6.67	181,000	219,000
1 month	5.78	157,000	94,900
2 months	4.89	133,000	160,600
Total	**----**	**----**	**474,500**
Mean per month	5.78	157,000	95,000

Note: * This assumes that there is a minimum of 6 inches of rainfall during the five (5-month "dry" season.

1) The diversion requirements assume 55 percent of the farm area is irrigated at any given time.

2) Assumes 55 percent distribution system losses.

In 1959, **Hawai‘i Water Authority** statistics show agricultural water demand for Waimānalo Irrigation System was 161 million gallons per year, with a revenue of $37,133. However, maintenance and operational costs for this system showed a deficit of $21,869, even with cost-reduction measures in place. The system served 814 acres, 119 of which were used by the University of Hawai‘i experimental farm.

The summary in the 1959 Annual Report[35] listed the following important findings in the Water Resources report.

- "*Variety of Problems. The rainfall of the state is relatively high, averaging better than 70 inches annually. However, development of Hawai'i's water resources is both difficult and costly due to extreme variations in distribution of rainfall, wide differences in monthly, seasonal, and annual rainfalls, recurring droughts, lack of suitable impounding reservoir sites, problems of salt water intrusion in basal ground-water supplies, and mountainous topography*."

- "*Adequacy of Water Resources. Water problems in Hawai'i are not problems of inadequacy or impending inadequacy of available water resources. With proper planning and management, there will always be adequate water resources in the State — at a price. The problem is to supply water in the quantity needed, when needed, and where needed for municipal, military, irrigation, and industrial uses.*"

- "*Water Usage. Water utilization in the state in 1957 amounts to approximately 700 billion gallons, of which 60 percent was derived from surface-water sources and the balance from subterranean supplies. Principal categories of water use were domestic and municipal, 5 percent; irrigation, 74 percent; and industry, 19 percent, of which three-fourths was used for development of hydro-electric power. Per capita use in 1957 was approximately 3,440 gallons per day, a figure over double the average of the mainland United States.*"

- "*Changing Conditions. The water sources of Hawai'i have been extensively developed during the past eighty years by individuals, private business, and governmental agencies to meet various needs as they arose. Changing economy in the state and greater competition for undeveloped or partially developed water sources will impose increasing problems in the further exploitation of water*

[35] This was the last report from the Hawai'i Water Authority, as the functions of the Authority was transferred to the Hawai'i Department of Land and Natural Resources.

> *resources. These problems can best be met through proper long-range planning, coordinated efforts, and sound management."*

The Authority summarized water duty by crop, stating that irrigation varies greatly due to climate, soil conditions, method of application, and other factors, but mainly due to differences in crop requirements. For sugar cane, the water requirement is between eight (8) to nine (9) acre-feet per acre per year. However, if more water is available, demand could shoot as high as ten (10) or more acre-feet per acre per year. The eight (8) acre-feet per acre per year converts to approximately 7,140 gpd/acre, and nine (9) acre-feet per acre per year converts to 8,035 gpd/acre.

Heavy water-use crops are those grown in paddies or by flood irrigation, such as taro, rice, watercress, and lotus roots. For high-quality (prime) watercress, water demand is approximately three (3) acre-feet per acre per day, or about one (1) million gpd/acre. Pineapple cultivation has a water demand of approximately six (6) acre-inches per year. The variety of diversified agriculture crops, as well as the effects of climate and soil, creates a range of water demand from one and one-half (1 1/2) acre-feet per year per acre (1,340 gpd/acre) to three (3) acre-feet per acre per year (2,680 gpd/acre), with some crops exceeding five (5) acre-feet per acre per year (4,463 gpd/acre).

The 1959 Water Resources report also looked at the following water conservation measures:

- For surface water development
    - Seepage reduction,
    - Soil conservation practices,
    - Reduction of surface evaporation, and
    - Waterproofing catchment areas;

- For ground water development
    - Reducing leakage from the Ghyben-Herzberg lens,
    - Recharging, and
    - Artesian well sealing;

- Other conservation measures
  - Reuse of industrial and irrigation waters,
  - Use of treated sewage,
  - Reforestation,
  - Cloud seeding, and
  - Saline conversion.

The final recommendation was:

> *It is recommended that in order to encourage the expansion of diversified farming in the interest of the State's economy, the Legislature give consideration to some form of subsidization for irrigation projects where financial help is needed. Existing statutes require repayment of principal and interest for capital costs of construction which, in some instances, may make the cost of irrigation water too high for economic farming.*

In the late 1990s, the **State of Hawai‘i, Department of Agriculture** and its partners developed watershed plans for several irrigation systems in the state. The Lower Hāmākua Ditch (LHD) Watershed Plan and Final Environmental Impact Statement computed water demand by crop, which was based on pan evapotranspiration results. Table 124 presents the various crop irrigation requirements for crops grown below the 500-foot elevation and above the 500-foot elevation in the Kukuihaele to Pa‘auilo area. The 80 percent chance of rainfall represents the rainfall expected on average during the driest and second driest years of a ten-year group. The 50 percent rainfall represents the median annual rainfall, or the average rainfall condition. The average daily irrigation requirement (Table 125) is based on the peak irrigation month that typically corresponds to the month with the highest evapotranspiration rate and lowest rainfall.

Table 124
Summary of Average Daily Crop Water Demand
Lower Hāmākua Ditch, Kukuihaele to Pa'auilo
(gpd/acre)

		Crop Water Demand Below 500 feet			**Crop Water Demand Above 500 feet**	
Rainfall		50%	80%		50%	80%
Banana		2,211	3,236		1,425	1,964
Coffee		1,471	2,079		852	1,296
Papaya		1,471	2,079		852	1,296
Macadamia nut		1,140	1,578		562	992
Foliage/flowers		1,808	2,655		1,140	1,600
Truck crops		1,140	1,578		562	992
Reference Crop		1,500	2,100		900	1,350
Effective Daily Rainfall (inches)		*0.11*	*0.09*		*0.13*	*0.10*
(gpd/acre)		2,986	2,443		3,530	2,715

In 2008, **Ali Fares, Ph.D.** prepared the *Irrigation Water Requirement Estimation Decision Support System (IWREDSS) to Estimate Crop Irrigation Requirements for Consumptive Use Permitting in Hawai'i*, for the State of Hawai'i, Department of Land and Natural Resources, Commission of Water Resource Management. IWREDSS was updated in 2013, when Version 2.0 was released. IWREDSS is an Arc-GIS-based numerical simulation model developed to help estimate crop irrigation requirements for consumptive use permitting in Hawai'i. The model estimates irrigation requirements and other water budget components, including net irrigation water requirements, gross irrigation water requirements, water duty, gross rain, net rain, effective rain, runoff, canopy interception, potential evapotranspiration, reference evapotranspiration, and drainage.

Table 125
Summary of Average Daily Crop Water Demand
Peak Month
Lower Hāmākua Ditch, Kukuihaele To Pa‘auilo
(gpd/acre)

		Crop Water Demand Below 500 feet			**Crop Water Demand Above 500 feet**	
Rainfall		50%	80%		50%	80%
Banana		6,133	6,733		4,733	5,467
Coffee		4,600	5,167		3,367	4,067
Papaya		4,600	5,167		3,367	4,067
Macadamia nut		3,833	4,367		2,733	3,367
Foliage/flowers		5,367	5,933		4,067	4,767
Truck crops		3,833	4,367		2,733	3,367
Reference Crop		4,700	5,300		3,500	4,200
Effective Peak Month Rainfall (inches)		*1.67*	*1.25*		*2.21*	*1.66*

CWRM uses the IWREDSS software program to determine the water allocation for agriculture irrigation demand for an applicant (farmer). IWREDSS computes the irrigation demand based on the farm's location, crop type, acreage, and an 80 percent rainfall frequency (or an average drought rate of one in five years). Currently, IWREDSS can compute the irrigation requirements for approximately 50 crops.

The annual amount used by the applicant is computed on a moving annual total from the date of inquiry, and the applicant cannot exceed the moving annual total at any time. Therefore, if rainfall is less than the 80 percent rainfall frequency or the drought periods are longer than assumed, the applicant can easily exceed the annual allocation or will need to reduce the amount of acreage farmed to stay within the moving annual water allocation.

In 2011, **Mink and Yuen** performed a water study for Kula, Maui. The report computed the estimated water budget for the upper and lower Kula agriculture production areas. To perform the water budget analysis, the study analyzed the 30-year rainfall record of the Kula Branch Station. The study concluded that the 50 percent rainfall frequency was the median (normal); 80 percent rainfall frequency was equivalent to typical drought conditions, occurring at an average rate of once every five (5) years; and 90 percent rainfall frequency was equivalent to extreme droughts, averaging once every 10 years. Rainfall records indicate that during drought conditions, rainfall amounts range from zero (0) to less than one (1) inch. Water budget analysis results are shown on Table 126 for the three conditions: normal, drought, and severe drought.

Table 126
Average Daily Irrigation Water Requirements
Kula Farms

	Upper Kula Farms			**Lower Kula Farms**		
	Median Rainfall	**Drought**	**Severe Drought**	**Median Rainfall**	**Drought**	**Severe Drought**
Average Daily Water Requirement (gpd/acre)	2,577	3,029	3,221	3,889	4,371	4,577
Peak Daily Water Requirement (gpd/acre)	4,093	4,294	4,416	5,711	5,930	6,063

In 2014, **Giambelluca, T.W., et.al.** published the *Evapotranspiration of Hawai'i*. The 2014 Evapotranspiration of Hawai'i project was conducted under an agreement between the State of Hawai'i Commission on Water Resource Management and the U.S. Army Corps of Engineers, Honolulu District under Section 22 of the Water Resources Development Act of 1974. The development of the evapotranspiration, solar, and climate websites, including their interactive map tools, was supported by National Science Foundation Hawai'i EPSCoR grant no. EPS-0903833. The results are found on the website: http://evapotranspiration.geography.hawaii.edu/.

6.3 2014 INFORMATION GATHERING

To determine water demand for agriculture, surveys and interviews were undertaken with farmers throughout the state. Actual water use and water concerns were collected using two different methods: a formal survey of farmers in agricultural areas and informal interviews with farmers and system managers.

6.3.1 METHODOLOGY

During the formal survey, individual farmers and ranchers were asked specific questions about water use. Questions are shown in Appendix C. Research was conducted on 113 farms in the Waimānalo, Kahuku, Mililani, Kula, Pāhoa, Panaʻewa, Hāmākua, East Kauaʻi, and Molokaʻi agriculture parks. Additional water demand information was gathered from the Kunia agricultural area. The data was collected by professional field staff visiting each farm between April 10 and May 26, 2014. During the interviews, farmers and field staff defined the typical “wet season” to be January and February, and the typical “dry season” to be July and August.

In many cases, farmers did not know the precise number of gallons used on their farm. However, in most of these cases, farmers shared their monthly water bills, and, with the help of the water supply agencies on each island, the gallon usage by farm was computed. Due to variations in water usage and planted acreages, interviewers confirmed the information with the farmers with follow-up meetings or telephone conversations.

The information-gathering process involved informal discussions on water demand and irrigation systems with stakeholders, farmers, and ranchers. These informal discussions were held to collect additional information, provide quality control on the survey information, and to supplement information gathered from stakeholders.

6.3.2 DISCUSSION OF THE FORMAL SURVEY RESULTS

A summary of the formal survey data for average water usage by farms and by island is shown on Table 127. The maximum water requirement for the dry and wet seasons on the island of Hawaiʻi is influenced by the data reported from the Keāhole agriculture lots, which has average annual rainfall of 18 inches.

The dry season monthly averages range from 161,500 to 442,800 gallons per acre for most of the state, excluding Kauaʻi. This translates to a daily water demand ranging from approximately 5,200 to 14,500 gpd/acre. Note that some crops in different areas exceed 1 million gallons per month per acre, which is more than 32,000 gpd/acre. In addition, the on-farm irrigation type illustrates variations in water demand, as shown in Table 128.

Table 127
Monthly Average Farm Water Demand
(based on survey responses)

Location	Average Wet Season (gpd/acre)	Average Dry Season (gpd/acre)	Range Wet Season (gpd/acre)		Range Dry Season (gpd/acre)	
			Min	Max	Min	Max
Hawaiʻi	4,164	5,298	0	87,432	0	87,432
Maui	3,304	10,139	0	8,197	295	24,792
Molokaʻi	6,237	14,520	63	32,787	63	98,361
Oʻahu	3,840	7,183	0	52,459	2	65,574
Kauaʻi	87	905	0	557	1	3,541

Table 128
Average Monthly Water Demand by Irrigation Type
(based on survey responses)

Irrigation Method	Number of Farms	Wet Season (gpd/acre)	Dry Season (gpd/acre)
Drips	49	3,680	9,260
Sprinklers	29	5,910	7,578
Water Hose	12	4,507	5,367
Ponds	1	59	5
Aquaculture	1	4,662	4,662

Table 129 presents the following information for each agricultural area included in the survey.

- The range of water demand during the dry season and estimated annual average water use.
- Farm water demand computed based on actual cultivated area, not the total parcel area.
- Average annual rainfall.
- The vegetation zone based on the Ripperton and Hosaka maps.

Table 129
Surveyed Farm Water Usage and Rainfall

Location	Average Dry Season Water Usage* (gpd/acre)		Estimated Average Annual Water Usage* (gpd/acre)		Average Annual Rainfall (inch)**	Vegetation Zone***
	Low	High	Low	High		
Pāhoa	0	5,059	0	4,662	134	D1
Pana‘ewa	0	13,230	0	6,809	129 - 140	D1
Keāhole	725	87,432	725	87,432	18	A
Kula	295	24,792	148	14,875	16 - 27	B
Moloka‘i	63	98,361	63	65,674	17 - 21	A & B
Mililani	118	65,574	59	59,016	26 - 37	B
Waimānalo	2	8,431	2	7,561	51 - 67	C1 & D1
Kahuku	173	39,742	173	19,871	43 - 52	B - C1
Kaua‘i	1	3,541	1	1,770	45 - 52	C1

NOTES: * Farm acreage is based on planted area.
** Giambelluca, T.W., et al., *"Online Rainfall Atlas of Hawai‘i"*
*** Ripperton and Hosaka, "*Vegetation Zones of Hawai‘i*"

Based on the farms surveyed, average farm water demand for the dry season (lower rainfall period) is 214,000 gallons per acre per month, and the estimated annual average is 170,000 gallons per acre per month. This computes to a daily water demand of about 7,020 gpd/acre for the dry season and 5,560 gpd/acre on an annual basis, or 1.8 inch-acre and 1.4 inch-acre per week, respectively. Water demand from other farms located on leeward portions of the islands average 8,425 gpd/acre for dry months, with an annual average of 7,344 gpd/acre.

6.4 RECOMMENDED WATER DEMAND

6.4.1 2004 AWUDP WATER DEMAND

The 2004 AWUDP determined that analysis for the recommended water demand shall be based on metered irrigation water demand data. This methodology was selected for its reflection of actual growing methods. For certain commercial crops, a growing cycle may include several harvesting cycles during a calendar year. Portions of the land may be rotated out of cultivation and left unirrigated for a short period of time as part of routine farming activities.

To account for such practices, the 2004 AWUDP water demand was based on metered irrigation water data. The Lālāmilo section of the Waimea (Upper Hāmākua) Irrigation System was selected for this analysis. The Lālāmilo area has been cultivated for diversified crops by dedicated, full-time farmers for many years.

Based on eight (8) years of records, an average of 3,400 gpd/acre (rounded from 3,461 gpd/acre) was determined to be the application rate of irrigation water use for diversified crop farming in Lālāmilo. Therefore, the 2004 AWUDP concluded that 3,400 gpd/acre is the best available estimate for diversified agriculture water demand. This recommended water demand rate is tempered by an acceptable level of conservation practices, including the Hawai‘i Board of Agriculture administrative rules governing irrigation systems' conservation practices.

6.4.2 CURRENT WATER DEMAND

This AWUDP update revisits the recommended water demand estimate for diversified agriculture. The analysis considers metered irrigation water data from farming areas throughout the state and historic water demand. The analysis of the water demand found the following average water demand rates.

- The 2014 farm survey data identified an average annual farm water demand of 4,022 gpd/acre at the water meter. This demand rate is based on the cultivated land area and metered irrigation water data at farms that practice good farming principles, such as crop rotation. Crop rotation allows the land to rest (remain fallow) between crops, and in the surveyed farms the average planted area was approximately 48 percent of the cultivatable land and 52 percent remained fallow (with no cover crop).

- The Kunia, Oʻahu, farms reported that the water demand for 2012 and 2013 was an average of 4,034 gpd/acre at the water meter. This demand rate is based on the cultivated land area, as well as metered irrigation water data at farms that implemented crop rotation and use no cover crop.

- The historical data on diversified agricultural water demand, not including sugar cane cultivation, provided a computed average of 3,781 gpd/acre. The farming practices considered in this evaluation also implemented 50 percent planted area with no cover crop on the unplanted area (crop rotation).

The average water demand rate of these three (3) data sets is 3,946 gpd/day. Therefore, it is recommended that the planning-level water demand rate is 3,900 gpd/day at the farm meter, based on 50 percent field rotation (annually) and no cover crop. Allowing lands to remain fallow for part of the year is considered a good farming practice. Conversely, if farmers do not fallow the fields, they are likely to rotate the plantings with other crops. In similar farming scenarios, if little or no crop rotation (100 percent of the farmable land is planted) occurs and irrigation water is required for 100 percent of the fields annually, then the average water demand is expected to double, and the associated water demand planning estimate is 7,800 gpd/acre.

To provide an average water demand rate for diversified agriculture, an effort was made to exclude outlier data. In calculating the average water demand of 3,946 gpd/day, wet crops such as taro and aquaculture were excluded from the average computations. The remainder of the data used in the calculations cover a wide range of farming scenarios, including both dry (higher water demand rate) and wet (lower water demand rate) growing regions, to arrive at the average water demand rate.

The aforementioned water demand is based on typical farming conditions, averaged on an annual basis. However, for planning purposes, it should be noted that for dry periods throughout the year or during drought conditions, water demand is higher to account for the lack of rainfall. During the dry months, the same farms reported the following water demand rates.

- The 2014 farm survey data identified an average dry-month farm water demand of 7,775 gpd/acre at the water meter. This demand rate is based on the cultivated land area and dry-month metered irrigation water data at farms that implement an average of 48 percent crop rotation and use no cover crop.

- The Kunia, Oʻahu, farms had an average dry-month water demand of 8,556 gpd/acre for 2012 and 2013. This demand rate is based on the cultivated land area and dry-month metered irrigation water data at farms that utilize good farming practices, implement crop rotation, and use no cover crop.

The average dry-month/drought water demand from the two (2) data sets computed to 8,166 gpd/acre, as the farmer is required to significantly increase water to the crops to maintain an economic level of production. Therefore, it is recommended that a planning-level water demand of 8,100 gpd/day be considered for dry-month/drought conditions, based on a 50 percent field rotation (annually), at the farm meter. In similar farming scenarios, if the majority or all of the lands are planted (little or no crop rotation), then the irrigation water is required for 100 percent of the fields annually, the average water demand during dry months/drought conditions is expected to double, and the associated planning estimate is 16,200 gpd/acre. This planning average water demand factor for dry/drought conditions is provided with consideration of drought planning, potential climate change variations, and for growing regions on the leeward side.

Table 130 presents multiple water demand planning rates to represent generalized farming practices and rainfall conditions that are commonly used or encountered throughout the state. The table includes rates for dry/drought conditions; likewise, the Plan user should recognize that wet regions are likely to use less water for their crops.

Users of these demand rates should note that water use varies by many factors, and a one-size-fits-all approach should not be applied for every agricultural endeavor. Chapter 7 delves into these factors in more detail. Furthermore, if a specific area (site) is being developed or used for agriculture, a site-specific study should be performed to determine the water demand rate and water storage, as well as to develop potential water management techniques.

Users of these water demand planning rates may refer to Table 130 to estimate the gallons of water that may be needed for a given area. For example, if the farmer allows the land to remain unplanted (non-irrigated) 50 percent of the time, the annual average water demand rate for planning purposes is 3,900 gpd/acre. If the land is planted and irrigated throughout the year, the annual average water demand for planning purposes is 7,800 gpd/acre. For irrigated pastures, the water demand rate is estimated to be 8,000 gpd/acre or higher and will be dependent on location, soil type, and climatic factors.

These water demand rates are for statewide planning for agricultural water demand. If a specific site is being studied, a site-specific water demand analysis should be completed. For aquaculture and wetland taro, the water demand rate will be dependent on the crop, technologies used, location, and farmer preference. Non-irrigation uses, such as pest control, will be dependent on the farming practices, crop, and pest control measures.

The water demand rates provided in this document are for farming and agricultural uses only, and do not apply to “gentleman farms.” The estimated rates reflect water demand at the farm meter for agricultural planning considerations, but do not reflect water source planning. To estimate a planning water demand rate at the source, a distribution system loss factor should be used. In the past, the distribution loss factor was based on an estimated distribution system loss of 50 percent or 65 percent,[36] and 50 percent in the 2004 AWUDP. If a 50 percent distribution loss was assumed and applied to the agricultural water demand rate of 3,900 gpd/acre at the farm meter, the corresponding source production (flow) rate estimate would be 7,800 gpd/acre. To better estimate source production requirements, further studies of water losses for the specific distribution and storage components should be performed for each agricultural water system.

Table 130
Agricultural Water Demand Planning Rates
(at the farm meter)

Description	**Water Demand (gpd/acre)**
Diversified agriculture (for usable acreage that is 50 percent planted)(average condition) (e.g. leafy vegetables and truck crops)	3,900
Diversified agriculture (for usable acreage that is 100 percent planted) (e.g. nursery, feed, and forage crops)	7,800
Diversified agriculture (for usable acreage that is 50 percent planted) under drought conditions or in dry areas	8,100
Diversified agriculture (for usable acreage that is 100 percent planted) under drought conditions or in dry areas	16,200
Irrigated pastures dependent on grass varietal, soil, and climatic conditions (for usable acreage that is 100 percent planted)	8,000
Aquaculture, taro, and other wet crops	Dependent on crop and location

[36] The Hawaiʻi Irrigation Authority used a range from 50 to 65 percent distribution loss in the computation of source planning for Waimānalo, 1956.

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CHAPTER 7
FACTORS AFFECTING AGRICULTURAL WATER DEMAND

Agriculture looks different today – our farmers are using GPS and you can monitor your irrigation systems over the internet.
Debbie Stabenow

Agricultural water demand for crops is determined by factors such as leaf coverage, soil type, and climate. However, government policies, market forces, and environmental factors also impact crop demand. The quantitative impacts from these factors are difficult to determine, and the significance of the impact is typically proportional to the intensity of the factor. Other factors impact water availability, such as government policies, climate, and development cost.

As some of the factors affect both water demand and water availability, this chapter is organized by categories. Section 7.1 discusses water use by crop type. Section 7.2 discusses increase in market demand, which relates to water demand, and section 7.3 discusses environmental factors. Section 7.4 discusses how government policies impact agriculture water availability and demand, and section 7.5 summarizes legal rulings by the CWRM and/or the State of Hawai‘i courts, which impact water rights, water availability, and management. Section 7.6 discusses other considerations for water demand during farm planning and design.

7.1 WATER USE FOR CROP TYPE

The survey shows a wide range of water demand due to climatic conditions, soil characteristics, and farmer preference. Table 131 presents a summary of statewide water demand by crop type and provides a comparison to the HDOA 2004 AWUDP water demand guidelines. The maximum water demand is important, as it provides an indication of water demand during the dry season. These maximum water demand rates may be useful in developing water demand for issues such as climate change, drought mitigation, and sustainability.

Similarly, the cultivation of wetland taro shows a high variability of water demand. A USGS report[37] on taro cultivation measured water temperature and water flow for 19 complexes on the islands of Kauaʻi, Oʻahu, Maui, and Hawaiʻi. The water measurements were taken during continuous flooding periods on mature crops, and therefore includes both consumptive and flow through water demand for taro. The wetland taro water demand by county is summarized in Table 132.

Table 131
Comparison between 2004 AWUDP
Water Use Guidelines and 2014 Farm Survey Results
(gpd/acre)

Commodity	2004 AWUDP	2014 Farm Survey		
		Average	Min.	Max.
Potted plants	6,000	21,411	94	87,432
Orchids	3,700	1,892	393	3,356
Vegetables	4,050-6,700	3,923	148	12,545
Taro dry	4,000-8,000	10,631	10,246	11,017
Field crops (including grains)	6,700-7,700	3,538	2	11,340
Banana	n/a	4,570	557	19,871
Anthuriums	n/a	1,869	0	6,809
Trees and fruit trees	n/a	3,039	9	15,747

Note: n/a - not available

[37] Gingerich, S.B., et. al., *Water Use in Wetland Kalo Cultivation in Hawaiʻi*, U.S. Geological Survey Open-File Report 2007-1157, 2007.

Table 132
Summary of Water Use Calculated for Lo‘i Complexes
(gallons/acre/day)

County	Average	Average Windward	Average Leeward
Kaua‘i	120,000	97,000	260,000
O‘ahu	310,000	380,000	44,000
Maui	230,000	230,000	Not available
Hawai‘i	710,000	710,000	Not available
All measurements	260,000	270,000	150,000

Reference: Gingerich, S.B., et. al., *Water Use in Wetland Kalo Cultivation in Hawai‘i*, U.S. Geological Survey Open-File Report 2007-1157, 2007.

7.2 INCREASED MARKET DEMAND

During the study, there were agricultural opportunities to increase production in several areas based on the consumer market. Two (2) of these opportunities may have a significant impact on water demand and are steps toward fulfilling the State’s policy of self-sufficiency.

The first opportunity is the growing interest in the cultivation of wetland taro, which will necessitate an increase in water demand, as taro is one of the highest water demand crops per acre. Another opportunity is the expanding market for grass-fed beef and locally finished meats. This opportunity also increases the need for grass pastureland, which requires water irrigation at approximately two (2) inches per acre per week, depending on climate, soil, and grass variety. Note that a unit of cattle will need to be sustained on grass for approximately 18 months, thus requiring stable irrigation to provide economic value for the rancher and to maintain the “grass-fed” label.

7.3 ENVIRONMENTAL FACTORS

Environmental factors, such as drought and climate change, impact agricultural water demand. Average water demand is based on a crop receiving typical average annual rainfall. As drought conditions and climate change alter rainfall events, there will ultimately be extended periods of no rainfall. During these zero (0) rainfall events, irrigation water must supply the total water need for the crop. In some areas, this water demand may exceed 8,000 gpd/acre. Rainfall frequency also impacts the water availability to the crop and aquifer recharge.

7.3.1 RAINFALL FREQUENCY

Irrigation cycles are dependent on rainfall events, but daily rainfall can vary in frequency and intensity, and is not indicative of the average monthly data reports. For example, two (2) rainfall event charts are presented for the Kunia Substation rainfall gauge on O‘ahu. The first chart, in Exhibit 36, presents the rainfall events of January 2011, and the second chart, in Exhibit 37, presents the rainfall events of January 2014. The monthly rainfall totals are about the same, as January 2011 had a total of 3.3 inches, and January 2014 had a total of 3.59 inches. This rainfall amount is equivalent to approximately 3,000 gpd/acre if distributed uniformly over the month.

In this example, although the total monthly rainfall is similar, 3.3 versus 3.59 inches, the number of “dry days” (less than 0.1 inches of rainfall)[38] in January 2011 is 26, compared to 18 in January 2014. Therefore, to provide consistent water to crops, the farmer would need to irrigate approximately 12 times in January 2011, compared to approximately seven (7) times in January 2014. For all crops, evenly distributed water supply (rainfall or irrigation) is conducive to optimal growth. For example, consider a crop such as lettuce:

> "*Fluctuations in soil moisture, especially during the later stages of development, are severely detrimental to optimal growth. Too much water during this period, along with high temperatures, may result in loose, puffy heads in heading types of lettuce. Too dry*

[38] Also, note that light rainfall events (less than 0.1 inches) are not effective, as the rain evaporates prior to being absorbed into the soil, thus rendering it unusable by the plant.

conditions during this period may induce premature bolting (forming flowers and seeds).”[39]

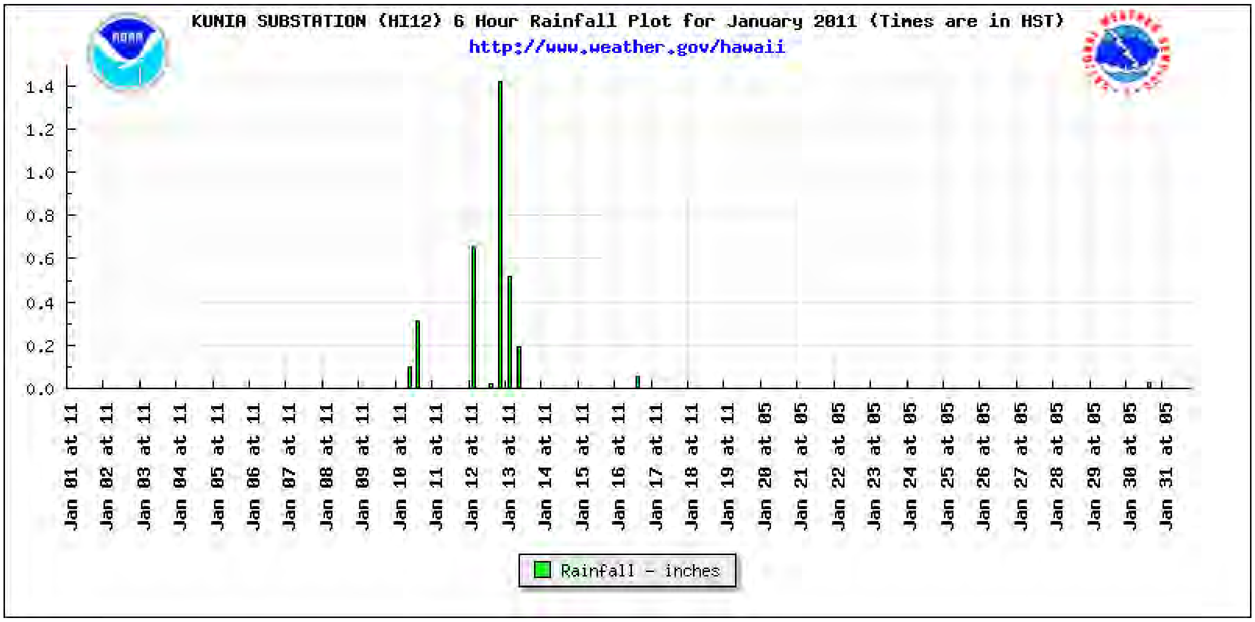

Exhibit 36. Rainfall Plot for January 2011, Kunia Substation (HI12), estimated rainfall total is 3.3 inches.

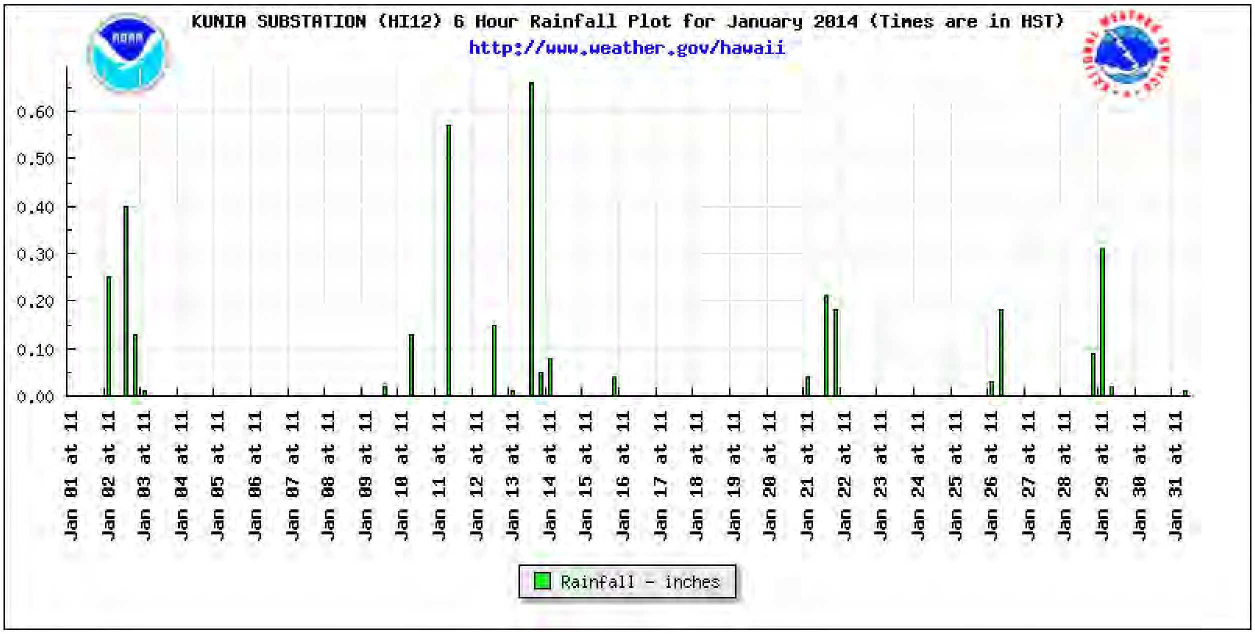

Exhibit 37. Rainfall Plot for January 2014, Kunia Substation (HI12), estimated rainfall total is 3.59 inches.

[39] University of Hawaiʻi, College of Tropical Agriculture and Human Resources, Farmer's Bookshelf - Lettuce, http://www.ctahr.hawaii.edu/fb/lettuce2/lettuce2.htm#Fertilizer.

7.3.2 DROUGHTS

Certain areas within the state have endured droughts with disastrous impacts to agricultural production. If agriculture is to survive, the availability of agricultural commodities in the market needs to be dependable. In addition, if the State's policies continue to trend toward sustainability and food security, the importance of available water during drought conditions is even more critical. A recent paper by Howitt, et.al., reported the economic impact of the 2015 drought in California, which had a direct cost to the California economy of approximately $1.8 billion and indirect economic impact of half that amount. Crop revenue losses were approximately 2.6 percent of total crop revenue, and about 45 percent of the land had turned idle or fallow.

In Hawaiʻi, drought impacts can be seen in the South Kohala and Kula regions of the state. In the South Kohala region of Hawaiʻi Island, a long drought between 2007 and 2008 reduced agricultural exports from this area. The number of cattle units shipped out of Kawaihae Harbor dropped from an average of 304 prior to 2007 to an average of 43 after 2008. In 2008, the number of cattle units exported through Kawaihae Harbor was zero. Similarly, the number of agricultural shipping containers[40] dropped from an average of 842 prior to 2007 to an average of 594 after 2008. The global recession of 2008 probably compounded the problem.

The impact on droughts on the Lower Kula agricultural area was documented in the 2011 *Kula Stormwater Reclamation Study.*[41] The lower Kula agricultural area generated an estimated net revenue of $2.1 million in 2003 from 215 farms on approximately 570 acres. The drought between 1998 and 1999 created a water restriction of 10 percent for a period of 20 months. Table 133 presents the estimated decrease in agricultural production due to water restrictions.

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[40] Agricultural containers are represented as twenty-foot container units (TEU) for statistical purposes.

[41] Mink and Yuen, Inc. & Associates, *Kula Stormwater Reclamation Study, Task 1, Existing Conditions Report*, Central Maui Soil and Water Conservation District and USDA Natural Resources Conservation District, September 2011.

Table 133
Estimated Agricultural Production Impacts Due To Ten Percent (10%) Water Restriction

Crop	Decrease Crops Planted	Decrease Acres Harvested	Decrease Pounds Harvested
Truck Crops	42%	31%	33%
Protea	Not available	16%	44%
Fruit	5%	13%	24%
Other	20%	3%	8%
Average	22%	16%	27%

Secondary impacts of drought include the establishment of hardier invasive plant species, such as the deadly fireweed. Fireweed invades weakened pastureland and displaces grazing grass. The fireweed is a poisonous plant. If consumed by cattle, it may be fatal. In addition, drought-stricken agricultural lands have little or no vegetation; therefore, erosion and runoff will occur during large rainfall events and pollute receiving waters such as the coastal ocean areas.

7.3.3 CLIMATE CHANGE

As the ongoing discussion on global warming and climate change continues, there is growing certainty that the amount and frequency of rainfall will change, along with temperature, carbon dioxide, and ozone levels. These factors will influence agriculture in different ways as a long-term global event. The effects of these changes will be felt within the planning period, but the magnitude and extent are under debate and study. Climate change has a high probability to impact crop production, crop species, and market availability.

Farmers and ranchers are keenly aware of the impacts of climate change and have significant insight into the impacts of climate change in the daily working of their crops. The impacts of climate change to the agricultural industry can be in form of, but not limited to, sea level rise, temperature change, carbon dioxide levels, intense rainfall, and drought.

The University of Hawai'i at Mānoa Sea Grant study[42] summarizes the changes in precipitation from historical records, showing a decrease in rainfall over the last century. Observations also show that rainfall intensity and frequency has changed, with O'ahu and Kaua'i exhibiting less intense rainfall events and Hawai'i Island more intense rainfall events. Maui has shown a mix of rainfall intensity. Other pertinent observations are that droughts in recent decades have longer duration, and prevailing northeasterly trade winds have decreased in frequency over the last 40 years.

Due to the global nature of climate change, taking a narrow view of how it affects Hawai'i would be incorrect. The health of Hawai'i's agricultural industry depends on a thriving export market, and disruptions in the supply chains, fluctuations of the global economy, wars, and natural disasters have impacted Hawai'i's exports.

Climate change will impact the global agricultural industry. Because Hawai'i imports approximately 85-95 percent of its food and other agricultural commodities, climate change will impact food availability and prices. Short- and long-term agricultural water demand planning should not readily assume there will always be an adequate supply of food or other agriculture commodities from other domestic and global agricultural producers to import.

Therefore, given the State's policy of food security, import replacement, and overall sustainability, water supply and storage capacity will need to be increased to maintain and increase crop productivity and economic stability for farmers. This also increases the need to develop water sources to maintain productivity during longer dry/drought conditions, as well as through loss of surface water sources. In addition, climate change may change crop types and agricultural growing areas.

Because the water situation will change as climate change progresses, two (2) issues have been raised. First, the change in intensity and duration of rainfall

[42] University of Hawai'i at Mānoa Sea Grant College Program, *Climate Change Impacts in Hawai'i - A summary of climate change and its impacts to Hawai'i's ecosystems and communities.* UNIHI-SEAGRANT-TT-12-04, June 2014.

needs to be accounted for by increasing water storage and upgrading distribution systems. Second, with increased drought, water demand for farms will increase to keep farm production at its current level, especially if the State's policies for a diversified agriculture industry, food security, and buying Hawaiʻi-grown products are to be met. Drought-level irrigation will increase the total water requirement of the crop, as stated in the water budget equations (normal rainfall + irrigation).

Aside from crop production, including livestock and aquaculture, the impact of climate change on the farm-to-market system is less clear. Current research is focused on crop production, but more research should be completed on:

- The supply and distribution chain;
- Farm inputs;
- Nutrition changes;
- Invasive species;
- Fisheries and aquaculture (marine and freshwater);
- Integration of non-food crops, other than agroforestry, into the analysis; and
- Mitigation options.

Recently the USDA[43] has been supporting and encouraging cover crops and has formed a new partnership with the organization, Farmers for Soil Health. The use of cover crops offers the farmers a climate mitigation strategy which will remove CO_2 from the atmosphere. In addition, cover crops make the soil healthier, increase water storage potential, and less vulnerable to wind and water erosion. The trade-off is an increase in water demand to grow the cover crop versus fallow land. Therefore, if cover crops are planted the agricultural water demand per acre will increase by as much as double, depending on the cover crop, soil and other factors.

[43] USDA, U.S. Agriculture Secretary Tom Vilsack Highlights Key Work in 2021 to Combat Climate Change, USDA Press Release 0014.22, 2022.

7.4 GOVERNMENT POLICIES THAT MAY AFFECT AGRICULTURE

In Hawai‘i, government policies impact funding availability, as well as the creation of new rules and regulations. At this point in time, the following policies may influence agricultural production: sustainability and self-sufficiency, and import replacement. As these policies affect the agricultural production, there may be an impact on the overall agricultural water demand.

7.4.1 SUSTAINABILITY AND SELF-SUFFICIENCY

Although the State has studied and developed policies toward self-sufficiency, Hawai‘i currently imports somewhere between 85 and 95 percent of its food, significant amounts of animal feed and fodder, and significant amounts of flowers and foliage. Although the goal of **self-sufficiency**[44] is considered worthy by some, it is seen as unachievable by others. On the other hand, some farmers do consider **sustainability**[45] as an achievable goal.

A good first step toward achieving statewide sustainability is to develop a sustainable agricultural industry, both in resources and economics. The current movement is focused on developing sustainable food production, which is only one sector of the agricultural industry.

To be considered sustainable, the product must be marketable, have good and consistent quality, be reasonably priced, provide profitability to the farmer, and have a dependable supply to meet consumer demand. Inconsistent local availability of commodities leads to a dependency on imports. If farmers are to be expected to provide quality and consistent commodities, they must have

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[44] **Self-sufficient** is the ability *to maintain oneself or itself without outside aid: capable of providing for one's own needs (a self–sufficient farm)* (http://www.merriam-webster.com/). Therefore, by definition, Hawai‘i would not be able to import or to export agricultural commodities to be 100 percent self-sufficient. More so, the example of a self-sufficient farm is somewhat of an oxymoron because farms are commercial entities that export (sell, barter, or trade) their commodities to off-farm consumers. In addition, other inputs, such as seed/plantlets, fertilizer, feed, research, water, energy, tools, etc., are needed to cultivate a crop or grow livestock, and to operate and maintain the farm.

[45] **Sustainability** is "of, relating to, or being a method of harvesting or using a resource so that the resource is not depleted or permanently damaged" *(*http://www.merriam-webster.com).

an adequate and stable water supply for their crops, especially during severe weather conditions.

In addition to water supply and market, other factors, such as labor, cost of other inputs, transportation, and market trends, affect the agricultural industry. In 2010, SMS[46] studied the beef industry as it relates to self-sufficiency. Of 59,000 head of cattle sold to market in 2008, 43,000 were shipped out of state. In addition, the study computed that an additional 337,500 acres of grass pasture would be required to wean and raise 30,000 head of cattle for local consumption. The key issues are:

- The need for sufficient acreages with adequate water to be drought-resistant and irrigated to accommodate calf-to-cow finishing, and to provide a reliable and constant supply to the Hawaiʻi market;
- Lower slaughter and processing costs, which requires greater economies of scale (constant supply), and newer slaughter and processing facilities;
- A larger market and cost-effective, reliable transportation between islands; and
- Sufficient demand for grass-fed, locally grown beef that will command a higher price.

In 2012, the State of Hawaiʻi published *Increased Food Security and Food Self-Sufficiency Strategy.*[47] The purpose of the strategy was to increase the amount of locally grown food consumed by Hawaiʻi residents. The definition of **food self-sufficiency** is: the extent to which Hawaiʻi satisfies its food needs from local production. The strategy is addressed to state agencies and programs due to their statewide scope and geographic coverage and meant to be a living document. The strategy has three (3) objectives:

- Increase demand for and access to locally grown foods;
- Increase production of locally grown foods; and
- Provide policy and organizational support to meet food self-sufficiency needs.

[46] SMS, *Increase Food Self Sufficiency Report*, February 2010.

[47] State of Hawaiʻi, Office of Planning, Department of Business Economic Development & Tourism, *Increased Food Security and Food Self-Sufficiency Strategy*, in cooperation with the State of Hawaiʻi, Department of Agriculture, 2012.

The study found the following self-sufficient facts as of 2012:

- Hawaiʻi is close to self-sufficiency in the production of watercress, Chinese cabbage, mustard cabbage, green onions, and Asian vegetables. Local farmers also supply 75 percent of tomatoes, sweet potatoes, cucumbers, and sweet corn. Most lettuce and other vegetables are imported.
- Fruits such as watermelon, papaya, pineapple, and banana are mostly Hawaiʻi grown. Significant amounts of other fruits are imported.
- Based on a 2007 report, 150 head of cattle are slaughtered weekly, accounting for about 6 percent of local consumption.
- Hogs and pigs grown in Hawaiʻi have been on a steady decline from 1970 to 2009.
- Hawaiʻi was self-sufficient in eggs in the 1970s with 240 egg farms; however, there are currently less than 100 egg farms operating in Hawaiʻi today.
- In the 1970s, Hawaiʻi was self-sufficient in milk with 120 milk operations, but currently there is only one (1) dairy operation.

The key will be to first make the agricultural industry economically sustainable. However, the recent cessation of sugar cane cultivation by HC&S on Maui and the closure of Hāmākua Springs on Hawaiʻi Island does not bode well for the future.

7.4.2 IMPORT REPLACEMENT

The theory of import replacement was discussed in 1953 (Philipp) to expand the output of Hawaiʻi's diversified agriculture industry. Philipp stated:

> ***A Challenge***
> *It is evident that many of Hawaiʻi's diversified agricultural industries show promise for expansion and that such expansion would materially strengthen Hawaiʻi's economy. To bring it about, men are needed with vision, enterprise, venture capital, and capacity for hard work.*
>
> *The expansion of the diversified agriculture of Hawaiʻi is a challenge to all the people of Hawaiʻi.*

The issues and improvements detailed by Philipp are similar to current issues. The key issues were as follows.

- Reduce Costs
    - Increase Labor Productivity
    - Better Management and Buying Practices
    - Larger Farms
    - Greater Diversification of Farms
    - Increase Functional Specialization on the Farm
    - Market Development
- Environmental Conditions
- Land and Water
    - Development of low-cost irrigation water
- Credit
- Research, Education, and Governmental Actions
- Agricultural Planning

In 2008, University of Hawai‘i, College of Tropical Agriculture and Human Resources (CTAHR), and the HDOA released a paper on improving Hawai‘i's food self-sufficiency.[48] It is noted that the importation of food allows for cheaper food costs and a greater variety of food. Although some are willing to pay more for Hawai‘i-grown products, higher prices are typically due to substantial “mark-ups” by wholesalers and retail outlets. The study recognizes that Hawai‘i will continue to import food, but there are benefits in purchasing and producing Hawai‘i-grown food such as:

- Supporting the local economy keeps money flowing through our community;
- Maintaining health, as the nutritional content of locally grown food is often higher, since many vegetables begin to lose their nutritional value after they are picked;

[48] Leung, Ping Sun and Matthew Loke, *Economic Impacts of Increasing Hawai‘i's Food Self-Sufficiency*, CTAHR Cooperative Extension Service, El-16, December 2008.

- Producing and buying Hawai‘i-grown products decreases the “food miles” involved in transporting food, thus reducing their carbon footprint; and
- Decreasing the risk of the importation of harmful invasive pests that could damage agriculture and natural resources.

The study concluded that doubling the consumption of Hawai‘i-grown food products based on 2005 statistics (approximately 15-20 percent) would generate farm-gate value of $119 million, which would translate to $238 million in sales and $8.7 million in state tax revenue. This forecast assumed that there were available resources and infrastructure to double production.

7.5 LEGAL RULINGS AFFECTING WATER

Navigating law, water rights, and management in Hawai‘i can be complex, expensive, and time consuming. Experience to date indicates that securing water rights for agriculture may often be beyond the means of individual farmers. Therefore, in addition to preserving and maintaining agricultural water infrastructure, a State commitment to assisting farmers in securing water for agricultural purposes through regulatory processes is essential for the preservation and protection of agriculture in Hawai‘i.

The law of water rights and management in Hawai‘i is set forth generally in the General Water Resource Management Principles and Policies section of the Water Resource Protection Plan, prepared and adopted by the CWRM, and will not be repeated here. Instead, this section discusses significant cases decided by the CWRM and/or Hawai‘i courts as they affect agriculture, as well as a few issues of especial relevance to agriculture.

7.5.1 MAJOR WATER CASES

Most of the contested cases before the Water Commission have entailed years of expensive litigation. Of the five (5) major cases discussed below, three (3) have directly involved water for agriculture. Two (2) of those three cases involved the last surviving sugar plantation in Hawai‘i and its shutdown in 2016. In the third case, owners of large tracts of agricultural land bore the litigation costs instead of their lessee-farmers. As the transition from large-scale mono-cropping to smaller-scale diversified farming continues in Hawai‘i, it is unlikely that individual farmers will have the ability to protect or obtain rights to water for agricultural endeavors through similar types of proceedings.

Waiāhole Ditch. For about 100 years, the Waiāhole Ditch system had been delivering water from streams in Windward Oʻahu or from dikes in the Koʻolau Mountains to irrigate sugar cane and other crops in Central and Leeward Oʻahu. In the early 1990s, Oʻahu Sugar Company, the last sugar plantation on Oʻahu, announced that it would cease operations. The announcement set in motion the first large contested case under the State Water Code (enacted in 1987), in which the Water Commission had the responsibility of balancing varying interests in water. Primarily, the conflict revolved around the potential for replacing sugar cane with diversified agriculture in Central and Leeward Oʻahu, which would rely on the continued use of the Waiāhole Ditch system versus restoration of streams in Windward Oʻahu.[49] The contested case took place as the transition from sugar to diversified agriculture was taking place, and the uncertainty about the availability of water affected the investments necessary for the transition and the speed with which the transition occurred.

The Waiāhole Ditch contested case involved more than a dozen parties, a lengthy initial hearing before CWRM, two (2) remand hearings, and three (3) appeals to Hawaiʻi appellate courts. The case combined processes for amending interim instream flow standards (IIFS) for four (4) Windward Oʻahu streams with applications for water use permits for users of Waiāhole Ditch water in Central and Leeward Oʻahu. Commenced in 1993, the case was finally concluded in 2010. Diversified farmers interested in farming the former sugar lands with water from Waiāhole Ditch included part-time vegetable and herb farmers on less than one (1)-acre plots, a 40-acre banana farm, highly professional growers of vegetable crops and landscape plants, and multinational seed companies. Most of these farmers, however, did not bear the costs of the contested case proceedings (which, conservatively, must have run into the millions of dollars); instead, the large landowners, interested in retaining the value of their lands for agriculture, bore most of the burden of the years of contested case proceedings. In the end, roughly 13 MGD was allocated for uses in Central and Leeward O’ahu, and roughly 16 MGD was restored to Windward streams.

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[49] Dike water in the Koʻolau Mountains, if not developed by the Waiāhole Ditch system, would feed Windward Oʻahu streams through seeps and springs.

Probably the most significant outcome of the Waiāhole Ditch case was the Hawai‘i Supreme Court’s articulation of the public trust doctrine and public trust uses of water. The public trust doctrine says that some resources are so important to public interest that no individual (person or company) can own it and do with it as the individual pleases. Instead, these resources are “owned” in common by all, and government must have the authority to make sure it is used for the public good. Only in very rare instances is the government allowed to abdicate this authority.

Furthermore, because of the importance of the resource to the public interest, the government has a duty to ensure that the resource will continue to be available for generations to come. On the other side of the argument:

> *“The water resources trust also encompasses a duty to promote the reasonable and beneficial use of water resources in order to maximize their social and economic benefit to the people of this state.”*

The concept of public trust “uses” recognizes some uses as being of such importance to public interest that the State gives special protection to water resources to ensure those interests are protected. In the Waiāhole Ditch case, the Hawai‘i Supreme Court identified (1) resource protection; (2) domestic uses; and (3) protection of traditional and customary native Hawaiian rights as purposes for having a water resources trust.

Significantly, the court did not identify agriculture as a public trust use. To the contrary, the court identified farming in Central and Leeward O‘ahu as “for private commercial gains,” which are not protected under the public trust. Notwithstanding being relegated to lower priority, there was sufficient water in the Waiāhole Ditch system to adequately provide for public trust uses and to meet the demands of agriculture. Today, diversified agriculture thrives on lands historically served by the Waiāhole Ditch.

Wai ‘Ola O Moloka‘i and Kukui (Moloka‘i) Cases. Two (2) water use permit contested cases from the island of Moloka‘i involved domestic uses of water for existing and planned housing and commercial developments. Although these cases did not involve agricultural use of water, at least two (2) significant rulings impact uses of water, including for agriculture.

One is that the Hawai‘i Supreme Court added a fourth public trust use, namely, reservations of water for the Department of Hawaiian Home Lands (DHHL). Any proposed use of water requires a demonstration that such use will not adversely impact DHHL’s need for water in the future.

Second, an applicant seeking an allocation of water has the burden of showing that the proposed withdrawal and use of water will not adversely affect traditional and customary Native Hawaiian rights. In meeting that burden, the applicant has the responsibility to discover what traditional and customary Native Hawaiian practices occur in the area, determine how those practices may be affected by the proposed withdrawal and use of water, and suggest mitigative measures to address negative impacts. When the applicant proposes the withdrawal of ground water, the impact on ground water discharge into the ocean, the consequent impact on the marine environment, and impact on traditional and customary Native Hawaiian gathering practices in the nearshore area must all be addressed.

Nā Wai ‘Ehā. Nā Wai ‘Ehā refers to the waters of the Waihe‘e River, North and South Waiehu, ‘Īao, and Waikapū Streams on the island of Maui. For nearly 150 years, the waters of Nā Wai ‘Ehā had been diverted and transported through a complex ditch system, primarily to irrigate sugar cane, but also for other agricultural purposes and domestic uses. Additionally, the four (4) ahupua‘a of Nā Wai ‘Ehā were an area of extensive lo‘i kalo and comprised the largest continuous area of wetland taro cultivation in the islands.

By 2004, when a petition was filed to amend the IIFS for the Nā Wai ‘Ehā streams, the sugar cane lands that had been cultivated by Wailuku Sugar Company had been transitioned to urban-type developments and some diversified agriculture. However, HC&S still depended on this ditch system to irrigate about 5,000 acres of its 35,000-acre plantation. While kalo and other crops were being grown on the extensive kuleana lots within the watershed, the cultural renaissance sparked growing interest in opening more lo‘i kalo and in restoring stream flows.

Unlike the Waiāhole Ditch case, where there was enough water to generally accommodate different interests, meeting demands for Nā Wai ‘Ehā water likely meant the reduction of existing uses and negatively impacting ongoing agricultural activities. This recognition that there would not be enough water to satisfy the various needs for water prompted the designation of Nā Wai ‘Ehā as the first surface water management area in the state, meaning that each and every entity desiring to use Nā Wai ‘Ehā water, whether the use had been ongoing for a century or more, or was proposed for a future project, had to apply for and obtain a water use permit issued by the Water Commission.

Before any surface water allocations could be made, the Water Commission had to first determine how much water would be available for off-stream uses. In other words, the Water Commission had to first decide on the IIFS for each of the Nā Wai ‘Ehā streams before considering the applications for allocations of water. The IIFS was determined through a contested case proceeding, which included five (5) parties and was held between 2007 and 2010.[50] The Water Commission’s decision, issued in 2010, was appealed and the Hawai‘i Supreme Court remanded the case to the Water Commission on several issues. Although remand proceedings commenced, the parties mediated a settlement, thus truncating the process on remand. The Water Commission approved and adopted the mediated settlement in April 2014.

Subsequently, the Water Commission has been grappling with scores of claims of appurtenant rights to, and for water use permits for existing uses of Nā Wai ‘Ehā water.

East Maui Irrigation System. The East Maui Irrigation System (EMI) is a highly complex ditch system that was constructed in phases between 1876 and 1923. It has continually served HC&S’s Maui plantation and currently irrigates approximately 30,000 acres of HC&S’s 35,000-acre plantation.

In 2001, Na Moku Aupuni o Ko‘olau Hui (Na Moku) filed a petition to amend the IIFS for 27 streams in East Maui. EMI operates diversions on 23 of those 27 streams. At the time the petition was filed, the EMI system had been primarily used for sugar cane irrigation.[51] In other words, unlike the Waiāhole Ditch and Nā Wai ‘Ehā situations, the request to amend the IIFS was not triggered by a transition in the use of lands or water.

[50] Other consolidated proceedings included water use permits for small amounts of water from ground water sources and a waste complaint. These, and an unsuccessful attempt at mediation, occurred between 2004 and 2007.

[51] The EMI system also provides water to the County of Maui for treatment for domestic potable uses and for its agricultural park.

Breaking from precedent set by the Waiāhole Ditch and Nā Wai ʻEhā cases, the Water Commission in 2008 and 2010 set new IIFS for 27 East Maui streams through public meetings, rather than contested case processes. In 2010, Na Moku petitioned for a contested case process to set the IIFS for these East Maui Streams. The petition was denied by the Water Commission on the basis that IIFS amendments were not subject to contested case proceedings, notwithstanding the fact that IIFS amendments for four (4) Windward Oʻahu streams and for the Nā Wai ʻEhā streams on Maui were established through contested cases. However, the Hawaiʻi appellate courts disagreed with the Water Commission, ruling that claimants of appurtenant or riparian rights to water, or those who claim that their traditional and customary Native Hawaiian rights may be affected by the IIFS decisions, had a right to have the IIFS determined through contested case proceedings. The CWRM Decision and Order on the IIFS was issued in June 2018.

7.5.2 WATER MANAGEMENT AREAS AND PERMITTING

Water rights and uses in Hawaiʻi are governed by the State Water Code, HRS Chapter 174C, and the common law. Water use is regulated by the Water Commission through a permit system in designated water management areas (WMA). Outside of WMAs, permits for water use are not required; however, extraction of the resource is regulated through well construction and pump installation permits (ground water), and stream channel alteration and stream diversion work permit (surface water).

HRS § 174C-41(a) explains the purpose of WMAs:

> ***"Designation of water management area.*** *(a) When it can be reasonably determined, after conducting scientific investigations and research, that the water resources in an area may be threatened by existing or proposed withdrawals or diversions of water, the commission shall designate the area for the purpose of establishing administrative control over the withdrawals and diversions of ground and surface waters in the area to ensure reasonable-beneficial use of the water resources in the public interest."*

In WMAs, any withdrawal, diversion, impoundment, or consumptive uses of water requires a water use permit (WUP) issued by CWRM (use of reclaimed wastewater is not governed by this provision). A permit must be obtained to continue uses of water that predated the designation of the WMA and before any new uses of water can occur. Obtaining a permit entails filing out an application that addresses several criteria.

Of significance to a farmer is the need to demonstrate that the amount of water being requested is reasonable and that the water will be used in an efficient manner. The CWRM utilizes the Irrigation Water Requirement Estimation Decision Support System (IWREDSS) developed by the University of Hawai‘i College of Tropical Agriculture and Human Resources to benchmark the reasonable amount of water required for the type of crop planned for cultivation in the particular location. If the amount of water requested deviates from (exceeds) the IWREDSS benchmark, the applicant will have to proffer an explanation. Also, if a less efficient method of irrigation is proposed (e.g., overhead sprinklers instead of drip), the applicant will probably have to explain why the less efficient method is appropriate.

The applicant for a WUP also must demonstrate that use of alternative sources of water is not practicable or not in the public interest. For example, if an applicant proposes to use surface (stream) water for irrigation, the alternative sources discussion may state that reclaimed water is not appropriate for the type of crop grown, that municipal sources or desalinization would be too expensive, and that public policy favors using non-potable surface water, instead of potable ground water, for irrigation purposes.

Over the past several years, some farmers have experienced unexpected challenges associated with permitting in WMAs that do not arise in non-designated areas. One issue has been the availability of “backup” water or a secondary source to meet agriculture water demand. In Hawai‘i, where surface water flows fluctuate greatly over very short periods of time, reliance solely on surface water for irrigation needs can be risky. A solution is to have a “backup” well to supply ground water (which is generally more expensive) as a supplemental source when surface water is inadequate. However, in WMAs, where the amount of water permitted for a particular agricultural use is tied to water duties for particular crops in particular locations, a “backup” allocation would have the appearance of far exceeding the reasonable amount of water required, even though, in actuality, the "backup" water would be used only in the event that the primary source is inadequate to meet the permit allocation amount.[52] This issue would not occur in a non-designated area, where the criteria for development of a backup well depends solely on availability of water at the well site and the mechanical characteristics of the well.

Applicants for WUPs have also had to address issues unrelated to the availability and protection of water resources. For example, in 2013, CWRM denied WUPS to two applicants requesting 6,000 gallons per day (0.006 MGD) and 8,000 gallons per day (0.008 MGD), respectively, for aquaculture purposes.[53] The applicants were asked three (3) questions: 1) what would be the impact of the brine (the byproduct of desalinization would impact the nearshore environment, even though the amounts were small); 2) whether aquaculture ponds attract invasive birds that interbreed with native ducks, and 3) whether the proposed withdrawal of water would impact traditional and customary Native Hawaiian gathering practices in the nearshore area. Because the applicants could not answer these questions, the WUP applications were denied. Had these aquaculture farmers been in non-designated areas, they would likely have to address these issues with other agencies, such as the Department of Health on the brine issue, and the U.S. Fish and Wildlife Service and Hawai‘i Department of Land and Natural Resources Forestry and Wildlife Division on the invasive bird issue. Unlike DLNR, these other regulatory agencies rely on their own expertise to advise on their decisions, whereas the Water Commission, in such areas, expects applicants to provide the expertise in order to obtain the WUP, even for small amounts, which adds to the financial burden of the farmers.

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[52] In 2012, the Water Commission failed to approve Monsanto's application for a backup ground water source for its Kunia, O'ahu, farm to be used in the event the Waiāhole Ditch system is unable to deliver Monsanto's allocated amount. Although ground water was available, the permit was denied on the basis that, "on the books," Monsanto would have a double allocation when the allocation of the ground water permit being requested was added to Monsanto's Waiāhole Ditch permit.

[53] WUP applications from Norman Rizk and Richard Foster for allocations of brackish water from the Kaluako‘i aquifer on Moloka‘i for aquaculture purposes.

7.5.3 INTERIM INSTREAM FLOW STANDARDS

An interim instream flow standard (IIFS)[54] is a determination made by CWRM as to how much water must flow in a stream at a particular location. It is possible that one stream may have more than one IIFS, e.g., *x* MGD measured at Location A and *y* MGD measured at Location B. The IIFS for a stream could change depending on different times of the year, or even different times of the day.

The IIFS for any particular stream is the result of an analysis by the Water Commission as to the water requirements for a variety of public interests, both instream (such as for stream biota, recreational uses, scenic and aesthetic values, and hydropower) and off stream (such as for taro cultivation, agricultural irrigation, and domestic and municipal uses). There is no formula to apply. Necessarily, the Water Commission will have to exercise its discretion and judgment in setting IIFS.

For most of the 376 perennial streams in the state, the current IIFS is the “status quo” as of a specific date (generally between 1988 and 1992). This status quo IIFS is “diversion-based,” in that it says that whatever diversions were in place at a particular date (effective date of the IIFS) could continue until either the IIFS was amended or the IIFS established.

Because most of the IIFS are diversion-based, any proposal to construct a new diversion or to modify an existing diversion to increase the amount of water diverted could trigger the need for an IIFS amendment.[55] The IIFS amendments to date, however, have been established pursuant to petitions filed by private entities. In all cases to date, IIFS amendments have been the subject of litigation conducted over periods of years.

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[54] The Water Code makes a distinction between instream flow standards (sometimes referred to as “permanent”) and interim instream flow standards, the former intended to be of a longer duration and, therefore, subject to a more extensive process for adoption. To date, however, every IIFS amendment has been subject to lengthy, fact-intensive proceedings, and no “permanent” IFS has yet been adopted for any Hawai‘i stream by the Water Commission. Therefore, the discussion in this section will refer to IIFS only.

[55] If the additional diversion amount is small relative to stream flows, an IIFS amendment may not be required.

New IIFS were established for Waiāhole, Waianu, Waikāne and Kahana Streams in Windward O‘ahu through the Waiāhole Ditch contested case. Some water was restored to each of those streams, and, in the case of Kahana Stream, the existing diversions were closed, thus restoring Kahana as an undiverted stream.

IIFS proceedings for ‘Īao, Waihe‘e, Waiehu, and Waikapū Streams — collectively known as Nā Wai ‘Ehā — were established in 2014 following settlement in a contested case proceeding. Some water was restored to each of the streams. In other words, less water is available for off stream uses under the 2014 IIFS. HC&S's January 2016 announcement that it would cease sugar cane cultivation and transition to diversified agriculture has triggered a reconsideration of the IIFS, but it is unlikely that more water would be made available for off stream users.

A petition was filed to amend the IIFS for 27 streams in East Maui. The Water Commission acted on the petition in two (2) phases, amending the IIFS for eight (8) streams in 2008, and the remaining 19 streams in 2010. Departing from the practice of amending IIFS through contested case proceedings, as was done in the Waiāhole Ditch and Nā Wai ‘Ehā cases, the commission utilized a process of obtaining data through staff research, stakeholder input, and public testimony. In 2010, Na Moku challenged this process, and the courts ruled that Na Moku had a right to have the IIFS determined through a contested case process. Therefore, the Water Commission’s 2008 and 2010 decisions have been vacated, and the IIFS for these East Maui streams are currently undergoing contested case proceedings.

7.5.4 APPURTENANT RIGHTS

Appurtenant rights are incidents of land ownership and are rights to the use of water utilized by parcels of land at the time of the original conversion into fee simple lands. The rights run with the land and are not personal. The measure of an appurtenant right is the amount of water utilized at the time of the Mahele, generally, but not exclusively, for taro cultivation. Once an appurtenant right is recognized and quantified, current use is not limited to its specific use at the time of the Mahele, but for uses on the parcel of land that are reasonable and beneficial.

In 1978, the Hawaiʻi State Constitution was amended by adding Article XI, section 7, which expressly protects appurtenant rights. The Constitution's protection of appurtenant rights is reflected in the 1987 State Water Code, HRS § 174C-63.

The CWRM has the legal authority to determine appurtenant rights pursuant to HRS § 174C-5(14). Until CWRM designated Nā Wai ʻEhā as a surface water management area, requests for determination of appurtenant rights have been rare. However, upon designation of the Nā Wai ʻEhā surface water management area, and the consequent requirement to obtain water use permits for use of Nā Wai ʻEhā water, approximately 100 appurtenant rights claims were filed for Nā Wai ʻEhā alone.

Proving the existence and the quantification of an appurtenant right to a parcel of land can be difficult. Documentation showing that the parcel, or a portion of the parcel, was being used as a residence or for cultivation at the time of the Mahele is essential, but oftentimes elusive. For example, documents often do not state what use was being made of the land at the time of the Mahele, but there may be circumstantial evidence, such as the existence of an ʻauwai running through the parcel. The appurtenant rights claimant may also have to prove that the right was not extinguished.

Common misunderstandings arise about the relationship of appurtenant rights and kalo cultivation. Although kalo cultivation of a parcel of land at the time of the Mahele may be the source of the appurtenant right, the water associated with that right can be used today for any reasonable, beneficial purpose. Conversely, cultivating kalo today, even in a traditional manner, does not create an appurtenant right where none existed for that parcel at the time of the Mahele.

Another misconception about appurtenant rights is that it is a Native Hawaiian water right. As noted above, appurtenant rights were attached to parcels of land and, unless extinguished, continue to be attached to the parcel, regardless of change in ownership. The landmark *McBryde* case (*McBryde Sugar Company, Ltd. v. Robinson*, 54 Haw. 174 1973) involved the quantification of appurtenant rights claimed by two (2) large sugar plantations on Kauaʻi.

A significant advantage of appurtenant rights is that the right is not lost due to nonuse and has some priority over other uses of water. For example, if a current owner chooses to start growing crops on a parcel of land that had not been cultivated for generations, but to which appurtenant rights are attached, the current owner should be able to obtain water for the parcel, even if it means that other cultivators in the area may have to reduce their water usage to accommodate the appurtenant right. Of course, this means that the farmer on a parcel of land without appurtenant rights to water faces insecurity that the amount of water being relied upon may be reduced by a late claim to appurtenant rights.

There is a distinction between an appurtenant right and the exercise of that right. The CWRM has the authority to determine whether an appurtenant right(s) attaches to a parcel of land and the amount of water that accompanies that right. How that right is exercised, however, is the responsibility of the right-holder. For example, water delivered through a ditch system (whether privately or government-owned) is not a right to use the delivery system. Use of the delivery system is generally through an agreement, whether formal or informal, between the right-holder and the operator of the system. If the operator of the system requires payment for use of the system, or decides to discontinue delivery, that dispute does not bear on the appurtenant right to water, and, generally, will not involve the CWRM.

Similarly, the existence of an appurtenant right does not automatically entitle the right-holder to divert water from the stream in exercise of that right without having first obtained the appropriate permit(s) for stream diversion works or stream channel alteration, both of which are administered by the CWRM.

7.6 PLANNING CONSIDERATIONS

The following topics were discussed during our interviews with farmers as important topics to be considered for agricultural water systems.

7.6.1 RELIABILITY

A reliable water supply throughout the year is necessary to provide a constant source of commodities to the marketplace, and to grow the agriculture industry. The water use will change as farmers change crops, planting regimes, and production volumes as the market changes, both locally and globally.

The use of monthly or annual rainfall averages does not provide accurate data to determine the water use per farm and will change yearly as rainfall and evapotranspiration changes per year.

Therefore, water reliability and backup systems need to be in place to assure farmers that the water requirements of their crops are to be met year-round, especially to promote increased sustainability for food and food security, but more so economic sustainability for the agriculture industry. Therefore, some of the larger farms have created back-up plans for water reliability by increasing storage, and/or having water supplies from different water systems. However, this increases the cost of production that will either be absorbed by the farmer or passed on to consumers of the commodity.

7.6.2 WATER PRESSURE AND FLOW

Water pressure is a key point in many systems. The design of the system must consider adequate water pressure requirements based on the irrigation systems used by the various farming operations. Ample water pressure is determined by farm layout, supply lines, and irrigation method (overhead, drip, flooding, etc.).

Water pressure is a concern in certain ditch and public water systems, especially those farms with long irrigation pipe networks. The issue is compounded as farmers water their crops simultaneously during the day. In one irrigation system, the private owner manages water demand by scheduling water irrigation times for each farm.

7.6.3 BEST MANAGEMENT PRACTICES

Water is also required for cover crops or alternative plantings. Although growing these crops increases water demand, it is deemed necessary as “best management practices” (BMP) for these lands. In addition to BMPs, the use of cover crops or mulch between planted rows minimizes weeds and conserves soil moisture.

Conservation tillage is any method of soil cultivation that leaves behind the previous year's crop residue (such as corn stalks or wheat stubble) before and after planting the next crop to reduce soil erosion and runoff. To provide these conservation benefits, at least 30 percent of the soil surface must be covered with residue after planting the next crop. Some conservation tillage methods forego traditional tillage entirely and leave 70 percent residue or more. Conservation tillage methods include no-till, strip-till, ridge-till, and mulch-till. Each method requires different types of specialized or modified equipment and adaptations in management.[56]

Some of the grain corn operators use technology to minimize their cultivation footprint. The use of global positioning satellite data allows companies to plant seeds in the same location over time. This practice minimizes the disruption of soil between planting rows.

7.6.4 OTHER WATER DEMAND

Agricultural water demand is typically focused on the irrigation aspects of farming. However, depending on the commodity, post-harvest processing can use as much as 30 percent of the total water demand. For certain commodities, farmers use agricultural water to eliminate or control pests, emulate growing habitats, and/or provide alternative growing conditions for commodities. For example, hydroponics and aquaponics, by their very nature, use water to create an environment for raising crops and aquatic life.

[56] http://www.mda.state.mn.us/protecting/conservation/practices/constillage.aspx. Accessed 2015.

The high-water demand of wetland taro, for example, is required to keep the plant's temperature below 80.6 degrees Fahrenheit or 27 degrees Celsius. Lower plant temperature inhibits the growth of viruses. Some studies even suggest 25 degrees Celsius would be more effective. Of the hundreds of thousands of gallons of water per acre per day used in wetland taro production, only a small percentage is used for irrigation.

For Certified Nursery growers on the Big Island, water is used for the post-harvest treatment for pests. As much as 20 percent of a farm's water demand is used to produce a clean commodity for market. For example, to mitigate the movement of coqui frogs from their Certified Nurseries, exported plants are doused with a hot-water treatment for 20-30 minutes. The hot-water treatment has a 100 percent (100%) efficacy rating for coqui frogs and can also be used effectively against other pests, such as slugs.

For seed companies planting Genetically Modified Crops (GMOs), water is used to "flush" fields after harvesting, promoting the growth of any corn seeds remaining in the fields. The USDA permit condition[57] to allow for these plantings is as follows: *mandatory fallow period in which irrigation is provided to allow for germination of volunteers*.

During this mandatory fallow period, these "volunteers" are destroyed by seed companies as part of their permit condition. The destruction of volunteers is necessary to maintain the purity of the next crop to be planted in that field.

Other uses of water for agriculture include, but are not limited to:

- Commodity preparation, cleaning, packaging, and processing (for example, one farmer interviewed uses 80,000-100,000 gallons per month, which is approximately 25-30 percent of the farm's irrigation requirements;
- Production area treatment (pest and disease control);
- Pre-shipment watering;
- Treatment of infested commodities;
- Pre-shipment treatment to remove pests;

[57] USDA permit to grow Genetically Modified Organisms, with Hawai'i Department of Agriculture concurrence.

- Cover crops to prevent soil erosion, replace nutrients, etc.;
- Worker requirements;
- Regulatory requirements; and
- Animal water requirements (animal husbandry).

7.6.5 SECONDARY SOURCE

As water is critical to the production of agricultural products, many water systems have backup plans to maintain water for crops in an emergency. These backup water sources may consist of wells, use of city/county water systems, and/or purchasing water from neighboring water systems. Most of these agricultural water systems rely on surface water diversions that will be the first to dry up in low rainfall periods. Therefore, as food security is a state goal, the development of long-term backup sources and/or long-term storage should be a priority.

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CHAPTER 8
FORECAST ANALYSIS

The goal of forecasting is not to predict the future but to tell you what you need to know to take meaningful action in the present.

Paul Saffo

This section develops an agricultural water demand forecast for the next five (5) years, as required by HRS 174, and a long-range (20-year) forecast, as recommended in the AWUDP Framework. To develop the forecast, the analysis included a review of the forecast in the 2004 AWUDP, analysis of the collected water use and farm data, and analysis of past agriculture statistics.

Section 8.1 provides a review of the 2004 AWUDP forecasts. Section 8.2 discusses land-based forecast modeling, and Section 8.3 discusses using a linear regression model for the forecast. Section 8.4 discusses the recommended water demand forecast, and Section 8.5 lists limitations and constraints of the forecast.

8.1 2004 AWUDP FORECAST

The 2004 AWUDP based the forecast on three (3) planning considerations as follows:

- Potential new diversified crops, including crops consumed by Hawai‘i's Asian market, other seed crops, and tropical specialty fruits;
- Niche markets and off-season market development, such as greens to Canada, local produce to local hotels during off-season months, aquaculture, and annual specialty events; and
- Import replacement crops that would focus on growing crops typically brought in from the continental United States or internationally.

To assess the land area needed within the planning period to increase agricultural production, the 2004 AWUDP analyzed three (3) factors: 1) annual population projections, 2) replacing imported fresh vegetables and fruits, and

3) maintaining past growth rates of farm values. The increased acreage was multiplied by 3,400 gpd/acre to determine the increased water demand. Table 134 summarizes the 2004 AWUDP results in five (5)-year increments.

Table 134
Island Summary of the 2004 AWUDP Forecasts
Additional Water Demand* (MGD)

County		Additional Acreage (acres)	Years 1-5	Years 6-10	Years 11-15	Years 16-20	Total
Kaua'i	Worst	3,545	3.27	2.80	2.89	3.09	12.05
	Best	14,198	13.15	11.20	11.55	12.36	48.27
O'ahu	Worst	2,226	2.08	1.75	1.80	1.93	7.57
	Best	8,939	8.43	7.00	7.23	7.73	30.39
Moloka'i	Worst	446	0.42	0.35	0.36	0.39	1.52
	Best	1,787	1.67	1.40	1.45	1.55	6.08
Maui**	Worst	891	0.84	0.70	0.72	0.77	3.03
	Best	3,544	3.29	2.80	2.89	3.09	12.05
Hawai'i	Worst	1,782	1.66	1.40	1.44	1.54	6.06
	Best	7,120	6.9	5.60	5.74	6.18	24.21
TOTAL	Worst	8,890	8.27	7.00	7.21	7.72	30.23
	Best	35,588	33.44	28.00	28.86	30.91	121.00

Notes: Worst Case - diversified agriculture would replace 10 to 20 percent of imported fruits and vegetables.
Best Case - diversified agriculture would replace 50 percent of imported fruits and vegetables.
* Based on water usage rate of 3,400 gpd/acre
** This does not include HC&S' 2016 decision to end sugar cultivation and transition to diversified agriculture. There will be an increase in diversified agriculture acreage but probably no increase in water demand.
Reference: 2004 Agricultural Water Use and Development Plan.

The population growth rate was based on DBEDT population forecasts and diversified agriculture historical growth rates obtained from the Hawai'i Agricultural Statistics (HASS). From 1982 to 2001, the 2004 AWUDP used an average growth for diversified agriculture between three (3) and five (5) percent annually.

To forecast the impact of replacing imported fruits and vegetables, two (2) scenarios were evaluated: 1) "Best case" and 2) "Worst case." The "best case" scenario was conservatively based upon the current percentage of the total market supply which could be met by local production. The analysis predicted the local production should be able to replace 40 percent of imported fruits and vegetables. For the "worst case" scenario, a review of studies by others on the growth of farming in the state showed that with status quo farming operations, local production would replace 10 to 20 percent of imported fruits and vegetables. Therefore, the analysis used the 10 percent growth rate to forecast future agricultural growth based on the replacement of imported fruits and vegetables. There was no analysis for other commodities, such as flowers, foliage, or meats.

8.1.1 DISCUSSION OF 2004 AWUDP FORECAST

According to the 2004 AWUDP, the increase in agriculture is not related to population growth, as Hawaiʻi imports 85 to 95 percent of commodities. In addition, industry growth is related to the national and global economy, as Hawaiʻi's agricultural industry exports many commodities. Therefore, a consideration in the 2004 AWUDP forecast was the import replacement program. Although this topic has been much discussed since 1950 or earlier, and has long been and continues to be a primary objective for agricultural growth in the state, there has not been significant growth in this area. A similar state objective is sustainability, which has lost ground since 1970. According to the 2012 State of Hawaiʻi Food Security study, Hawaiʻi has lost a significant portion of its dairy and egg production when compared to 1970.

One of the factors used in the 2004 forecasts was an agricultural growth rate between three (3) percent to five (5) percent. Using the methodology indicated in the 2004 AWUDP, the economic value of "diversified agriculture" shows an actual average annual growth rate of approximately 6.5 percent from 2000 to 2011. This is a slightly larger growth rate than the growth rate used in the 2004 AWUDP.

The economic impact of agriculture in local markets has not been studied comprehensively, but pricing data shows a demand for Hawaiʻi-grown products. A 2012 study for HDOA-Plant Quarantine Branch on import replacement showed that Hawaiʻi-grown commodities were marked up higher by retailers and wholesalers when compared to non-Hawaiʻi products.

The study found that wholesalers are buying Oʻahu-grown commodities at prices similar to those of imported commodities (free-on-board/freight-on-board (FOB) Honolulu). However, the study also shows that the markup by wholesalers and retailers are greater for Hawaiʻi-grown commodities (35 percent) versus the markup on imported commodities (27 percent). The study also concluded that the larger farms on Oʻahu have changed the market for diversified agriculture in the state, making Oʻahu more self-sufficient in produce items such as tomatoes, bananas, watermelons, etc.

8.2 LAND-BASED MODEL ANALYSIS

Historically, Hawaiʻi's sugar industry developed its agricultural water systems to irrigate land for agricultural production, sugar cane transport, and mill water. The water demand per acre was typically consistent if the crop was the same. At the peak of the monocrop industry in 1920, approximately 250,000 acres were in production, with an average diversion of 800 MGD of surface water and about 400 MGD of groundwater.

Therefore, traditional water demand forecasts were based on a water demand rate per acre multiplied by the number of acres of agricultural land. Over time, the amount of land used for agriculture decreased from 1,969,345 acres in 1987 to 1,926,971 in 2012, based on the agriculture-designated lands by the State of Hawaiʻi Land Use Commission.

A steeper decline in agriculture land area is shown in the USDA National Agricultural Service Statistics (NASS) census data provided in Table 135. The data shows a significant decrease in land used for crop cultivation, from 499,504 acres in 1959 to 174,042 acres in 2012. During this same period, the area of irrigated cropland decreased from 141,179 acres to 81,813 acres.

Table 135
Specific Agriculture Data from Census of Agriculture - Hawai‘i[58]
(land area in acres)

Year	Land in farms	Total Cropland	Harvest Cropland	Other (a) Cropland	Irrigated Cropland
1959	2,461,454	499,504	176,410	155,755	141,179
1982	1,957,501	346,113	155,960	156,596	145,982
1992	1,588,843	293,371	136,431	119,330	134,338
1997	1,439,071	292,107	100,094	150,179	76,971
2002	1,300,499	211,120	109,461	65,119	69,194
2007	1,121,329	177,626	103,120	51,013	58,635
2012	1,129,317	174,042	99,031	67,473	81,813

Note: a) Other Cropland includes land that have cover crops, soil-improvement grasses that are not harvested or pastured, crops that have failed, summer fallow croplands, or are idle.

Utilizing a land-based forecast, the NASS data shows a decrease in irrigated farmland, which translates to a decrease in total water demand. Assuming a water demand rate of 3,400 gpd/acre, the daily water demand would have been 278 MGD in 2012, compared to 480 MGD in 1959. In this model, the availability of water should not be an issue, as the amount of water required for irrigation of agricultural lands had dropped by about one-third (1/3) since sugar was king, and about one-half (1/2) since 1959. Past studies have reported water withdrawal quantities in the state to be as high as 1.2 billion to 1.9 billion gallons per day for surface and groundwater combined.

The correlation of land area to water demand is also complicated by the assumption that all crops have the same water demand, and one water demand rate is sufficient to compute the total agricultural water demand in the state. Based on the survey data from 2014, a correlation of water demand to land area was performed. The correlation coefficient[59] computation returns

[58] USDA, National Agricultural Statistics Services, "Census of Agriculture - State Data," various years

[59] Reference: https://support.office.com/en-us/article/CORREL-function-995DCEF7-0C0A-4BED-A3FB-239D7B68CA92

the correlation coefficient of the two number arrays and determines the relationship between two properties. In general, the closer the correlation coefficient is to one (1), the better the correlation between the two properties. The correlation coefficient of an array of x-values and an array of y-values is computed using the following equation.

$$Correl(X,Y) = \frac{\sum (x-\bar{x})(y-\bar{y})}{\sqrt{\sum (x-\bar{x})^2 \sum (y-\bar{y})^2}}$$

Where: $\bar{x}$ *and* $\bar{y}$ are the sample means for the array of x-values and the array of y-values, respectively.

Table 136 shows the correlation factor[60] between irrigation water demand to cultivated land area. The analysis shows fair to good correlation between irrigation water demand and land in areas growing crops with similar water demand rates, such as leafy vegetables. This correlation increases significantly for these farming areas if outlier data points are removed. In farming areas which have a diverse mix of crops, the correlation is poor to none.

The farm survey provided data on land use on the farm. Table 136 presents the percentage of the total farm area being used for cultivation at the time of the survey. There are numerous reasons for lower utilization of farmland for cultivation, such as, but not limited to, farm structures, access roads, unusable land such as steep slopes and rock outcrops, lack of water, lack of labor, market demand, crop rotation, and farmer preference. The areas that produce mainly vegetable and produce crops have an average cultivated area of 48 percent of the total parcel acreage, demonstrating the 50 percent crop rotation (planted area) land factor.

[60] The correlation factor shows the relationship or correlation between two properties. The closer the correlation factor is to 1, the closer the relationship is between the two properties.

Table 136
Correlation of Land Area to Water Use
(based on cultivated area)

Location	No. of Farms Used to Compute Correl. Factor	Average Cultivated Area / Total Area (all farms)	Correlation Factor (land area vs. water use)
Kula	7 of 9	29%	0.98
	9 of 9		0.74
Kaua‘i	7 of 7	41%	0.92
Pāhoa	12 of 15	80%	0.90
	15 of 15		0.67
Mililani	9 of 10	59%	0.90
	10 of 10		0.61
Kahuku	9 of 11	44%	0.89
	11 of 11		0.75
Moloka‘i	9 of 9	60%	0.88
Waimānalo	11 of 11	71%	0.16
Pana‘ewa	11 of 11	89%	0.05
Keāhole	10 of 10	75%	-0.19

Therefore, as there is a diversity of crops today, and crops may change to meet consumer demand or for economic reasons, the water demand computation by land area may not provide an adequate value for the overall agricultural water demand. Each agricultural water system will have a water demand rate based on the climate, soil, crop diversity, and farming techniques used by the individual famer.

In addition, the survey and NASS data shows that land should not be a limiting issue for the development of agriculture. The limited farm survey completed in 2014 showed that the cultivated acres in certain locations are at or below 50 percent of the total farm acreage. The NASS data shows a steady decrease in cropland since 1959. In addition, other forms of gardening and agriculture increase the growing acreages beyond traditional agricultural lands. These include aquaculture, greenhouse agriculture, rooftop gardens, vertical planting, and indoor agriculture.

One of the ongoing issues regarding production and water use on agricultural lands is the so-called “gentleman farms” that take advantage of agricultural water rates and reduced fees and taxes but do not add or have limited value to the farm gate value. The study did not attempt to classify these gentleman farms, as the acreages per farm are usually small (2 acres or less) and beyond the scope of this study.

8.3 LINEAR REGRESSION MODEL ANALYSIS

The regression model forecasts are based on the NASS economic data to determine future agricultural industry trends. A linear regression analysis based on historical agriculture farm gate values is shown on Table 137. The linear regression was computed using three (3) ranges of historical data, and three different trend lines emerged. The three (3) ranges of historical data were as follows: 1) from 1978 to 2012; 2) from 1992 to 2012; and 3) from 1997 to 2012. It was assumed that 1) the growth of production is related to economic forecasts; 2) the increase in production will translate to an increase in the number of acres in active cultivation, thus increasing water demand; and 3) land availability is not a constraint, although for the individual agricultural water systems, land may be a growth constraint.

When using the statistics, it is important to note that the pineapple industry was listed as a separate sector and not included in the diversified agriculture statistics prior to 2007. As the pineapple industry has diminished, the pineapple industry value was included into the “diversified agriculture” totals in 2007. Therefore, it caused a step function increase in the diversified agricultural statistics.

The three (3) forecasts are shown on Exhibit 38, based on three (3) different trend years: 1) using the data from 1978 to 2012 results in an average annual future growth rate of 0.5 percent per year; 2) using the data from 1992 to 2012 results in a future growth rate of 1.2 percent a year; and 3) using the data from 1997 to 2012 results in a future growth rate of 1.2 percent per year. The average growth rate of the three (3) scenarios is 0.6 percent. The 1978-2012 data set analysis takes a longer view of the historical trend in Hawai‘i's agriculture, in a modern-day setting. The 1992-2012 data set starts at a time when agriculture was declining, with most of the sugar mills closed and the pineapple industry winding down.

Table 137
NASS Farm-Gate Value Statistics

YEAR	VALUE	PERCENT CHANGE
1978	$419,251,000	--
1982	$558,608,000	33.24%
1987	$609,740,000	9.15%
1992	$552,054,000	-9.46%
1997	$496,935,000	-9.98%
2002	$533,423,000	7.34%
2007	$513,626,000	-3.71%
2012	$661,347,000	28.76%

The 1997-2012 data set uses a low point in the agriculture value as the starting point, thus providing a higher trend line and reflecting the growth of the diversified agriculture industry.

As the agriculture industry grows, the secondary or trickle-down effect would be approximately two (2) billion to three (3) billion dollars to Hawai‘i’s economy. The 68-sector 2005 Hawai‘i State Input-Output Model provides a tool to estimate the potential economy-wide impacts for agricultural growth. Based on the model, an increase in $1 of farm-gate value would generate $2.06 in sales, $0.54 in earnings, and $0.078 in state tax revenue.[61] The model also estimates that for every million dollars of farm-gate sales, approximately 25 new jobs will be created.

[61] ibid (Ping Sun and Loke, Matthew, 2008)

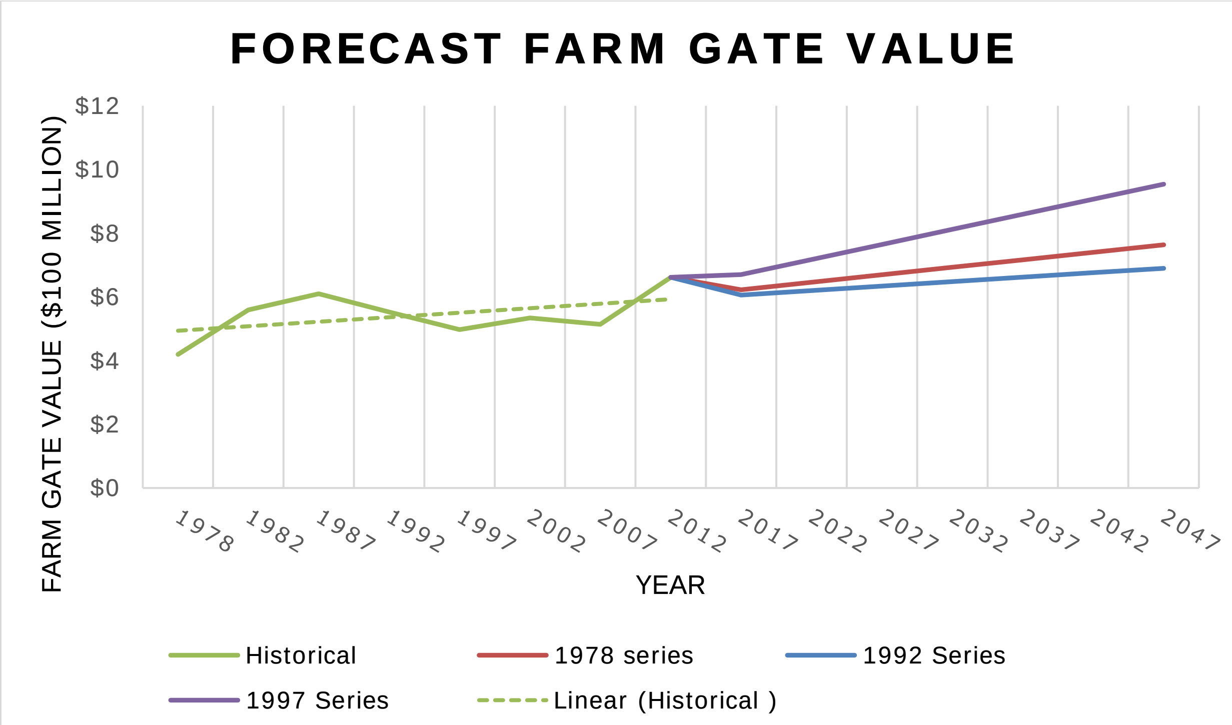

Exhibit 38. NASS Farm Values-Based Economic Forecasts

8.4 RECOMMENDED AGRICULTURAL WATER FORECAST

One of the goals for this AWUDP is to ensure the agriculture water infrastructure has the capacity to support the growth of diversified agriculture. Therefore, the recommended forecasts are developed to support these goals. The economic value of the agricultural systems is highlighted in a report of the Wahiawā Irrigation system (2008). The report states that the area serviced in the Poamoho, Hale‘iwa and Waialua areas had an estimated farm-gate value of $37.7 million in 2007. The estimated total impact, both direct and indirect, was computed to be $85.2 million dollars for the same year. These economic values were based on 6,400 acres of agricultural lands, of which 55 percent are under cultivation. The report also indicated that additional water supply may allow increased use of the remaining 45 percent of fallow leased lands (6,400 acres). In addition, portions of the 1,715 acres of land currently not leased could be under production if tenants and water were available.

The potential for increased production from an agricultural water system is provided in the report by Mink and Yuen for the Lower Kula Water system.

The report surveyed farmers in the Lower Kula area to assess the potential of greater productivity if water supply was increased and reliable. The results of the survey are shown in Table 138.

Table 138
Estimated Potential for Increased Production
Increased Water Supply and Reliability
Lower Kula (2003)[62]

Crop	Would Grow Additional Acres of Same Crop	Would Grow Acres of New Crop	Would Expect Higher Yields
Truck	79%	75%	88%
Protea	46%	23%	77%
Fruit	20%	36%	71%
Other	33%	33%	72%
Average	45%	42%	77%

8.4.1 POTENTIAL LAND USE

Based on the analyses of agricultural water systems, the agricultural land use for each system was computed and is summarized in Tables 139 to 142. The tables present the amount of land used for field crops, other crops, and grazing. "Other crops" include all diversified agricultural crops, such as vegetables and truck crops, which are not considered field crops or grazing. In addition, the potential area available for increased farming activity is based on an analysis of the land use within the service area, as well as discussions with water system managers. The potential agricultural areas do not include areas that would require a new agricultural water system.

The 2004 AWUDP estimated the amount of unused agricultural lands in the 13 studied systems to be 35,588 acres, or approximately 40 percent of the total acreage of the 13 systems. This study shows that there are approximately

[62] Mink and Yuen, Inc. & Associates, *Kula Stormwater Reclamation Study, Task 1, Existing Conditions Report*, September 2011.

29,870 acres available for agriculture, however, some of the systems did not report available agricultural lands. Based on the GIS and the inventory studies, there is approximately 114,360 acres of the total service area not used for agriculture. However, these unused areas include unusable lands, such as roadways, gullies, etc. If a factor of 40 percent (similar to the 2004 AWUDP) is used, the estimated available land area is 45,744 acres.

Table 139
Agricultural Land Use by System, Kaua'i County

Irrigation System	Field Crops (acres)	Other Crops (acres)	Total Cultivated (acres)	Grazing (acres)	Total Active (acres)	Available Land (acres)
Kaloko	0	61	61	945	1,006	---
Stone Dam	0	8	8	51	59	---
Kalihiwai	184	189	373	10	383	245
Anahola	107	409	516	2,039	2,555	1,454
Upper and Lower Līhu'e	229	608	837	1,636	2,473	---
Upper and Lower Ha'ikū	205	591	797	2,142	2,939	---
Waiahi-Kuia Aq. and Kōloa-Wilcox	889	1,501	2,390	2,871	5,601	---
Olokele	7,472	934	8,406	1,385	9,791	---
East Kaua'i	---	---	1,530	4,380	5,910	---
Kaua'i Coffee	---	---	3,900	490	4,390	2,319
Kekaha	6,517	---	6,517	0	6,617	2,626
Kōke'e	---	---	---	1,192	1,192	992
TOTAL			25,335	17,141	42,916	7,636

Table 140
Agricultural Land Use by System, Oʻahu

Irrigation System	Field Crops (acres)	Other Crops (acres)	Total Cultivated (acres)	Grazing (acres)	Total Active (acres)	Available Land (acres)
Oʻahu Ditch	4,602	4,313	8,915	1,590	10,505	4,595
Opaeʻula and Kamananui	158	1,575	1,733	2,719	4,452	---
Former Galbraith Lands	0	993	993	0	993	0
Kahuku (HDOA portion)	0	198	198	0	198	0
Waimānalo	---	---	810	110	920	470
Waiāhole	---	---	4,000	---	4,000	3,290
TOTAL			16,649	4,419	21,068	8,355

Table 141
Agricultural Land Use by System, Maui County

Irrigation System	Field Crops (acres)	Other Crops (acres)	Total Cultivated (acres)	Grazing (acres)	Total Active (acres)	Available Land (acres)
Upper Kula	---	---	400	250	650	420
Lower Kula	---	---	1,252	---	---	1,253
East Maui	---	---				---
West Maui/Pioneer	---	---	6,320	---	6,320	2,610
Molokaʻi	---	---	2,670	680	3,350	6,382
TOTAL			10,642	930	10,320	10,665

Table 142
Agricultural Land Use by System, Hawai'i County

Irrigation System	Field Crops (acres)	Other Crops (acres)	Total Cultivated (acres)	Grazing (acres)	Total Active (acres)	Available Land (acres)
Ka'ū	6,353	1,850	8,203	28,087	36,290	---
Kohala	0	1,064	1,064	4,823	5,884	---
Kehena	0	7	7	9,178	9,185	---
Lower Hāmākua	---	---	310	3,670	3,950	1,714
Waimea (Upper Hāmākua)	---	---	740	570	1,310	1,000
TOTAL			10,324	46,328	56,619	2,714

8.4.2 RECOMMENDED FORECAST FOR AWUDP UPDATE

Due to Hawai'i's dependency on an aging water infrastructure, future agricultural production will depend on the operational capacity of these water systems. Therefore, the AWUDP updated forecasts are based on three (3) forecast scenarios of the ability of the water system to deliver water and capture currently untapped agricultural lands for cultivation. The three (3) forecast scenarios are 1) no action, 2) maintained water systems, and 3) large capital investment.

For the maintained and large capital investment scenarios, an agricultural growth rate of 0.6 percent per year is assumed. Unfortunately, a lack of agricultural statistics hampers the development of an accurate baseline for agricultural water demand in 2015. Therefore, a computed baseline was prepared based on available irrigation system data and spatial analysis from irrigation systems. For irrigation systems without reported flow, the baseline was computed using a water demand rate for the crops. In this calculation, water demand rate for field crops was 7,800 gpd/acre, and diversified crops were 3,900 gpd/acre (assuming field rotation). The computed baseline for water at the source is based on 50 percent system loss. The estimated forecast for the next 20 years is presented in Table 143.

The forecast demand is provided by county (Table 144). As this is a planning-level baseline, the following assumptions were used for the three (3) scenarios. In addition, water demand for East Maui and Wailuku irrigation systems are not included due to recent legal proceedings and business decisions. All forecasts are unconstrained and assume that new sources/intakes will be developed when needed and includes total active and available land acreages from each of the counties in the preceding tables.

8.4.2.1 No-Action Scenario

The agricultural water systems will continue to age and deteriorate unless action is taken. Over time, the systems will become unusable and prone to catastrophic failures. There are examples of how neglected systems have deteriorated and been abandoned, such as the Lower Anahola ditch system. Revitalizing such deteriorated systems would be challenging and costly, especially when compared to a system that has been regularly maintained. In this scenario, no resources are used to maintain or rehabilitate the systems.

Table 143
Water Demand Forecast at Source
(MGD)

	FORECAST		
	2020	**2025**	**2035**
Statewide (Estimated 2015 baseline demand 651 MGD)			
No Action	488	326	0
Maintained	672	693	734
Increased Investment	956	1,027	1,170

Table 144
County Water Demand Forecast at Source
(MGD)

	FORECAST		
	2020	**2025**	**2035**
KAUA'I COUNTY (Estimated 2015 baseline base demand – 250 MGD)			
No Action**	187	112	0
Maintained	257	265	281
Increased Investment	319	329	349
HONOLULU COUNTY (Estimated 2015 baseline demand -145 MGD)			
No Action**	109	73	0
Maintained	150	154	163
Increased Investment	215	219	229
MAUI COUNTY* (Estimated 2015 baseline demand – 116 MGD)			
No Action**	87	58	0
Maintained	119	123	130
Increased Investment	203	206	214
HAWAI'I COUNTY (Estimated 2015 baseline demand – 141 MGD)			
No Action**	106	71	0
Maintained	146	150	159
Increased Investment	219	273	379

Note: * Maui County does not include HC&S and West Maui Irrigation systems
** No Action is based on a linear decay, actual failure is unpredictable

Therefore, under the no-action scenario, the future water flow reduces to zero (0) during the planning period. Table 143 shows the zero (0) flow condition statewide, and Table 144 shows the zero (0) water flow by county. Agricultural production will decrease significantly and be dependent on available rainfall to maintain crop viability.

The loss of agricultural production due to the failure of agricultural water systems will be detrimental to the industry, and that impact is compounded with the loss of HC&S and Hāmākua Springs. This loss will have a significant impact on the state's economy and socioeconomic factors. The state's goals for food security, diversified agriculture, and import replacement would not be realized. In addition, the potential environmental impacts would include an increase in fallow lands that leads to increased runoff into the ocean and onto reefs, and an increase in fugitive dust; changes to the aquifers benefiting from agricultural irrigation; and higher probability of increased urbanization of agricultural lands.

8.4.2.2 Maintained Water System Scenario

In the **maintained water system scenario**, funding is invested into water systems to maintain current flow rates and system capacities. In this scenario, the systems which are currently water limited will not be able to increase production, as water quantity cannot be increased. The systems which have surplus agricultural lands and sufficient water supply will be able to increase agricultural production until their water capacity is reached.

In this scenario, the agricultural farm gate value growth will follow the forecast growth trends based on historical data (Section 8.3) of less than one percent (1%) per year. Therefore, the corresponding agricultural water demand will slowly increase to approximately 734 MGD, as shown on Table 143. In addition to minimal growth in diversified agriculture and continuing deterioration of the system, the long-term concerns are as follows:

- Increased maintenance costs to provide consistent flow and labor costs;
- Inadequate water storage for long-term droughts;
- Systems will continue to deteriorate, and larger projects and increased funding may be needed in the long term;
- Need for additional water sources is required due to lack of rainfall (drought conditions) and climate change; and
- The current system distribution losses (non-revenue water) will remain or worsen.

8.4.2.3 Large Capital Investment Scenario

In the **large capital investment scenario**, the State of Hawai'i and private owners fund improvements to the public and private irrigation systems. The funding will improve the agricultural water systems beyond the 20-year forecast period. As stated by a system manager, "*We would like the system to last another 100 years*."

The forecasts shown in Table 143 show a slight growth rate in the first five years as the systems are being renovated (planning, design, and construction). Those systems with smaller projects may increase water demand and production in the latter part of the first five-year period. Those systems with larger projects and the new water system will be completed within the second five years or in the future. The significant increase in water availability will allow for increased water demand and agricultural production in available agricultural lands within the systems and the new systems proposed to be developed. In the latter portion of the forecast (15 to 20 years), the growth rate will slow as additional lands are occupied and will follow the historical growth rates for the industry.

The "Increased Investment" scenario incorporates the increase of grass-fed beef production and increases land area for this purpose. For the cattle industry, increased water supply may allow for 1) increased acreage for "finish grazing" or irrigated (managed) pastures to increase production of grass-fed beef[63], and/or 2) increased feed production if system owners are willing to open current non-irrigated land areas identified to feed and crop production. Based on the anticipated increase in water supply in the agricultural systems, the twenty-year forecast is shown on Table 143 as approximately 1,170 MGD.

The large influx of funds will provide for reliable water delivery to the farms, as well as a higher probability to increase agricultural production within the agriculture water system's service area. The increase in production may be as high as double the current production value in a few systems. To allow this potential to be realized, the funding would improve the system components in several ways:

[63] This forecast was not intended to meet the full requirement of grass-fed beef.

- Construction of the short-term (first five years) projects to address overdue maintenance issues, and in some cases long-term solutions to current issues;
- Increase of water storage capacity; and
- Increase water intakes and water sources.

The 1,170 MGD is an unconstrained agricultural water demand and based on increased grass-fed beef and diversified agricultural crops within the existing and new water systems. Historical reports on agriculture water demand indicates that the sugar industry used surface and groundwater between 1,200 MGD to 1,900 MGD. Due to the new policies, rules and regulations, and water-demand decisions, the 1,170 MGD agricultural water demand may not be achievable.

8.5 LIMITATIONS AND CONSTRAINTS

The change in the growth scenario will be impacted by the growth of diversified agriculture and other farming factors such as availability of labor, new pests and diseases, costs of producing commodities that compete with mainland import prices, costs for fertilizer, increased regulations, encroachment by non-agriculture uses, and increased environmental pressures.

The forecasts provide a guide to water demand, as the actual demand varies based on farmer practices, soil type, crop type, intensification, diversity, climate, politics, transportation costs, fuel and energy costs, market variability, consumer demand, etc. Due to the lack of accurate flow readings, the forecast is based on an estimated planning level baseline. As stated above, system owners and operators should analyze their systems to provide a more accurate forecast of agricultural water demand.

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CHAPTER 9
DEVELOPMENT PLAN

It is recommended that in order to encourage the expansion of diversified farming in the interest of the State's economy, the Legislature give consideration to some form of subsidization for irrigation projects where financial help is needed. Existing statutes require repayment of principal and interest for capital costs of construction which, in some instances, may make the cost of irrigation water too high for economic farming.
Hawai‘i Water Authority

The HRS 174C requires the inclusion of a master irrigation inventory plan. Two (2) of the required elements of the master irrigation inventory plan are 1) a five (5)-year program to repair the systems, and 2) a long-range plan to manage the systems. To fulfil these elements, a development plan is presented which acts as a roadmap for addressing agricultural irrigation infrastructure maintenance and provides an impetus to discuss future management strategies for each system.

These elements are vital for the current maintenance of the agricultural water systems, as well as their envisioned future use and potential expansion. As many of Hawai‘i’s agricultural water systems have been in use for nearly a century, their continued operation is the goal of system managers. However, many of these systems have not been continuously maintained throughout their transition from plantation agriculture to diversified agriculture. Therefore, the systems require major maintenance projects to remove overgrowth, repair components, rebuild intakes, and reestablish user access. In addition, the current rules and regulations for reservoirs, dams, and in-stream flow have significantly altered many systems’ water storage capacity and supply. These new rules and regulations affect the amount of water supplied to the farms, especially during drought conditions, and may impede the rehabilitation or growth of the affected system.

This Chapter presents:

- Section 9.1 the five (5)-year (short-term) CIP cost by county;
- Section 9.2 the potential management strategies; and
- Section 9.3 funding options.

9.1 FIVE-YEAR CAPITAL IMPROVEMENT PROGRAM

The five (5)-year (short-term) CIP is comprised of projects identified during the inventory assessment for the individual water systems.[64] Most of the CIP consist of urgent projects to maintain or increase water to agricultural users. The CIP cost beyond five (5) years were difficult to determine or will be determined based on the preliminary engineering and/or planning studies proposed in the short-term.

The short-term CIP is described in detail in the analysis for each agricultural water system, and Tables 145 to 149 provide summaries of the CIP cost. Table 145 summarizes the statewide CIP cost of approximately $168 million (one hundred sixty-eight million dollars) for the inventoried systems. Tables 146 to 149 summarize the CIP costs for short-term improvements for each system by county. The projects range from feasibility studies for two (2) new systems on Hawai‘i to upgrading open-ditch systems to new pipeline networks.

Table 145
Statewide CIP Summary by County
(2018 dollars)

COUNTY	2018-2023
KAUA‘I	$45,010,000
HONOLULU (O‘AHU)	$39,185,000
MAUI	$53,800,000
HAWAI‘I	$29,475,000
TOTAL	**$167,470,000**

[64] The CIP was determined with the assistance of the system managers and/or owners. Capital improvements are funded by the owners. Typically, government owned systems are funded by public funds and privately owned systems are funded by private funds.

Table 146
CIP Summary for Kaua‘i County Irrigation Systems
(2018 dollars)

System	2018-2023
Kalihiwai System	$220,000
Anahola DHHL System	$13,600,000
Kōloa-Wilcox Ditch (Lāwa‘i (A&B) Portion)	$1,350,000
East Kaua‘i System	$19,240,000
Kekaha/Kōke‘e	$11,000,000

Table 147
CIP Summary for O‘ahu Irrigation Systems
(2018 dollars)

Project	2018-2023
O‘ahu Ditch (Wahiawā, O‘ahu, Ito, and Helemano)	$8,360,000
Kahuku Irrigation System	$4,370,000
Galbraith Lands System	$17,000,000
Waiāhole Irrigation System	$5,730,000
Waimānalo	$4,800,000

Table 148
CIP Summary for Maui County Irrigation Systems
(2018 dollars)

Project	2018-2023
Upcountry Maui	$200,000
Moloka‘i	$9,160,000
Planning and preliminary design for New Lower Kula Irrigation System	$45,000,000

Table 149
CIP Summary for Hawai‘i County Irrigation Systems
(2018 dollars)

Project	2018-2023
Kehana Ditch	$7,250,000
Waimea Irrigation System	$6,700,000
Lower Hāmākua Ditch	$ 6,150,000
Planning study for new irrigation system(s) in South Kohala and Kawaihae area	$1,500,000
Planning study(s) for new irrigation system for Ahualoa, Waimea, and Lālāmilo areas	$1,500,000

9.2 LONG-RANGE PLAN FOR SYSTEM MANAGEMENT

Currently, the existing management of the state’s agricultural water systems is provided by various entities, depending on each system’s ownership. The HDOA-ARMD manages state-owned systems, with CIP funding provided by state bond funds and operational and management fees collected for water use. The ADC oversees and assists in the management of water systems which are transitioning from the plantation era to diversified agriculture. These systems are managed by ADC or private entities, and funding derives from state funds, private funds, and fees collected for water use. The private water systems are owned and managed by private owner(s).

The intent of this section is to propose strategies, ideas, etc. for consideration in the management of the irrigation system. It is not the intent of this section to determine or modify the management style, organization, etc. for each system. During the inventory and interview considerations, programs which have been implemented or are being pursued by others, or long-range CIP projects were discussed. The following section briefly presents these suggestions and programs by stakeholders for long-range plans.

9.2.1 CONSIDERATIONS

The following considerations presented themselves during the interview and inventory process.

- These water systems are currently a century old. Their age tends to increase operational and maintenance costs and require major improvements to extend lifespan. These improvements are seen in the five (5)-year development plan and shown in the water forecasts.

- The water systems were designed for monocrops such as sugar and pineapple, which may have longer maturation times and water requirements than other crops. Depending on the variety, sugar cane matures between 12 to 24 months, and pineapple fruits in approximately 18 months. On the other hand, diversified agriculture crops, such as leafy greens, mature between two (2) to four (4) months.

- During the plantation era, water resources were adequate for plantation needs and uses. However, in today's regulatory environment, there are limits to the amount of water available for agriculture.

- Honolulu Board of Water Supply rates governing the use of potable water are increasing. For example, if a farmer uses 7,000 gallons per acre per day, by 2023 the farmer's water rate may increase approximately $66 per month per acre from 2018.

- State of Hawaiʻi's goals, which require an increase in agricultural production, crop diversity, and economics, include:

    - Diversifying the economy;
    - Sustainability and self-sufficiency; and
    - Support of diversified agriculture.

9.2.2 LONG-RANGE DEVELOPMENT PLAN PROJECTS

The following are suggested projects which may help system owners and managers oversee and best use their limited resources. These are considered long-range programs, but the programs can be implemented as necessary by the system owner at any time.

Additional CIP Projects. The short-term projects included feasibility and/or preliminary engineering for new water systems in Lower Kula, Maui; the Honokaʻa-South Kohala region, Hawaiʻi; and the North Kohala-South Kohala region, Hawaiʻi. If these feasibility studies and preliminary engineering studies have positive results, there may be requests for CIP in the medium- to long-term (5 to 20 years) periods.

In addition, future projects being discussed as long-term projects include the use of pipelines to replace open ditch systems. These improvement projects may be performed in any of the open ditch systems, and will be dependent on various conditions, including funding. The pipelines will reduce maintenance costs and non-revenue water loss. It is recommended that such replacement projects focus on areas with high potential for debris, sediment, and rock accumulation, as well as areas that are difficult to access for maintenance. However, the pipelines will retard any net water gains (water seeping into the system) which may occur in unlined ditch systems.

Another future CIP project is the repair and maintenance of roads to access irrigation systems. This improvement is valuable to provide a more efficient access to the system areas, and promote ease and continued maintenance.

Reclaimed Water. Reclaimed water from WWTP can be considered for use on agricultural lands for certain irrigation purposes, subject to government regulations. In Hawaiʻi, the Department of Health classifies recycled water based on the level of treatment. The higher level of treatment, the broader the irrigation purposes — with fewer restrictions on use. From an economic perspective, the distribution of reclaimed water limits where the reclaimed water is used. It would be preferable to have the agricultural area down gradient (slope) from the WWTP. As most WWTPs are near the coast, there is limited potential applications for use of reclaimed water on agricultural lands.

The only irrigation system considering the use of reclaimed water is the Galbraith Land Irrigation System. This system plans to use reclaimed water from the Wahiawā WWTP, due to the irrigation systems location downgradient from the Wahiawā WWTP.

Automated Water Management Solutions. These systems offer a wide range of capabilities and are offered as customizable packages for the agricultural water system owner, operator, and end user. Comprehensive solutions have the potential to develop complex water budgets based on agronomic factors and monitoring. Benefits include reduced water consumption, manpower requirements for irrigation, and fertilizer expenses. In addition, these systems offer features such as, but not limited to:

- Water accounting and billing solutions;
- Automated real-time climate data, such as daily evapotranspiration and rainfall rates;
- Alerts and messages on system performance, including leak detection;
- Statistical agronomic factors per crop; and
- Multiple irrigation scheduling.

Monsanto has installed automated irrigation systems on their farms in Hawai‘i and reduced their water use by 20 percent (2014).[65] Their system is set up to be operated and monitored remotely. Monsanto is researching other technologies that have the potential to reduce crop irrigation demand. These systems may not be cost-effective for smaller individual farms but may be beneficial to water system owners and managers.

Distribution System Losses. Long-term projects should include distribution system loss studies. Distribution system loss is one component of non-revenue water. For these projects, the distribution system loss should be focused on the seepage loss through open ditch systems which are unlined or have lining which is failing. Currently, it is estimated that the distribution system loss is between 50 percent to 65 percent. However, each system is different, so it is recommended that a study be performed for each system and includes alternatives to reduce distribution system loss.

[65] Personal communication, May 29, 2014.

Invasive Species Eradication/Restoration. Invasive species have impacted irrigation systems through overgrowth, root damage, and clogs. Ironwood trees (*Casuarina*) are introduced plant species which are considered pests, or invasive plants. These trees, particularly their needles, increase maintenance problems for irrigation system operators, as the needles fall into the ditch and create “ironwood needle mat” clogs. The clogs reduce water flow and/or create overflow conditions, which lead to erosion and damage to ditch walls. Ditch managers clear these "mats" frequently, sometimes every day, to maintain flow. In addition, these trees prevent understory growth, which increases erosion with stormwater runoff.

Other invasive trees encountered during the site visits include eucalyptus (paper bark) and albizia. The albizia and eucalyptus are creating dams in natural waterways, reducing storage capacity of reservoirs, and blocking access roadways. Therefore, the eradication of invasive species, especially invasive tree species, will prevent further deterioration of irrigation systems and reduce maintenance costs for ditch managers. To mitigate erosion, projects should require replanting of the affected areas with applicable native species or non-invasive introduced species.

Water Storage. Certain systems need more water storage to increase reliability and stabilize flow. An analysis of each water system would determine the amount and location of such storage. As most of these systems are dependent on one (1) or two (2) surface water sources, it makes them very rainfall dependent, and the variation of flow by actual month can fluctuate greatly.

One example is at the Kehana Ditch. Over a period of several months, USGS measured the flow rate in the system. The flow varied from a low of zero (0) MGD to a high of 29.7 MGD. The average monthly flow during the measurement period also had a large fluctuation, ranging from four (4) MGD to nine (9) MGD.

One option to increase water storage capacity is to use underground storage systems. These underground storage units have been used on the continental United States as a method to control stormwater runoff. These units can be constructed under other manmade structures and do not pose flood hazards to downstream areas. However, large underground storage systems are costly and require large excavation quantities for installation.

Stormwater Recharge. Given the restrictions and safety concerns of dams, large-scale water storage projects would be difficult and costly to construct. However, as long-term droughts and heavier rainfall events are forecasted to continue, large water storage systems will be required to ensure the continued productivity of the agricultural industry, especially if sustainability and a healthy agricultural industry are goals of the state. One option is to re-consider aquifer recharge to store large quantities of water.

Hawai‘i's aquifers are naturally occurring and can store large amounts of water for long periods of time. In 1959, Hawai‘i Water Authority reported that HC&S's groundwater recharge program was performed using excess surface water from HC&S's extensive water ditch system. During an eight (8)-year period (circa 1959), HC&S diverted an average of 2,400 million gallons of surface water a year to recharge the groundwater aquifer. The most effective method at that time was to fill unlined reservoirs above their normal operating levels to increase the rate of seepage. This recharge program was performed with the assistance of the Territorial Commissioner of Public Lands, as Territory-owned waters were involved.

9.2.3 POTENTIAL MANAGEMENT STRATEGIES

The following are potential strategies which may be applicable to certain irrigation systems within the state.

9.2.3.1 Operation and Maintenance

Acquire easements or agreements. One of the obstacles for the plantation systems transferred to private ownership is the lack of maintenance easements or right-of-entry agreements to the irrigation system or water source. Without routine access to the system, portions of the system fall into disrepair or become clogged with debris, which limit the water flow to the users. In addition, clogs cause erosion of the ditch wall and increase ditch repair costs. Water system managers/operators are encouraged to work with agencies, such as Division of Forestry and Wildlife, and other landowners to resolve access issues to maintain these irrigation systems.

Reduce non-revenue loss. Implement measures to reduce non-revenue water (system losses), especially in open ditch areas, unlined reservoirs, or in leaking facilities. However, the seepage from unlined reservoirs is one of the better methods to perform aquifer recharge.

Establish operation and maintenance agreements. The system owner could consider establishing an agreement with farmers served by the system to assist in its maintenance and operation. These agreements should be associated with lower water use fees or reduced future rate increases. This option is limited to privately owned water systems, and not applicable to water systems owned or could be owned by the state.

Research technological management options. Due to the high cost of labor, system owners or managers should research the applicability of new technology to provide:

- Automated water management systems;
- Inspection and operations; and
- Water-use management.

Promote increased agriculture. To meet the state's goals and provide economic stability to the agriculture industry, the following concepts should be explored:

- Increase production in existing agricultural area systems by constructing new distribution systems or new water intakes;
- Develop new distribution systems for new production areas;
- Develop long-term strategies to maintain, secure, and increase water resources to IAL lands and agricultural lands, in general;
- Secure current water allocations for the long term; and
- Assist the agriculture industry to transport Hawai‘i-grown commodities to intrastate, interstate, domestic, and international markets.

9.2.3.2 Education and Outreach

Education is the key to water demand management, both for new and continuing farmers. Education topics should include water demand, water conservation, new technologies, and management strategies. State agencies should organize educational sessions with the following proposed strategies:

- First-generation farmers on irrigation and water use;
- Technology for improving water resource management and leak prevention; and
- Agricultural water roundtable, annually, for system owners to discuss agricultural issues and work on common solutions.

9.3 FUNDING

The statewide short-term improvements have repair and rehabilitation costs of approximately $168 million (2018 dollars). Most of the projects are to repair or re-open portions of the agricultural water system. Interviews with system managers demonstrate that they share a common goal of supplying water to agricultural interests for the long term. However, daily operations and maintenance budgets generally are not enough to perform all necessary repairs, as costs are rising for labor, overhead, material, and equipment. The stakeholders also state that there is no single commodity group within Hawaiʻi's agricultural industry that can afford to maintain or develop an agricultural water system.

As many of the state's water systems are almost a century old, they require significant improvements and major maintenance projects to continue long-term delivery of water to farms. This section discusses some funding options that may assist system owners.

Tax-exempt general obligation bonds may be used to fund the CIP owned by the State of Hawaiʻi. Private entities may utilize State of Hawaiʻi taxable general obligation bonds as CIP funding. Special purpose revenue bonds from the State of Hawaiʻi also may be used to fund CIP for agricultural enterprises serving IAL.

There is also the "private activity bond," which has an annual ceiling based on a percentage of the annual state ceiling for each calendar year, as follows:

- State - 50%;

- City and County of Honolulu - 37.55%;
- County of Hawai‘i - 5.03%;
- County of Kaua‘i - 2.41%; and
- County of Maui - 4.01%.

9.4 CONCLUSION

Agriculture is an essential component for the state to achieve its goals of sustainability and a diversified economy. The agricultural industry relies on these water systems to deliver inexpensive water to meet and expand agricultural production. By supporting, maintaining, improving, and expanding these water systems, the agricultural lands have the potential to maximize agriculture production to meet state and export market demands.

However, other factors, such as the aging farmer population, new rules and regulations, and social concerns placed on agriculture, will increase the costs and risks of farming. These systems have the potential to service approximately 41,200 acres of quality agricultural land for various crops, including the most productive agricultural lands in the state. Most of the crops in these agricultural water systems are food-related crops, which support the state's goal of food sustainability.

The investment into these agricultural water systems is the key to provide adequate water to continue to grow diversified agriculture. As the saying goes, *... without water there is no agriculture ...*, which is the reason these agricultural water systems were originally constructed — and why they need to be maintained for another 100 years.

CHAPTER 10
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No race can prosper till it learns there is as much dignity in tilling a field as in writing a poem.

Booker T. Washington

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APPENDIX B
AWUDP PORTION –
STATEWIDE FRAMEWORK
FOR UPDATING THE HAWAI‘I
WATER PLAN

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Department of Agriculture

Pursuant to Act 101, Session Laws of Hawaii (SLH) 1998, the Department of Agriculture (DOA) shall be responsible for preparation and regular updating of a State Agricultural Water Use and Development Plan (AWUDP). The initial plan shall be prepared and submitted to the legislature no later than twenty days prior to the convening of the regular session of 2000. Preparation of the AWUDP by DOA shall be coordinated with the CWRM for future incorporation into the SWPP.

Agricultural Water Use and Development Plan (AWUDP)

The major objective of the AWUDP is to develop a long-range management plan that assesses state and private agricultural water use, supply and irrigation water systems.

The plan shall address projected water demands and prioritized rehabilitation of existing agricultural water systems.

Legal Mandate and Specific Statutory Requirements - AWUDP

Based on the provisions of Act 101, SLH 1998, the AWUDP shall provide for:

- *A master inventory of irrigation water systems;*
- *Identification of system rehabilitation needs, costs and sources of funding for repair and maintenance;*
- *Development of prioritization criteria and a 5-year program for system repairs;*
- *Set up of a long range plan to manage the systems; and*
- *Incorporation of the above findings into the SWPP.*

Recommended Plan Elements

The effort described above is identified in the Act as a "master irrigation inventory plan" and should therefore be considered as an initial step in the development of a comprehensive Agricultural Water Use and Development Plan. The additional steps that would need to be taken to complete a comprehensive AWUDP should include the following:

1) Based on existing statewide agricultural land uses, assess the existing agricultural water irrigation needs of each of the counties.
2) Based on long-term agricultural crop development plans, develop a range of future agricultural irrigation water needs for each of the counties, including projected agricultural water demands of the DHHL.
3) Based on the information from the WRPP and the "master irrigation inventory plan," identify existing sources for irrigation water and assess any shortfalls or excess capacities in existing irrigation systems.
4) Identify options for development of additional and alternative irrigation water sources.
5) Identify options for conserving irrigation water and/or managing the uses to reduce the total irrigation water demand.
6) Develop strategies encompassing both demand management and resource development options.

In order for the AWUDP to be consistent with the SWPP, the WRPP and WQP, it should include the following elements:

1) Consistency with the WRPP – The AWUDP shall comport with the provisions of the Water Resource Protection Plan and should utilize the ground-water hydrologic units and surface-water hydrographic units designated statewide by the CWRM for the presentation of data and analyses.
2) Current and Future Demand Forecasts – The AWUDP should evaluate current and future water demands for agricultural programs and projects statewide to insure orderly authorization and development of existing water resources. The AWUDP shall consider a twenty-year projection period for analysis purposes.

   The review of all existing and contemplated agricultural projects shall be based upon water consumption guidelines and water demand unit rates used by the CWRM for the purposes of its water permit application review process. All *projects should indicate the following information, at a minimum:*

a) Type of project;
b) Source of water;
c) Existing uses;
d) Contemplated uses;
e) System capacity;
f) Location/Tax Map Key (TMK);
g) Project schedule;
h) Quality of water needed;
i) Basis for water demand projections (e.g. area, units, etc.); and
j) Primary source development plan for the project(s).

3) *Water demand-forecasting techniques – The forecasts developed by the DOA should identify the significant demand determinants used by the agency which may include but are not limited to:*
   - *The data, the sources of data, the assumptions, and the analysis upon which the forecast is based;*
   - *The relative sensitivity of the forecasts to changes in assumptions and varying conditions; and*
   - *The procedures, methodologies, and models used in the forecast, together with the rationale underlying the use of such procedures, methodologies, and models.*

   The approach used by the DOA in their forecasts should be based on sufficient historical data and at a minimum should result in high, medium, and low forecasts of average day demands. Additional forecasts of annual, seasonal, and peak-day system demands, as may be necessary should be based upon forecasted average day demands. The validity and reliability of the approach used by the DOA must be demonstrated and the agency must be prepared to discuss unexplained variation in demand.

4) *Integrated Resource Planning Elements – To provide consistency and coordination between the State Water Projects Plan and the County Water Use and Development Plan, the following elements of the IRP approach should be followed in the preparation of the AWUDP:*

   a) *Demand Forecast – The AWUDP shall include a range of forecasts of the amount of water required over the planning horizon. The DOA shall develop forecasts for multiple scenarios that are necessary or appropriate in the development of the SWPP and the County WUDP. Among the scenarios are the base case scenario (a scenario based on the most likely assumptions), a high-growth scenario, and a low-growth scenario.*

      Forecasts shall be based on yearly increments for the first 5 years. Thereafter, forecasts shall be based on 5-year increments to the year 2020. The DOA is encouraged to extend their forecasts beyond the year 2020, particularly when the forecasts for the initial 20-year period indicates that the limits of particular resources are within reach.

   b) *Water System Profiles - The AWUDP shall include a thorough description of current supplies, major conveyance facilities and storage reservoirs, re-use programs, and conservation programs that are currently in operation. This description shall also include resources, if any, to which the State, county, or private agricultural entities have made commitments. The ability of the current (and, if applicable, committed) system to meet future demands should be explored.*

   c) *Resource Development Options – As applicable, the AWUDP shall address the following types of resource options:*

      - *Supply sources, including both surface-water and ground-water supplies and various combined uses of the two. The issue of inter-basin transfers should be* *examined, with due regard to the environmental and cultural impacts in the basin of origin.*

- *Transmission and other infrastructure, including, but not limited to, major conveyance, treatment, and pumping facilities to relieve existing or anticipated constraints on effectively utilizing existing supplies.*
- *Storage facilities, to take advantage of annual, seasonal, daily, or diurnal variations in demands and/or available supplies.*
- *Conservation programs for agricultural water users. Conservation options should be considered as carefully as supply and facility options as to their ability to achieve objectives. In particular, the estimates for future program participation, costs, and savings should be enumerated and explained. As used here, the term "conservation programs" also includes conservation-oriented rate designs.*
- *Direct and indirect use of reclaimed wastewater for irrigation uses. Such options must be consistent with federal, state, and county laws and regulations.*

- *Source Development Plan – The AWUDP must include a source development plan based upon selected resource options. The plan shall be divided into three periods as follows:*
  - *Near-term (initial 5 years): For this period, the source development plan must detail all of the actions that need to take place to accommodate the projected agricultural water demands anticipated for the initial 5-year time frame. A near-term implementation schedule and a detailed description of each action shall be presented. This schedule shall reflect the anticipated timing and sequencing of all near-term actions. The schedule shall also include expected supply-side capacity additions and demand-side program penetration levels by year. Near-term actions may include, but are not limited to pre-design, design, construction, obtaining financing, information gathering, staff hiring, execution of initial*

conservation program phases, and additional stakeholder and public involvement activities. The 5-year plan should also include estimates of incremental annual capital and operating costs.

- *Medium-term (subsequent 5 years): The source development plan for the medium-term will require less detail, and should focus on major decision points and actions such as plan reassessments, and other actions that may require substantial advance preparation. Precise scheduling and sequencing of events is not critical. However, such information will need to be developed as part of subsequent updates to the AWUDP.*
- *Long-term (final 10 years): The long-term source development plan should serve to highlight major events that are anticipated in the final portion of the planning period. It is expected that detailed information may not be available for long-term plans, however, available data should be identified and sufficiently described.*

5) *Resource Strategies - The resource and facility options that are identified by the DOA in the AWUDP must be combined into resource strategies and integrated with the county strategies. A resource strategy is defined as:*

   A flexible sequence of supply, infrastructure, storage, and conservation program additions intended to meet agricultural water needs over the planning period.

   The DOA must be prepared to develop alternative strategies and to evaluate each strategy against the other. During the update of each county's WUDP, the DOA's strategies should be re-evaluated based upon county specific objectives and measurable criteria developed under the prescribed IRP process. The final product of this step should result in a manageable *number of strategies within the WUDP from which a final recommendation will be selected.*

6) *Uncertainties - The DOA should consider future uncertainties in the development of resource strategies. Source development strategies should provide for future contingencies that may arise in the face of particular outcomes. Sensitivity analysis of strategies developed by the DOA should be performed to evaluate the sensitivity of forecasts and outcomes to various future scenarios.*

7) *Updating – The responsibility for maintaining, monitoring, and updating the AWUDP document resides with the DOA. However, it is recommended that agricultural stakeholders annually update project information in order to monitor demand forecasts and implementation of water development strategies. The DOA should establish a mechanism for regular review of existing, planned, and proposed water resources to meet projected agricultural requirements.*

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APPENDIX C
FARMER SURVEY FORM

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APPENDIX

Appendix 1: Survey Instrument

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IRRIGATION SURVEY INSTRUMENT

By SMS Research on behalf of the Department of Agriculture

SMS Research on behalf of the Department of Agriculture is surveying to find an accurate interpretation of water usage from the farmers of Hawaii. Please answer the following questions as honest as possible. If you are uncomfortable answering any question or feel you cannot answer it honestly skip the question.
Your answers are completely confidential. All questionnaires will be anonymous. This survey will help us and our community to understand Hawaii's water usage better.

Q1. What Agricultural Park are you apart of?

____

Q2. What is the name of your farm?

____

Q2a. Is this your only property or do you farm at other properties as well?

- Only .... O
- Farm at others .... O

Q2b. (IF MULTIPLE) Can you please list the where these other properties are?

____

____

____

Please answer the following questions for this property only.

Q3. What is your role for farming at this farming operation?

- Owner .... O
- Overseer .... O
- Farm hand .... O
- Other (Specify) .... O

____

Q4. How long have you been farming?

- 1-5 Years .... O
- 5-10 Years .... O
- 10-15 Years .... O
- 15-20 Years .... O
- 20 or more Years .... O

Q5. How long have you been farming at this site?

- 1-5 Years .... O
- 5-10 Years .... O
- 10-15 Years .... O
- 15-20 Years .... O
- 20 or more Years .... O

Q6. What method(s) of water distribution do you currently use to water your cops? Select all that apply.

- Center-Pivot .... O
- Drip .... O
- Flood .... O
- Furrow .... O
- Gravity .... O
- Rotation .... O
- Sprinkler .... O
  - What type of head? ________________
  - How many? ______________________
- Subirrigations .... O
- Traveling Gun .... O
- Supplemental .... O
- Surface .... O
- Catchment System .... O
- Other (Specify) .... O

____

Q7. Is this irrigation system metered or non-metered.

- Metered .... O
- Non-Metered .... O

Q8. On an average month during the <u>dry</u> season about how many gallons of water do you use for irrigation?

______________________Gallons per month

If you do not know can you explain what type of irrigation you use each month and how long you use it?

Q9. On an average month during the <u>wet</u> season about how many gallons of water do you use for irrigation?

______________________Gallons per month

If you do not know can you explain what type of irrigation you use each month and how long you use it?

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ID#________________

Q10a. (HAND RESPONDENT ANSWER SHEET) Now if you could go through this table and select the crops you grow and answer the following questions for each crop. For each crop you grow, please write the estimated number of crops you have, the number of times you harvest this crop, the number of acres you use for that crop, the type of irrigation used to water that crop (drip, flood, sprinkler, etc.), as well as how many gallons of water per month you use for both dry and wet season.

Q10b. Please select which plant you grow and answer the following questions for each plant. Please write the estimated number of plants you have, the number of times you harvest this plant, the number of acres you use for that plant, the type of irrigation used to water that plant (drip, flood, sprinkler, etc.), as well as how many gallons of water per month you use for both dry and wet seasons.

Q10c. Please specify the type of livestock you raise, if any, in the table below. Please write the amount of livestock as well as the gallons of water you use for their care each month.

Q10d. What is your total acreage for all your crops? ________

Q11. Do you keep these crops for the whole year, or do you change crops in different seasons?

____

____

Q12. How do you determine how often you irrigate and how much water you add during the dry season?

Plants look wilted.. O
On a schedule basis...................................... O
Other (Specify) .... O
____

Q13. How do you determine how often you irrigate and how much water you add during the wet season?

Plants look wilted.. O
On a schedule basis...................................... O
Other (Specify) .... O
____

Q14. Please specify any crops that you rotate throughout the year.

Q15. What other agricultural activities (preparation, packaging, processing) do you do at this location?	Q15a. How much water do you use with each activity?

Q16. How many residential units are on this property? ______
Q17. How many people per unit? _____
Q18. How many gallons of water per unit is used a month? ______
Q19. How many months of the year are these units in use? _____

ID#________________

Q20. Do you have any issues with usage/availability that you think are important to discuss?

____
____
____

Q21. How would you rate your water service on a scale of 1 to 5, 1 being the worst and 5 being the best? _________

Q22. And why do you say that?

____
____

Q23. Where is your farm located?

Oahu.. O
Maui.. O
Hawaii.. O
Kauai .... O
Molokai .... O

Q23a. What is your farm location zipcode?

96☐☐☐

Interviewer:	
Date:	
Time of day:	
Respondent name:	
Respondent Contact Information	
Can you provide documentation of water usage?	
GPS Location :	

Thank you and have a nice morning/afternoon/evening.

If you have any questions please contact Jim Dannemiller at 808-440-0701 or jdannemiller@smshawaii.com

ID#________________

Respondent Copy

Q10a. Now if you could go through this table and select the crops you grow and answer the following questions for each crop. For each crop you grow, please write the estimated number of crops you have, the number of times you harvest this crop, the number of acres you use for that crop, the type of irrigation used to water that crop (drip, flood, sprinkler, etc.), as well as how many gallons of water per month you use for both dry and wet season.

Produce

Crop	Number of harvests per year	*Number of Acres	Type of Irrigation used to water crop	Gallons of water per month Dry Season	Gallons of water per month Wet Season
Alfalfa Initial					
*If less than .25 acres, please describe amount of land devoted to crop:					
Alfalfa Ratoon					
*If less than .25 acres, please describe amount of land devoted to crop:					
Banana Initial					
*If less than .25 acres, please describe amount of land devoted to crop:					
Banana Ratoon					
*If less than .25 acres, please describe amount of land devoted to crop:					
Cabbage					
*If less than .25 acres, please describe amount of land devoted to crop:					
Cantaloupe					
*If less than .25 acres, please describe amount of land devoted to crop:					
Coffee					
*If less than .25 acres, please describe amount of land devoted to crop:					
Dry Onion					
*If less than .25 acres, please describe amount of land devoted to crop:					
Eggplant					
*If less than .25 acres, please describe amount of land devoted to crop:					
Eucalyptus					
*If less than .25 acres, please describe amount of land devoted to crop:					

ID#________________

Crop	Number of harvests per year	*Number of Acres	Type of Irrigation used to water crop	Gallons of water per month Dry Season	Gallons of water per month Wet Season
Ginger					
*If less than .25 acres, please describe amount of land devoted to crop:					
Guava					
*If less than .25 acres, please describe amount of land devoted to crop:					
Heliconia					
*If less than .25 acres, please describe amount of land devoted to crop:					
Herbs (Basil, Rosemary, Thyme)					
*If less than .25 acres, please describe amount of land devoted to crop:					
Kikuyu Grass					
*If less than .25 acres, please describe amount of land devoted to crop:					
Lettuce					
*If less than .25 acres, please describe amount of land devoted to crop:					
Lychee					
*If less than .25 acres, please describe amount of land devoted to crop:					
Macadamia nut					
*If less than .25 acres, please describe amount of land devoted to crop:					
Other Melon					
*If less than .25 acres, please describe amount of land devoted to crop:					
Pineapple					
*If less than .25 acres, please describe amount of land devoted to crop:					
Pumpkin					
*If less than .25 acres, please describe amount of land devoted to crop:					
Seed, Corn					
*If less than .25 acres, please describe amount of land devoted to crop:					
Sugarcane Year 1					

ID#_______________

Crop	Number of harvests per year	*Number of Acres	Type of Irrigation used to water crop	Gallons of water per month Dry Season	Gallons of water per month Wet Season
*If less than .25 acres, please describe amount of land devoted to crop:					
Sugarcane Year 2					
*If less than .25 acres, please describe amount of land devoted to crop:					
Sugarcane Ratoon					
*If less than .25 acres, please describe amount of land devoted to crop:					
Sweet Potatoes					
*If less than .25 acres, please describe amount of land devoted to crop:					
Taro					
*If less than .25 acres, please describe amount of land devoted to crop:					
Ti					
*If less than .25 acres, please describe amount of land devoted to crop:					
Watermelon					
*If less than .25 acres, please describe amount of land devoted to crop:					
Herbs (Basil, Rosemary, Thyme)					
*If less than .25 acres, please describe amount of land devoted to crop:					
Biofuel Crops (specify)					
*If less than .25 acres, please describe amount of land devoted to crop:					
Other (specify)					
*If less than .25 acres, please describe amount of land devoted to crop:					
Other (specify)					
*If less than .25 acres, please describe amount of land devoted to crop:					

ID#________________

Q10b. Please select which plant you grow and answer the following questions for each plant. Please write the estimated number of plants you have, the number of times you harvest this plant, the number of acres you use for that plant, the type of irrigation used to water that plant (drip, flood, sprinkler, etc.), as well as how many gallons of water per month you use for both dry and wet seasons.

Plants/Botanicals

Crop	Number of harvests per year	*Number of Acres	Type of Irrigation used to water crop	Gallons of water per month Dry Season	Gallons of water per month Wet Season
Bromeliad					
*If less than .25 acres, please describe amount of land devoted to crop:					
Ferns					
*If less than .25 acres, please describe amount of land devoted to crop:					
Dendrobium, Pot micro-sprink					
*If less than .25 acres, please describe amount of land devoted to crop:					
Draceana, pot micro-sprink					
*If less than .25 acres, please describe amount of land devoted to crop:					
Orchids					
*If less than .25 acres, please describe amount of land devoted to crop:					
Xanthiums					
*If less than .25 acres, please describe amount of land devoted to crop:					
Other (specify)					
*If less than .25 acres, please describe amount of land devoted to crop:					
Other (specify)					
*If less than .25 acres, please describe amount of land devoted to crop:					
*Other (specify)					
If less than .25 acres, please describe amount of land devoted to crop:					

ID#________________

Q10c. Please specify the type of livestock you raise, if any, in the table below. Please write the amount of livestock as well as the gallons of water you use for their care each month.

Livestock

Livestock (Please specify)	Number of animals	Gallons of water used for care per month	Water usage for pasturage

APPENDIX D
HISTORICAL WATER FLOW DATA

WATER FLOW DATA - KAUAI COUNTY

Irrigation System	Hist. Ave. Flow (2) (mgd)	USGS(1) Location Date Range	USGS (1) Old HI Datum (Latitude Longitude)	USGS (1) Est. Mean Monthly Discharge (low) (mgd)	USGS (1) Est. Mean Monthly Discharge (high) (mgd)	Transmission Capacity (2)
East Kauai Irrigation System						[473]
Hanamaulu	[21]	Near Lihue 1910-1919	22°02'05" 159°25'36	9.7	23.9	
Stable Storm	[17]	Near Lihue 1937-2002	22°04'09" 159°26'46"	2.6	9.0	
Kapahi	[10]	Nr. Kealia 1917-2002	22°06'09" 159°22'28"	2.9	5.4	
Makaleha		Nr. Kealia 1936-1998	2°07'06" 159°22'04"	2.1	5.4	
Wailua	[10]	nr. Kapaa 1936-2002	22°04'34" 159°24'04"	6.0	14.2	
Aahoaka		nr. Kapaa 1966-1972	22°03'30" 159°23'49"	0.6	1.1	
Iliiliula-N. Wailua	[12]					
Kekaha Ditch Irrigation System	[56] 30	Camp 1 1908-1968	22°02'35" 159°38'29	33.6	40.7	[104] 40
Kokee Ditch Irrigation System	15	nr. Waimea 1926-1982	22°06'42" 159°40'43"	8.4	22.6	[105] 55
Kaloko and Puu Ka Ele Ditches						
Kahiliwai - (Porter)		nr. Kilauea 1934-1967	22°11'07" 159°25'58	1.3	3.1	
Kahiliwai - (Mill Ditch)						

WATER FLOW DATA - KAUAI COUNTY
(continued)

Irrigation System	Hist. Ave. Flow (2) (mgd)	USGS(1) Location Date Range	USGS (1) Old HI Datum (Latitude Longitude)	USGS (1) Est. Mean Monthly Discharge (low) (mgd)	USGS (1) Est. Mean Monthly Discharge (high) (mgd)	Transmission Capacity (2)
Puu Ka Ele		Near Kilauea 1932-1967	22°11'10" 159°24'17"	1.7	3.2	
Koloko		Near Kilauea 1932-1968	22°10'43" 159°22'59"	2.5	4.0	
• Anahola Ditch						
• Anahola Ditch		abv. Wasteway nr. Kealia 1915-1921	22°08'15" 159°22'31"	3.9	6.5	
• Lower • Anahola		nr. Kealia 1937-1995	22°08'14" 159°19'31"	0.8	2.1	
• Upper and Lower Lihue Ditches and por. Waiahi-Iliiliula Ditch						
• Lihue Ditch		nr. Lihue 1910-1919	22°01'45" 159°25'52"	3.7	7.8	
• North Wailua		blw. Waikoko Str. nr. Lihue 1965-2002	22°03'34" 159°28'00"	12.9	14.9	
• Waiahi-Iliiliula						
• Upper and Lower Haiku Ditches						
• Lower Haiku		nr. Puhi 1963-1971	21°58'20" 159°26'55"	2.2	8.4	
• Upper Haiku		nr. Puhi 1963-1971	21°58'48" 159°27'13"	2.1	10.3	

WATER FLOW DATA - KAUAI COUNTY
(continued)

Irrigation System	Hist. Ave. Flow (2) (mgd)	USGS(1) Location Date Range	USGS (1) Old HI Datum (Latitude Longitude)	USGS (1) Est. Mean Monthly Discharge (low) (mgd)	USGS (1) Est. Mean Monthly Discharge (high) (mgd)	Transmission Capacity (2)
Kauai Coffee Irrigation System						
Kamooloa						
Wainiha Power Plant	50					
Pump 3	[35] 34					
Alexander Reservoir	10					
Waiaha-Kuia Aqueduct, por. Waiahi-Iliiliula Ditch, and Koloa-Wilcox Ditch						
Waiaha-Kuia		nr. Puhi 1964-1971	21°58'36" 159°28'28"	1.6	7.8	60-90
Koloa Ditch		nr. Koloa 1964-1971	21°57'06" 159°28'11"	7.1	18.1	
Olokele Ditch						
Olokele Ditch	66	Makaweli Weir 1912-1917	22°00'06" 159°36'45"	30.4	49.8	
Hanapepe	35	blw. intake nr. Eleele 1930-1938	21°58'06" 159°32'05"	21.3	31.0	

1 USGS Surface –Water Monthly Statistics for the Nation (http://waterdata.usgs.gov/nwis)

2 Source: Wilcox, Carol, 1977

Hist. Ave. Flow - Historical Average Flows, based on the historical record

WATER FLOW DATA - MAUI COUNTY

Irrigation System	Hist. Ave. Flow (2) (mgd)	USGS(1) Location Date range	USGS (1) Old HI Datum (Latitude Longitude)	USGS (1) Est. Mean Monthly Discharge (low) (mgd)	USGS (1) Est. Mean Monthly Discharge (high) (mgd)	Transmission Capacity (2)
East Maui Irrigation System						440
(old) Hamakua	[65]	Honopou nr. Huelo 1918-1965	20°53'32" 156°15'17"	0.8	4.2	
Spreckels (old Haiku)	[30]	below Kaaiea nr Huelo 1918-1929	20°52'38" 156°12'05"	2.9	8.4	
Lowrie	[45]	Honopou nr. Huelo 1910-1985	20°54'45.2" 156°14'57.4" NAD83	18.1	30.3	60
New Hamakua	[54]	Honopou nr. Huelo 1918-1985	20°53'17.0" 156°15'11.8" NAD83	14.9	36.8	
Koolau	[55]	Wahinepee nr. Huelo por. 1922	20°51'35" 156°11'30"	21.3	98.2	85
New Haiku	[45] 25	Honopou nr. Kailua 1910-1985	20°54'56.1" 156°14'49.1" NAD83	11.0	25.9	100
Kauhikoa	[71]	Opana Weir 1910-1928	20°53'26" 156°16'33"	9.0	22.0	110
Wailoa	[110]	Honopou nr. Huelo 1922-1987	20°53'10.3" 156°15'08.7" NAD83	88.5	135.1	160-195

1 USGS Surface −Water Monthly Statistics for the Nation (http://waterdata.usgs.gov/nwis)

2 Source: Wilcox, Carol, 1977

Hist. Ave. Flow - Historical Average Flows, based on the historical record

WATER FLOW DATA - MAUI COUNTY
(continued)

Irrigation System	Hist. Ave. Flow (2) (mgd)	USGS(1) Location Date range	USGS (1) Old HI Datum (Latitude Longitude)	USGS (1) Est. Mean Monthly Discharge (low) (mgd)	USGS (1) Est. Mean Monthly Discharge (high) (mgd)	Transmission Capacity (2)
Maui Land And Pineapple/Pioneer Mill Irrigation System						
Honokohau	[35] 20	At Intake nr. Honokohau 1907-1913	20°57'50" 156°35'25"	19.4	22.6	[18] 35
Kauaula	4.5	nr. Lahaina 1912-1917	20°52'40.4" 156°37'21.9"	5.1	6.5	25.5
Olowalu	4	nr. Olowalu 1911-1967	20°49'33" 156°36'50"	3.8	5.5	11
Honolua (Honokohau_	[50] 30-18					
Honokowai	6					
Kahoma	3					
Kanaha	3.8					
Launiupoko	0.8					
Ukumehame	3					
Wahikuli	[5]					
Upcountry Maui Irrigation System	[3]					
West Maui Irrigation System						
Waihee Ditch (Sprekels)	[10] 10-2					
Waihee Canal (Ditch)	[27] 27					
Nine smaller ditches						
Molokai Irrigation System	[8]	Tunnel W. Portal 1965-2004	21°07'27" 156°59'50"	3.8	5.4	[36]

WATER FLOW DATA - HAWAII COUNTY

Irrigation System	Hist. Ave. Flow (2) (mgd)	USGS(1) Location Date range	USGS (1) Old HI Datum (Latitude Longitude)	USGS (1) Est. Mean Monthly Discharge (low) (mg)	USGS (1) Est. Mean Monthly Discharge (high) (mg)	Transmission Capacity
Waimea Irrigation System	[10] 8	Abv. Waimea Res. 1974 - 2004	20°03'35" 155°37'44"	3.6	8.4	
Lower Hamakua Ditch Irrigation System	[66] 30	Main Weir Kukuihaile 1964-1973	20°07'07" 155°35'09"	25.9	33.0	[tbd]
Kohala Ditch		Pololu 1927-1972	20°10'19" 155°44'20"	22.0	30.4	
Kehena Ditch		Kehena Ditch 1918-1966	20°07'25" 155°45'05"	4.2	9.7	

1. USGS Surface –Water Monthly Statistics for the Nation (http://waterdata.usgs.gov/nwis)
2. Source: Wilcox, 1977

Hist. Ave. Flow - Historical Average Flows, based on the historical record

WATER FLOW DATA - HONOLULU COUNTY

Irrigation System	Hist. Ave. Flow (2) (mgd)	USGS(1) Location Date range	USGS (1) Old HI Datum (Latitude Longitude)	USGS (1) Est. Mean Monthly Discharge (low) (mgd)	USGS (1) Est. Mean Monthly Discharge (high) (mgd)	Transmission Capacity
Oahu Ditch (Wahiawa, Helemano, and Tanaka)						
Oahu		Mauka Ditch nr. Wahiawa 1947-1968	21°30'48" 157°59'17"	2.3	3.0	
Wahiawa		At Wahiawa 2012-2013	21°30'02.0"158°03'03.7" (NAD 83)	6.5	12.3	
Opaeula, Kamananui						
Waiahole Ditch Irrigation System	42-27	Adit 8 1956-1969	21°157°57' 157°57'30"	22.6	35.3	100
Waiahole Ditch (continued)	[28]	Adit 8 2001-2003	21°157°57' 157°57'30"	6.5	9.5	[193]
Waimanalo Irrigation System						
		Nr. Waimanalo 1954-2002	21°20'45 157°45'11"	0.9	1.7	
		Ainoni Spring 1991-2002	21°21'03" 157°46'03"	0.5	0.8	
		Abv. Aninainui Tunnel 1991-2000	21°20'50" 157°45'26"	0.8	1.2	

1. USGS Surface –Water Monthly Statistics for the Nation, (http://waterdata.usgs.gov/nwis)
2. Source: Wilcox, Carol, 1977

Hist. Ave. Flow - Historical Average Flows, based on the historical record

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APPENDIX E
SATELLITE AND AERIAL IMAGERY ANALYSIS

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Crop Mapping for Ag Ditch Assessment, Methods Report
Hawaii: Kauai, Oahu, and Big Island
June 2015

Prepared by:

Resource Mapping Hawaii LLC

Stephen Ambagis

EXECUTIVE SUMMARY

This mapping project covered the agriculture areas of 3 Hawaii islands where existing ditch irrigation systems are in place (Kauai, Oahu, and Big Island). The product is a series of land cover maps indicating the distribution of different types of agriculture across the areas of interest. Each island was analyzed separately using a combination of satellite image analysis and aerial image interpretation. The data used were provided by Digital Globe and Resource Mapping Hawaii (RMH). The initial mapping was done on the 2 meter resolution satellite data acquired from 2011 using automated image analysis, an object based analysis using eCognition. A subsequent visual analysis was performed using a 4cm image data set collected by RMH in 2014. The final land cover maps were produced by manually assessing the entire initial satellite classification result in conjunction with the recent aerial data collected as "ground truth". A 100% visual review was performed and manual corrections applied where required. The islands of Kauai and Oahu were both mapped in the above described manner while Hawaii Island was only assessed using the automated analysis with the available satellite data. The agriculture classes that were defined were generally vague given the level of complexity associated with mapping specific species and or types of agriculture. A considerable amount of effort dedicated to determining the difference between active ranching lands and fallow tilled lands. Often these two states of use were confused and frequently overlapped given farming practices in the state of Hawaii. Each island had a different suit of dominant agriculture products and therefore required extensive review and refinement. All species of produce were lumped into one group as were all species of fruit and nut trees. Agroforestry species were also all lumped into a single class. In some cases individual species could be distinguished using the 4cm data but not consistently enough to warrant separate classes for this study. The maps produced are only a snapshot in time. From the evaluation of multiple data sets its clear that many of the common agriculture areas rotate crop covers and use from year to year.

It should be noted here that this analysis was done independently of information produced by either land owners or the state. The resulting data therefore has a level of objective observation different from most classical agriculture assessments that rely heavily on information gained from interviews or tax assessment based information.

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Methods REPORT

1 Introduction

Mapping crop types has been a perennially difficult process over the years. Recent improvements in satellite, aerial imaging, and image analysis technologies have brought this process into a more manageable state. Resource Mapping Hawaii (RMH) was hired to produce maps of the current crop types being produced in specific areas around the state. Previous mapping efforts involved the use of satellite imagery and object based analysis along with visual evaluation and refinement. In this most recent iteration RMH incorporated the use of high resolution aerial imagery into the process to help inform the satellite based mapping. This process was both instructive and successful.

2 Mapping Methods

2.1 Preliminary mapping products

The first phase of this mapping process was to do an initial evaluation of the available satellite data to determine both extents of the areas of interest as well as the feasibility to map the crop types of interest.

2.1.1 Available satellite data

An assessment was done for all of the available satellite data at that time. Of the data sets available one set was considered to be the most applicable as well as consistent across the entire state. In 2009/2010 NOAA and affiliates contracted Digital Globe to use its World View II (WV2) sensor to collect imagery for all the main Hawaii Islands. Once collected that data was made publicly available.

The WV2 sensor is capable of producing 7 bands of multispectral data at 2m resolution including deep blue, blue, green, yellow, red, red edge, near infrared1 and near infrared2. An 8th panchromatic band is also collected at 50cm resolution (Figure 1).

The WV2 data set that was collected and available covered the state with approximately 20% cloud cover and spanned approximately 2 years. The images were color balanced and mosaicked by NOAA personnel and made available. Due to the new capacity of that sensor in both spacial resolution, number of available bands, and geographic coverage it was determined to be the best data available for mapping crop type.

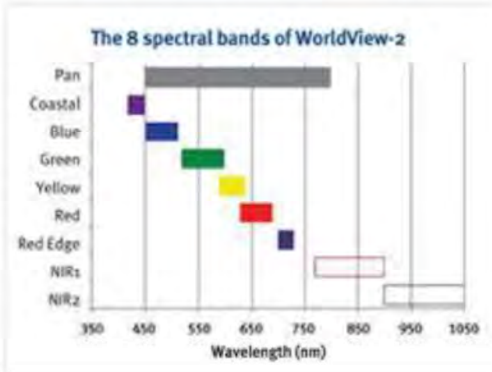


Figure 1 – 8 bands collected by the WV2 satellite sensor

2.1.2 Initial evaluation of satellite data products

An initial assessment was performed using the satellite data to determine its effectiveness for use in crop mapping. The data were imported into an object based classification software call eCognition, developed by Definiens and owed by Trimble Inc. It was determined from early mapping efforts that data with this level of resolution are better analyzed using object based approaches rather than pixel based classification approaches.

Preliminary assessments indicated that a number of crops were spectrally independent but positive identification of those crops was unclear without considerable ground assessment.

It was also determined that the areas under agricultural use of some kind were generally evident and definable in the satellite data using the object based classification approach.

2.2 Aerial imaging for crop determination

2.2.1 Initial flying and data collection

Data collection flights started at the beginning of 2014 and continued through September of that year. The aerial imagery collection was initially contracted to be at ground sampling distance (GSD) of 8cm. An initial assessment flight was done on the island of Kauai to determine the relative usefulness of the imagery to identify crop cover types. After initial evaluation it was determined that the requirements of this project required at least a doubling of resolution so the data was collected at an average of 4cm (GSD) for the remainder of the project. Due to the required doubling of the resolution it was determined that a strategic approach to the flying would be taken that would focus on areas of difficulty where crop type and or land use was unclear. All image data were post processed into fully ortho-recitified image mosaics ready for GIS analysis and interpretation alongside the satellite data being used for the mapping production. Maps of the actual area covered are in contained in figures **3** and **5**. A total of 21,795 acres were collected on the island of Kauai, 9114 on Oahu and 1500 on Big Island.

Data collection was generally straight forward with a few exceptions common to aerial imaging.

- The presence of clouds above the aircraft creating inconsistent shadows on the ground.
- Periodic high winds that created excessive turbulence and periodic “smearing” in the imagery.
- Variable lighting from time of day differences within a given area of interest.

2.2.2 Image processing of ortho-mosaics

All of the image data underwent the same processing workflow. The original TIFF data was converted from the PhaseOne proprietary format using their custom software CaptureOne. During this process the images were corrected for lens distortion, variable lighting, and systematic noise reduction or image sharpening.

The data were then imported in the IPS 3.4 (Icaros Inc. Image Processing Software) where the GPS and INS data were synced with the imagery data and then run through a standard photogrammetric aerial triangulation routine. Each block of data was systematically cleaned until a within model RMSE of >1.0m was obtained. Then a series of ground control points (GCP) were chosen from the World View 2 satellite data and the block then run again. By incorporating GCPs from the WV2 data we ensured that the aerial data would line up with the satellite data that was being used for the actual mapping portion of the process. Final RMSE for each block was brought to >1.5m with ground control.

The image data was then individually processed out into ortho images using the USGS 10M as elevation control. The resulting ortho-imagery was run through a stitching algorithm also part of the IPS 3.2 platform. During the stitching phase the imagery is color balanced and dodged to create a seamless mosaic ready for analysis. The data were exported into 2GB tiles in an uncompressed GeoTIFF format in the NAD 1983 UTM Zone 4 projection system to correspond with the WV2 satellite data.

2.2.3 Visual assessment of the aerial imagery for crop determination

From the initial test flight it seemed as though 4cm would be resolute enough to determine most crop types. In many instances this was the case. Crops such as coffee, corn, taro, and others 4cm data was sufficient for the positive determination. However, a number of other crops, primarily ones not grown at large scale such as most of the produce based crops were impossible to separate at this resolution. This is very similar to what RMH found when trying to identify and map invasive plant species in conservation units. It was found that most species level mapping within forest communities required 1cm level aerial imaging to successfully identify individual species. While this did come to be a limitation for the analysis the overall result was generally successful.

The basic approach to analysis consisted of a preliminary draft classification of the satellite data and then using the aerial imagery as ground truth information each cover class was evaluated to determine cover type. In the case of most crop species this approach worked well. In some cases such as determining the difference between fallow crop agriculture fields and either active or inactive grazing pastures this approach was only mildly helpful. Within the 4cm data certain characteristics such as obvious animal trails or variable grazing patters were evident. However this was not often the case. These classes tended to be difficult to distinguish from one another throughout the process.

2.3 Mapping of the satellite data

2.3.1 Object based image analysis

The primary analysis approach utilized during this mapping effort was an object based approach. This differs from traditional land cover mapping with imagery that usually employs a pixel based approach. Pixel level analysis evaluates each pixel based on its spectral components and their relative severability. This type of automated image analysis has long been used when the data available tended to be large pixels covering multiple cover types. With the technological development of higher resolution imaging systems, both satellite and aerial, analysis approaches have become more varied. With the WV2 data used in this project the pixel size was small enough that grouping pixels by their relative similarity can be more effective for defining certain cover types. Object based approaches tend to give the user the ability to incorporate another level of information that of object shape, size, and relative position. This is especially helpful when looking at cover types such as man produced crops that while often spectrally overlap with other plant species are usually planted with some level of consistency and geometric pattern easily recognizable to the human eye but not identifiable in a pixel based analysis.

The software eCognition Developer 9.0 was chosen to do this object based analysis and was developed by Definiens Inc and now owned and distributed by Trimble. It is the industry standard for object based mapping and has by far the most encompassing tool sets available for managing high resolution imagery.

For each site / island, the WV2 satellite data was imported into eCognition and then subset into a small representative area for initial mapping methods development. This significantly reduces the time to determine the best approach to mapping each area and it specific cover types. In some cases if the islands or areas of interest (AOI) are similar enough then the methods used for one site can be applied to the others. In the case of this analysis each of the sites posed their unique challenges and variable cover types that required a slightly different set of variables be applied to produce a reasonable outcome.

2.3.2 Kauai Island

The Island of Kauai was the first Island to be analyzed and coincidentally also contained the largest amount of area under agriculture production as well as the highest diversity of cover types. The total number of agriculture classes defined on this island was 13. Of those 13, 2 of the classes represented fallow crops or ranch lands.

The majority of cover classes used were fairly straight forward however a few presented challenges given the available data. For example the crops containing the common “produce crops” such as tomatoes, lettuces, and other smaller scaled crops were difficult to impossible to tell apart from either the satellite data or the aerial imagery. In such cases an overarching class was created to include all of those types of crop termed mixed produce. The same could be said for many of the fruit and nut tree varieties. The classes termed grazing, fallow grazing, and fallow agriculture were also quite difficult to separate consistently. These cover types are often intermixed and change from year to year.

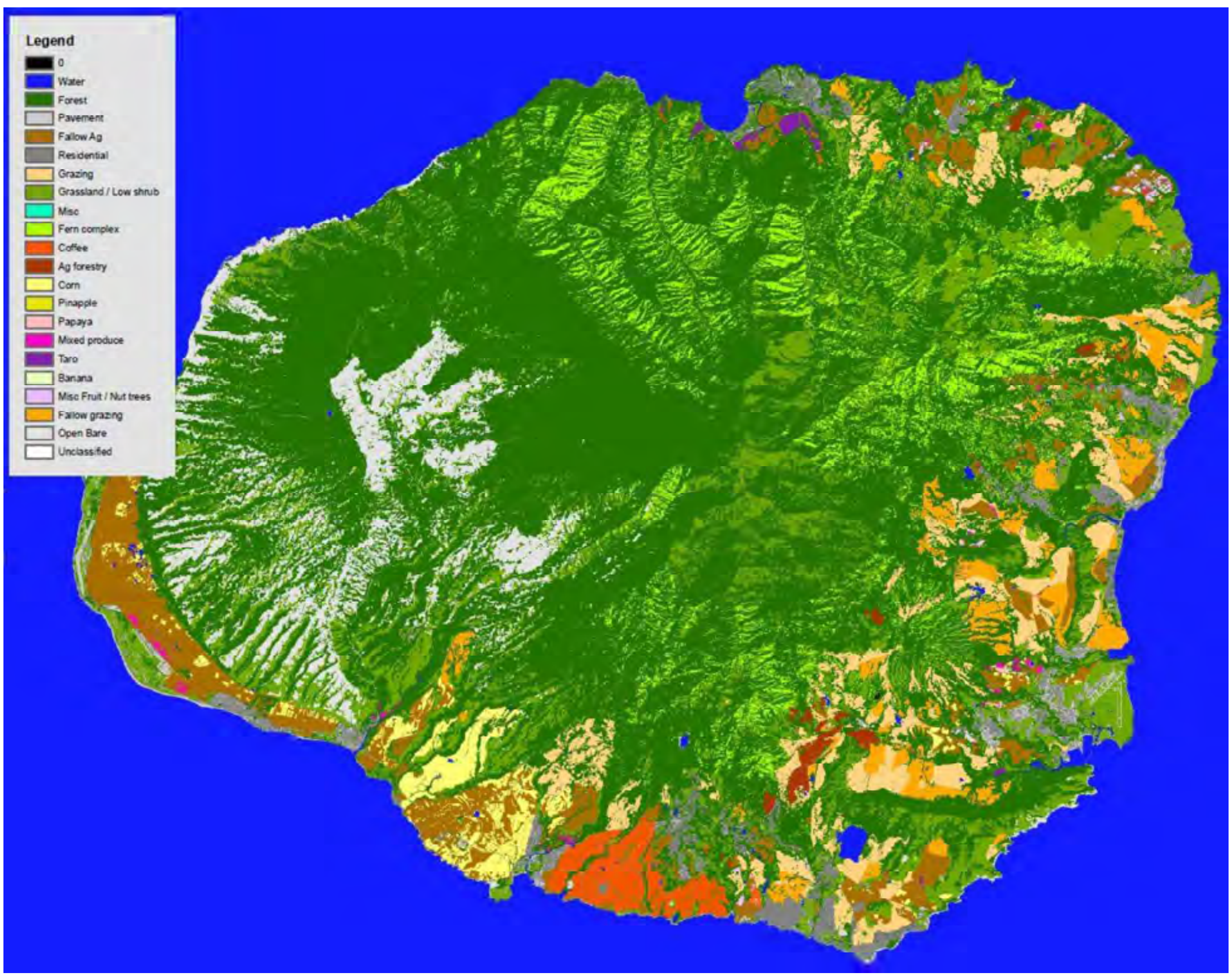


Figure 2 – Kauai Island agricultural land use classification

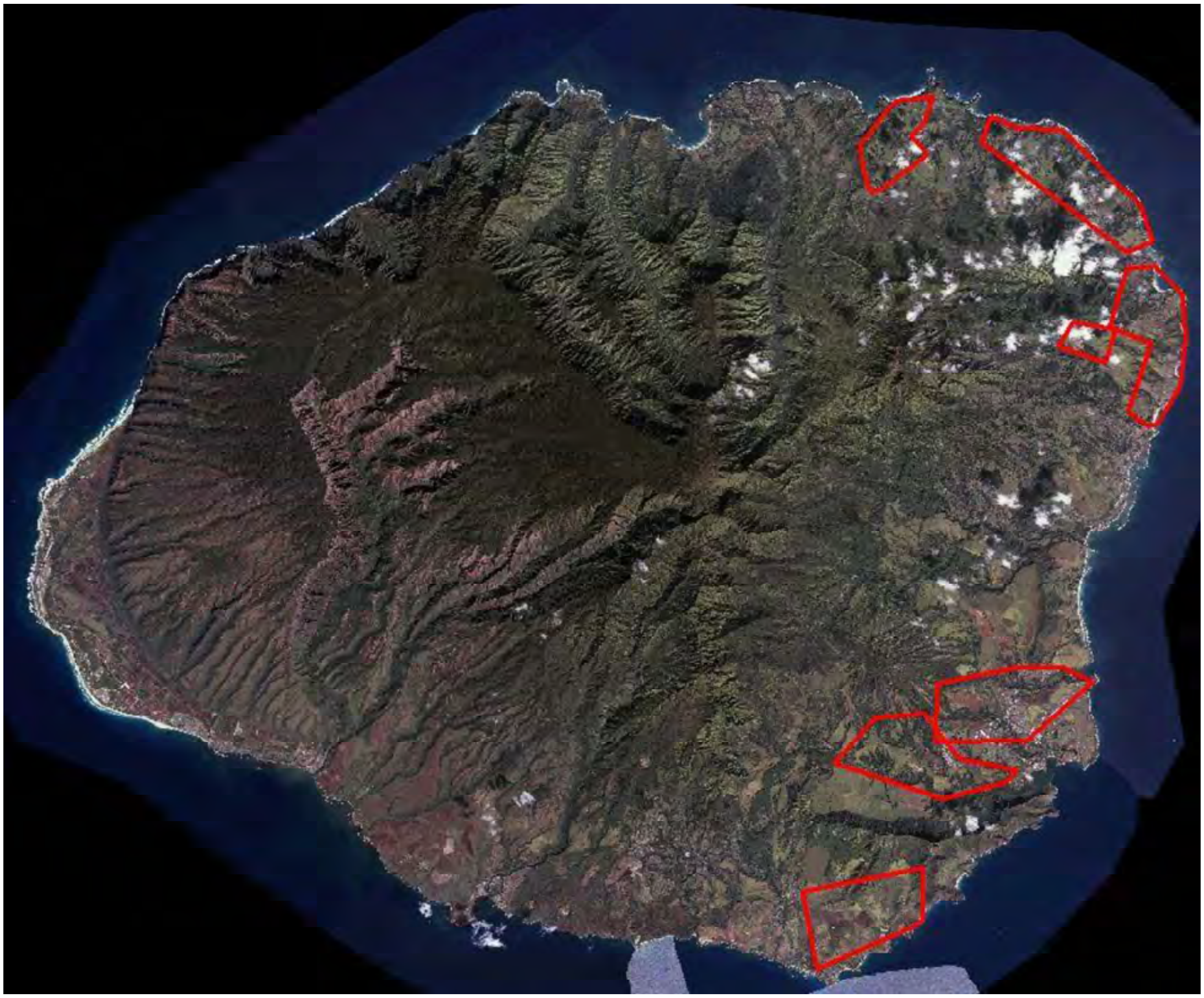


Figure 3 – Sites were 4cm aerial imagery was collected for visual referencing.

2.3.3 Oahu Island

For the island of Oahu the same number of agricultural classes was used totaling 13 in all. The amount of area under apparent agricultural use was less than Kauai with more emphasis on the larger crops of corn and pineapple. There was also a considerable amount of likely fallow agriculture with either some cover crop or bare ground. In this case it was clear that there were probably fallow agriculture lands that were not identified give their relative age of regrowth back to a more natural looking mix of plant species.

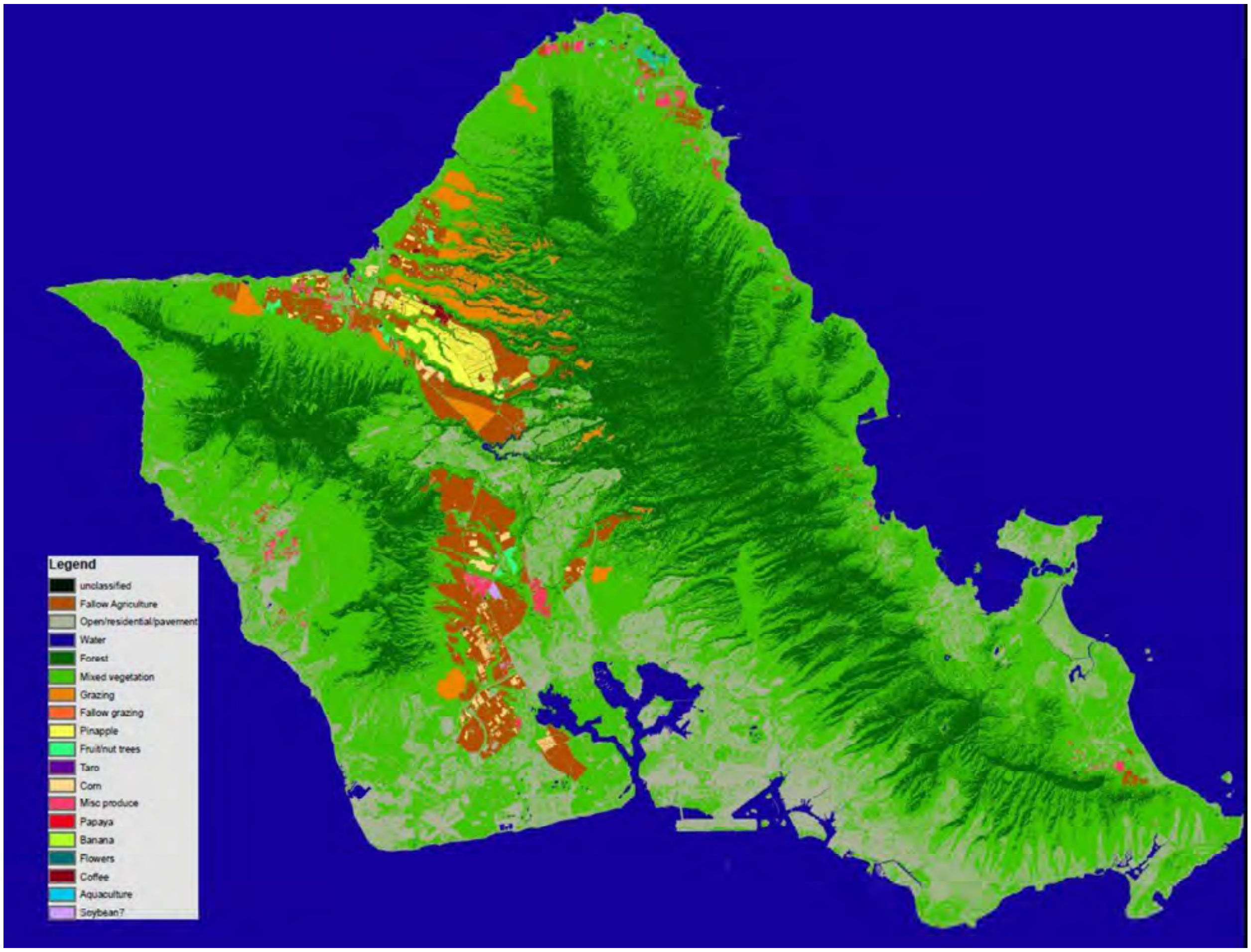


Figure 4 – Oahu Island agricultural land use classification

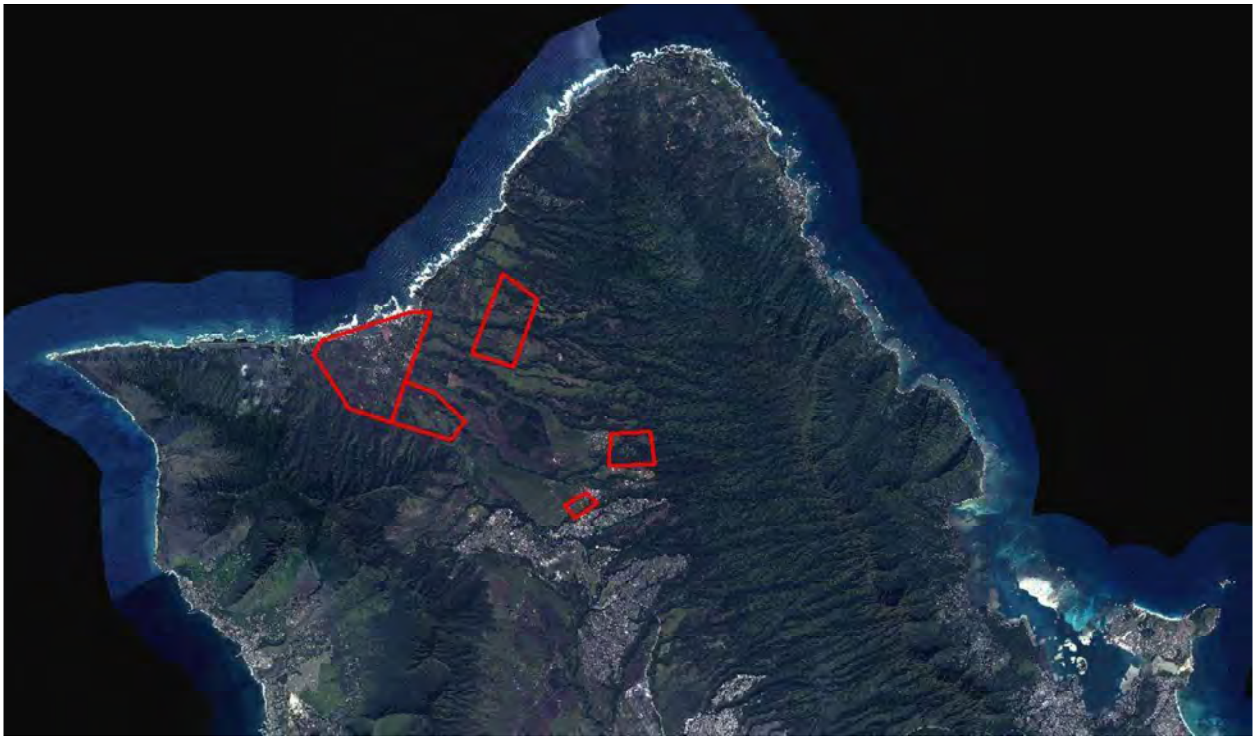


Figure 5 – Sites were 4cm aerial imagery was collected for visual referencing.

2.3.4 Hawaii Island

The Big Island of Hawaii was not evaluated in total in the same manner as the other islands given its size. The areas of interest were limited to the northern most section and southern most sections of the island. The other difference between this island and the others was related to the available satellite data at that time. The same world view 2 data was collected and distributed for this island as the others notable in that it was limited to 3 bands of information corresponding to the blue, green, and red bands. In the case of the other islands the full 8 multispectral bands were available to use. The limited amount of data did impact the final products but not in a considerable way given the predominant features that were used to map the agricultural classes.

In the case of the northern section of the island only 5 agriculture classes were deemed required and or identifiable. Such was not the case for the southern section of the island where more active classes were clearly evident.

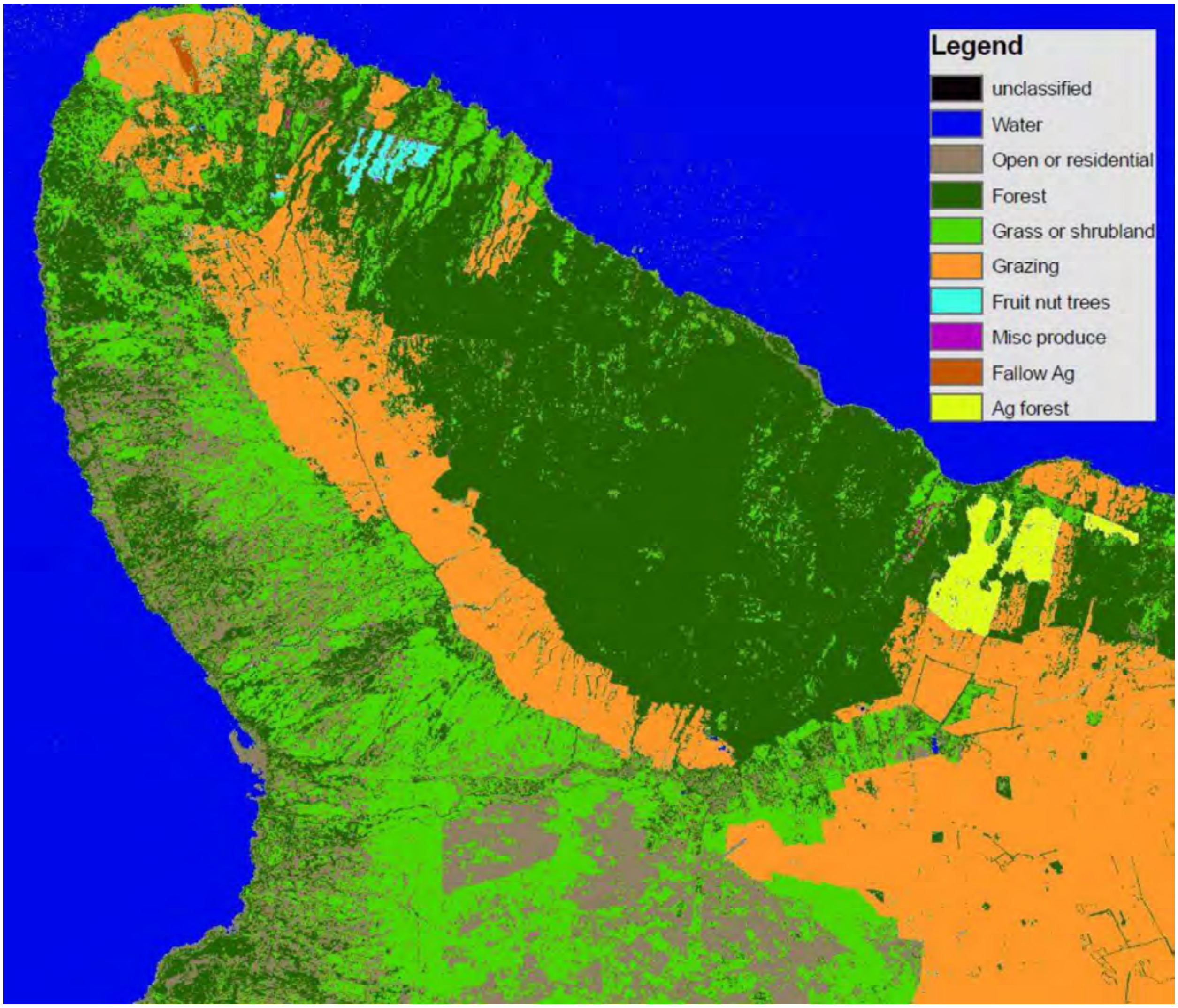


Figure 6 – Hawaii Island agricultural land use classification

2.3.5 Evaluation and clean up

After the preliminary object based semi-automated mapping process a visual assessment was done of all the agricultural areas comparing the results from the machine classified satellite data to what could be seen in the aerial imagery. If differences were detected, a manual reclassification was performed to the classified image. This process was done on each island where aerial data was collected or other available high resolution imagery could be incorporated. In some cases such as the south side of Hawaii Island, very little aerial imagery was available and so the classification relied primarily upon the machine classification and the interpreters local knowledge of the crops and land cover.

Visual examples of some of the different cover classes and the corresponding satellite data are provided in Appendix A below.

Appendix A

Figure 7 – Banana from the aerial imagery at 4cm.

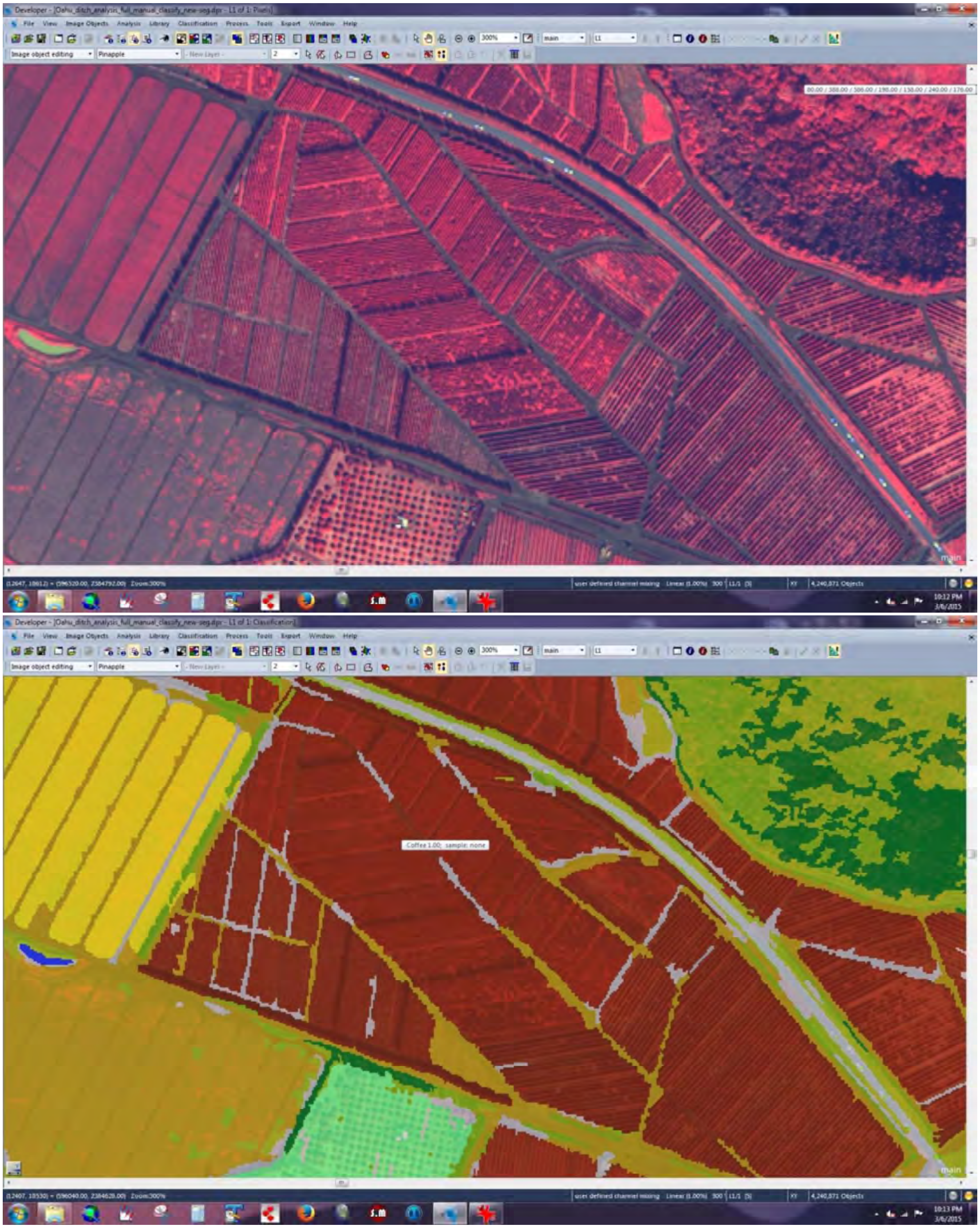


Figure 8 – Top: WV2 image. Bottom: Classified image with coffee identified in brown.

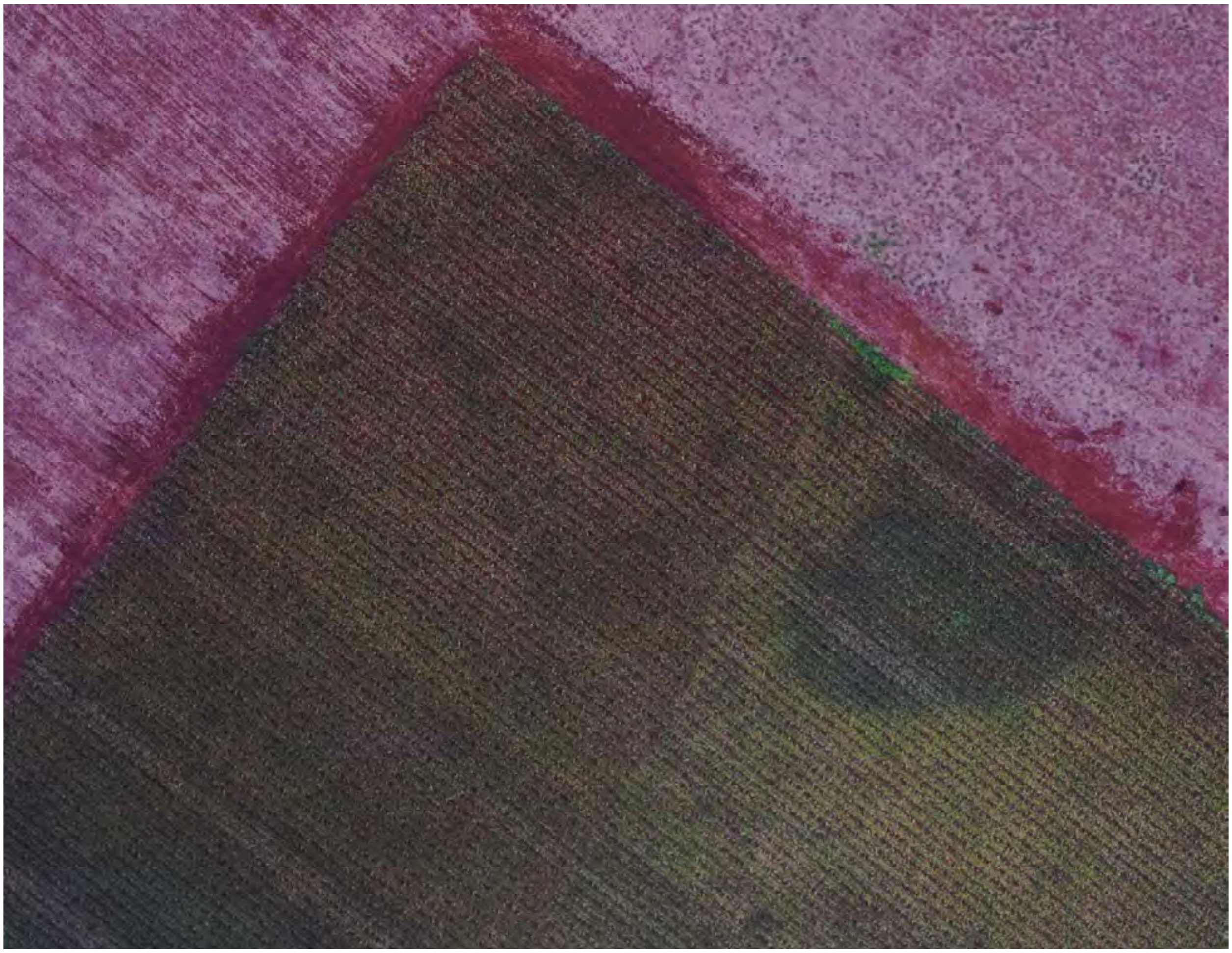
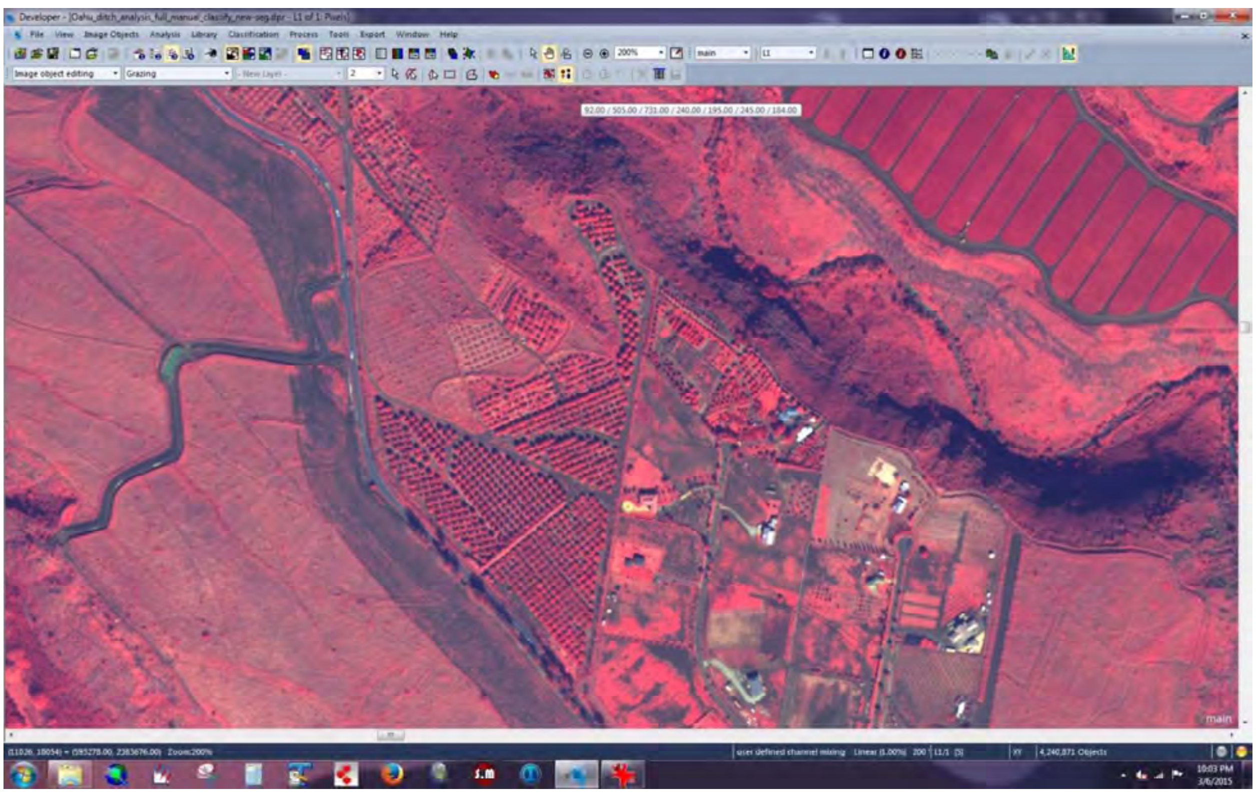


Figure 9 – Corn from the aerial imagery at 4cm.

Figure 10 – Top: WV2 image. Bottom: Classified image with corn identified in yellow.

Figure 11 – mixed fruit and nut trees from the aerial imagery at 4cm.



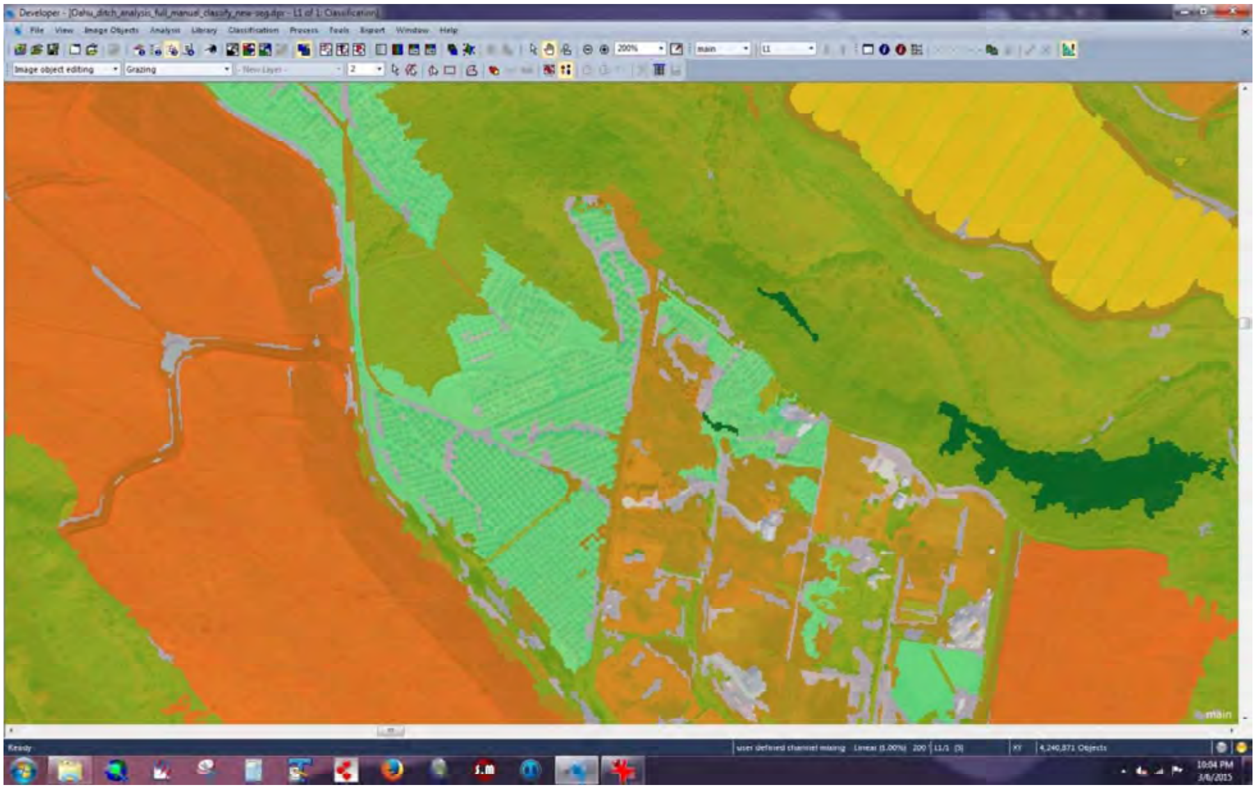


Figure 12 – Top: WV2 image. Bottom: Classified image with fruit trees identified in light green.

Figure 13 – mixed produce from the aerial imagery at 4cm.

Figure 14 – Top: WV2 image. Bottom: Classified image with mixed produce identified in purple.

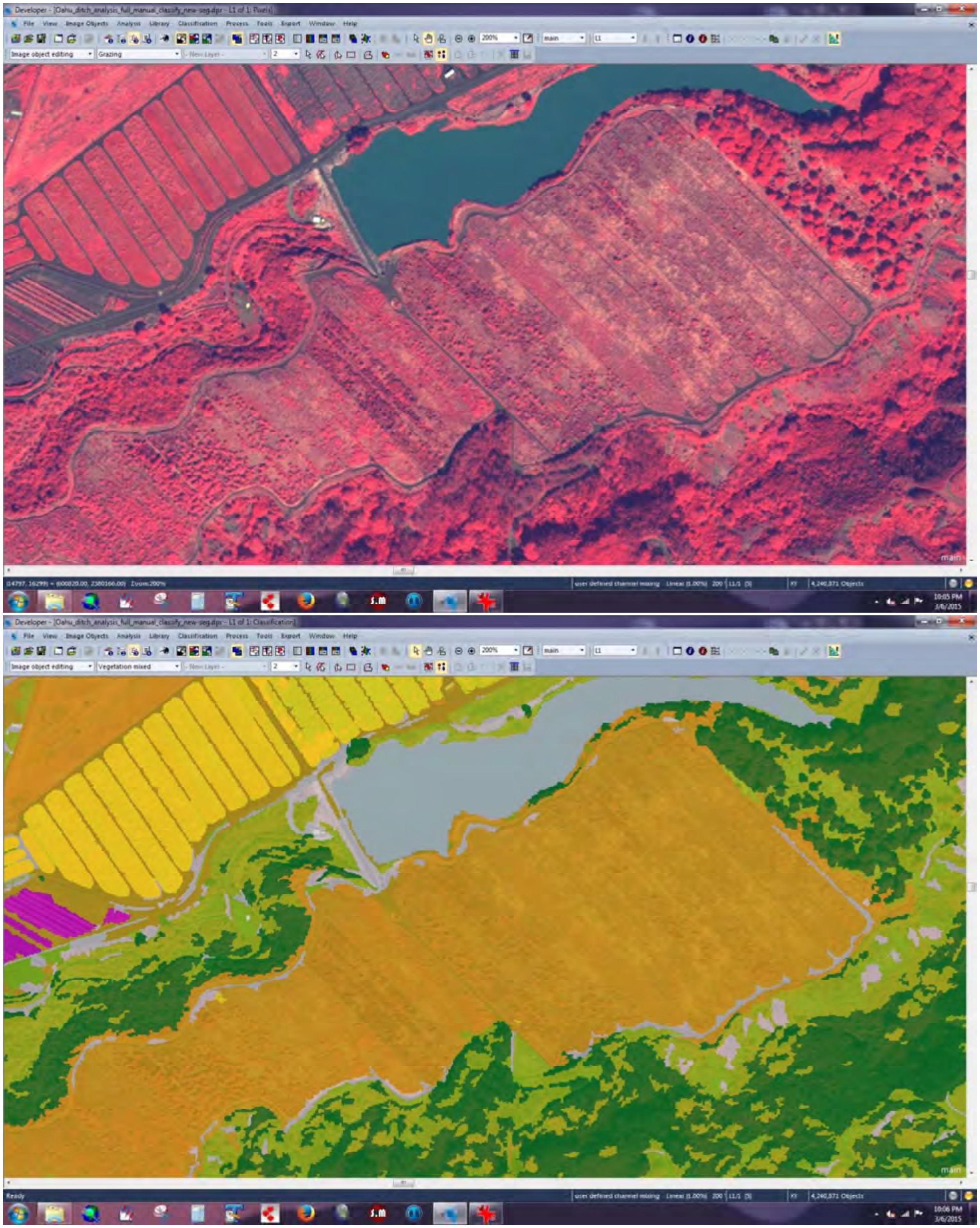


Figure 15 – Top: WV2 image. Bottom: Classified image with fallow agriculture identified in light brown.

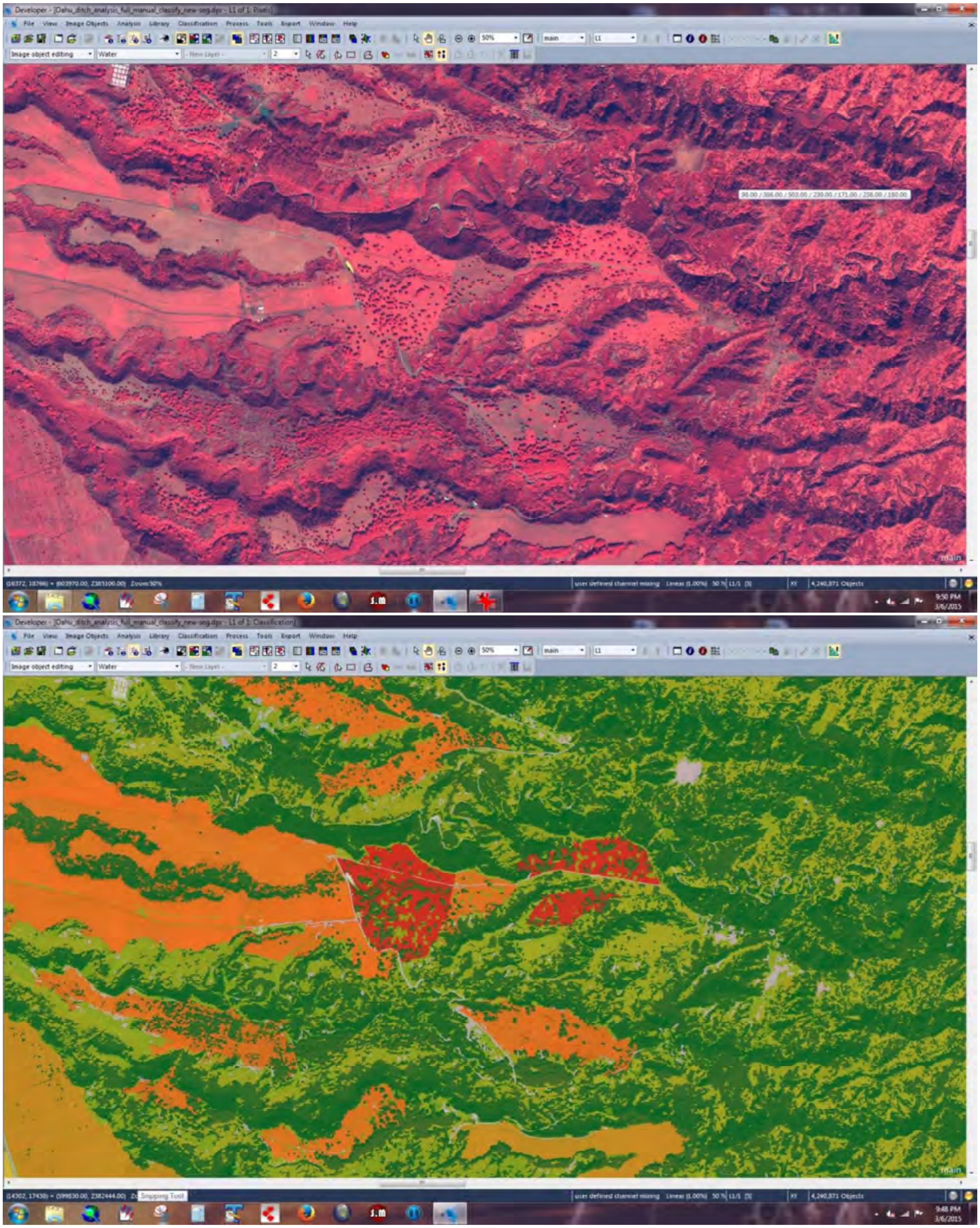


Figure 16 – Top: WV2 image. Bottom: Classified image with grazing identified in orange and fallow grazing in reddish brown.

APPENDIX F
AGENCY AND PUBLIC COMMENTS RECEIVED

AGENCY AND PUBLIC COMMENTS RECEIVED

The comments received on the December 2019 version of the AWUDP are included in this Appendix, along with the corresponding HDOA response letters. Comments were received from the following agencies and individuals.

State of Hawaii

- Department of Hawaiian Home Lands
- Department of Land and Natural Resources
  - Commission on Water Resource Management
  - Division of Forestry and Wildlife

County of Maui

- Department of Water Supply

Individuals

- Deborah Chai
- MauiGrown Coffee, Inc., James Kimo Falconer
- Kaanapali Land Management Corp., Richard Helland
- Tim Little

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DAVID Y. IGE
GOVERNOR
STATE OF HAWAII

JOSH GREEN
LT. GOVERNOR
STATE OF HAWAII

WILLIAM J. AILA, JR
CHAIRMAN
HAWAIIAN HOMES COMMISSION

TYLER I. GOMES
DEPUTY TO THE CHAIRMAN

STATE OF HAWAII
DEPARTMENT OF HAWAIIAN HOME LANDS

P. O. BOX 1879
HONOLULU, HAWAII 96805

December 18, 2020

TESTIMONY

TO: Suzanne D. Case, Chairperson
Commission on Water Resource Management (CWRM)

FROM: William Aila Jr., Chairman
Hawaiian Homes Commission

VIA: Email to dlnr.cwrm@hawaii.gov

SUBJECT: DHHL CCOMMENTS ON THE STATE OF HAWAI'I UPDATE TO THE AGRICULTURAL WATER USE AND DEVELOPMENT PLAN (AWUDP)

The Department of Hawaiian Home Lands (DHHL) has reviewed the current draft of the AWUDP. Based on our review, we join with the CWRM members who expressed significant concerns with the document during the information briefing provided on this matter.

<u>Comments on the Plan</u>

We begin by noting that there are some significant improvements to this draft of the AWUDP when compared to its 2004 version. We particularly appreciate that there was some attempt to place agricultural water use within the larger context of water policy and law in Hawai`i by reviewing relevant case decisions. We also believe the work to provide an updated, nuanced range of crop water demands will be of service to DHHL and other entities that plan for future agricultural use across Hawai`i. We also believe that the attention paid to DHHL Anahola lands and the potential to improve the upper Anahola irrigation system in order to provide irrigation water to DHHL lands is useful.

However, we do have some very significant concerns with the draft despite its positive aspects mentioned immediately above. These concerns fall into a broad theme: by repeatedly ignoring

DHHL needs, existing components of the Hawai`i Water Plan, and through direct statements in this draft, the agricultural water needs of DHHL beneficiaries are obscured and even presented negatively as a barrier to agricultural water use. We share the following observations in support of this conclusion:

- One of the most recent portions of the Hawai`i Water Plan updated is the 2017 Update to the State Water Projects Plan (SWPP), which focused on the water needs of DHHL for the next two decades - for potable *and* non potable use. DHHL staff and consultants worked closely over a number of years with staff of and consultants to the DLNR to develop the SWPP Update. Other than a single reference to the existence of the plan, there is absolutely no integration of that effort into this draft update. An integrated assessment would have focused on what would be needed to realize the proposed agricultural uses on DHHL lands.
- On page 117 the document states in relation to the Molokai Irrigation System that "The system serves agricultural lands and the Department of Hawaiian Home Lands" as if the former did not include the latter, farming occurs on Hawaiian Home Lands too.
- DHHL has significant agricultural lands in upcountry Maui at Kēōkea-Waiohuli, with agricultural homesteads and general agricultural lands. On page 122 of the document, it notes attempts to expand the upcountry system to DHHL lands would be deferred, with no explanation or analysis of impact to AWUDP plan goals.
- The discussion of the Kehena Ditch system (Section 3.3.3, beginning on page 103) is significantly inadequate. This system diverts water from state lands, and provides a brief note that it provides water to two private landowners. This completely ignores the intended and potential relationship between the source and extensive DHHL lands at Kawaihae. The reader is left with the impression that the only potential agricultural use of the waters there are by private ranches.
- In Section 4.2.2 on the Koke`e Ditch System, even the most basic publicly available information on planned improvements to the system and the delivery of water to DHHL lands to the Pu`u `Opae area was ignored.

- The document section focused on expanding agricultural areas completely ignores any DHHL lands designated for agricultural use across the entire state.

We also note two errata

- On page 148, the correct name is the Wailuku River (not the Iao stream)
- In section 7.2 the study conflates consumptive and flow through water demands for kalo

Conclusion

Faithfully carrying out the Hawaiian Homes Commission Act was a condition of statehood and is a Constitutional requirement (Article XII, Sections 1-4) that applies not only to DHHL but all parts of the state, including the Department of Agriculture. Incorporation and integration of DHHL needs is a fundamental requirement of all actions by the CWRM, including adoption of any components of the Hawai`i Water Plan, including this draft AWUDP. As is described in HRS §174C-101(a), the Commission's decision on this AWUDP:

> shall, to the extent applicable and consistent with other legal requirements and authority, incorporate and protect adequate reserves of water for current and foreseeable development and use of Hawaiian home lands as set forth in section 221 of the Hawaiian Homes Commission Act.

We do not believe that this document protects current and foreseeable development and use of water by DHHL, and may well encourage the opposite. More collaboration with DHHL on this document is encouraged prior to its adoption. Mahalo for the opportunity to comment.

JOSH GREEN, M.D.
Governor

SYLVIA LUKE
Lt. Governor

PHYLLIS SHIMABUKURO-GEISER
Chairperson, Board of Agriculture

MORRIS M. ATTA
Deputy to the Chairperson

State of Hawai'i
DEPARTMENT OF AGRICULTURE
KA 'OIHANA MAHI'AI
1428 South King Street
Honolulu, Hawaii 96814-2512
Phone: (808) 973-9600 FAX: (808) 973-9613

December 6, 2022

Mr. William Aila Jr., Chairman
Hawaiian Homes Commission
Department of Hawaiian Homelands
91-5420 Kapolei Parkway
Kapolei, HI 96707

Dear Mr. Aila:

SUBJECT: Response to Comments Regarding December 2019 Agricultural Water Use and Development Plan Update

The Hawaii Department of Agriculture (HDOA) received your comments regarding the December 2019 Agricultural Water Use and Development Plan Update (AWUDP Update). The HDOA is appreciative of your review and comments to this important document. The shared commonality between all of the commentors and the HDOA, is a collective respect and appreciation for water.

We have reviewed your comments and provided responses in the Attachment. The HDOA also prepared a 2021 Revised Edition to the December 2019 AWUDP. The Revised Edition is intended to address specific comments made during the public review period. A copy of the 2021 Revised Edition will be available at: https://hdoa.hawaii.gov/arm/.

Please note that some public comments are beyond the scope of this current document. These comments will be noted and consulted for future AWUDP updates.

Thank you again for your comments to the AWUDP Update, as well as your support of agricultural water and its role in the agricultural industry. Please contact Ms. Janice Fujimoto, Agricultural Resource Management Division, at 808-973-9473 with any questions.

Sincerely,

Phyllis Shimabukuro-Geiser
Chairperson, Board of Agriculture

cc: DLNR, Commission on Water Resource Management

ATTACHMENT
DHHL Comments and Responses

Comments on the Plan

We begin by noting that there are some significant improvements to this draft of the AWUDP when compared to its 2004 version. We particularly appreciate that there was some attempt to place agricultural water use within the larger context of water policy and law in Hawai'i by reviewing relevant case decisions. We also believe the work to provide an updated, nuanced range of crop water demands will be of service to DHHL and other entities that plan for future agricultural use across Hawai'i. We also believe that the attention paid to DHHL Anahola lands and the potential to improve the upper Anahola irrigation system in order to provide irrigation water to DHHL lands is useful.

However, we do have some very significant concerns with the draft despite its positive aspects mentioned immediately above. These concerns fall into a broad theme: by repeatedly ignoring DHHL needs, existing components of the Hawai'i Water Plan, and through direct statements in this draft, the agricultural water needs of DHHL beneficiaries are obscured and even presented negatively as a barrier to agricultural water use. We share the following observations in support of this conclusion:

One of the most recent portions of the Hawai'i Water Plan updated is the 2017 Update to the State Water Projects Plan (SWPP), which focused on the water needs of DHHL for the next two decades - for potable and non-potable use. DHHL staff and consultants worked closely over a number of years with staff of and consultants to the DLNR to develop the SWPP Update. Other than a single reference to the existence of the plan, there is absolutely no integration of that effort into this draft update. An integrated assessment would have focused on what would be needed to realize the proposed agricultural uses on DHHL lands.

Response: The HDOA's objective in the preparation of this Update was to inventory existing plantation irrigation systems and address agricultural water demand on a statewide basis. It was intended as a standalone document to represent the agricultural needs in the state water planning process. It is intended for this AWUDP Update to complement the 2017 State Water Projects Plan Update and may be used to address DHHL needs and considerations with respect to agricultural water.

- On page 117 the document states in relation to the Molokai Irrigation System that "The system serves agricultural lands and the Department of Hawaiian Home Lands" as if the former did not include the latter, farming occurs on Hawaiian Home Lands too.

  Response: This comment is addressed in the Revision.

- DHHL has significant agricultural lands in upcountry Maui at Keokea-Waiohuli, with agricultural homesteads and general agricultural lands. On page 122 of the document,it notes attempts to expand the upcountry system to DHHL lands would be deferred, with no explanation or analysis of impact to AWUDP plan goals.

Response: Comment noted. This comment will be considered in the future AWUDP.

- The discussion of the Kehena Ditch system (Section 3.3 3,beginning on page 103) is significantly inadequate. This system diverts water from state lands, and provides a brief note that it provides water to two private landowners. This completely ignores the intended and potential relationship between the source and extensive DHHL lands at Kawaihae. The reader is left with the impression that the only potential agricultural use of the waters there are by private ranches.

  Response: Comment noted. This discussion is based on the operations at the time of the survey, and has been revised to note that they are the current users. In addition, the subsection regarding Assessment of Needs acknowledges that other potential agricultural water users may be identified. Please note that Chapter 5 proposes expansion of irrigation systems and Kawaihae is presented as a potential area for agricultural growth.

- In Section 4.2.2 on the Koke'e Ditch System, even the most basic publicly available information on planned improvements to the system and the delivery of water toDHHL lands to the Pu'u 'Opae area was ignored.

  Response: Detailed information about the Kokee Ditch System was previously included in the 2004 AWUDP, Chapter 6, but was not restated here. The document also notes that the development of the system needs to be reassessed due to the 2017 settlement with CWRM. As for planned improvements, Section 4.2.2 notes that development of the system needs to be addressed. Other system updates may be provided in subsequent versions of the AWUDP.

- The document section focused on expanding agricultural areas completely ignores any DHHL lands designated for agricultural use across the entire state.

  Response: The AWUDP discusses the expansion of agricultural areas within the focus of lands directly related to the old plantation irrigation ditches pursuant to the legislative intent. Development of new water systems not related to old plantation systems are included for information and as gathered during our interviews. In future updates of the AWUDP, HDOA will again reach out to DHHL for their input into the plan.

We also note two errata

- On page 148, the correct name is the Wailuku River (not the lao stream)

- In section 7.2 the study conflates consumptive and flow through water demands for kalo

  Response: These comments are addressed in the Revision. The comment regarding the kalo study is addressed in Section 7.1.

<u>Conclusion</u>

Faithfully carrying out the Hawaiian Homes Commission Act was a condition of statehood and is a Constitutional requirement(Article XII, Sections 1-4) that applies not only to DHHL but all parts of the state, including the Department of Agriculture. Incorporation and integration of DHHL needs is a fundamental requirement of all actions by the CWRM, including adoption of any components of the Hawaii Water Plan, including this draft AWUDP. As is described in HRS §174C-101(a), the Commission's decision on this AWUDP:

> *shall, to the extent applicable and consistent with other legal requirements and authority, incorporate and protect adequate reserves of water for current and foreseeable development and use of Hawaiian Home Lands as set forth in section 221 of the Hawaiian Homes Commission Act.*

We do not believe that this document protects current and foreseeable development and use of water by DHHL, and may well encourage the opposite. More collaboration with DHHL on this document is encouraged prior to its adoption. Mahalo for the opportunity to comment.

Response: Thank you for your comment. The AWUDP is intended as a living document to represent irrigation water needs to support agricultural in Hawaii, including on DHHL lands. We look forward to working with DHHL in the future.

COMMENTS RECEIVED FROM THE

STATE OF HAWAII

DEPARTMENT OF LAND AND NATURAL RESOURCES

COMMISSION ON WATER RESOURCE MANAGEMENT

CWRM's Major Issues for Discussion w/DOA

I. <u>Consistency with Code and Framework Requirements</u> – While the statutory requirements are clearly stated, the Framework elements should also be stated up front. For the majority of the systems, the following information is lacking:

- extent of rehabilitation needed for each system (HRS 174C-31(e)(2))
- future demand forecasts, particularly for lands designated IAL (HRS 174C-31(e)(4))
- criteria to prioritize rehabilitation of the systems (HRS 174C-31-(e)(6))
- system shortfalls and excess capacities (HWP Framework Element 3)
- options for development of additional and alternative water sources (HWP Framework Element 4)
- water conservation programs and measures (HWP Framework Element 5)

We note that the majority of the systems studied in this update are private systems that did not allow visual inspection, and so the extent of rehabilitation needed (and a 5-year implementation plan) could not be developed.

II. <u>Agricultural water duties</u> - the recommended planning-level agricultural water demand rates at the farm-level water meter are considerably higher than the duties assigned by the CWRM in other water cases. These duties are based on surveys of actual use at individual farms. Because the duties are based on actual planted acreages, DOA should consider applying IWREDSS to see what computed irrigation makeup water would be needed assuming efficient on-farm water use. (CWRM staff provided the IWREDSS model and training to DOA's consultant.) The proposed duties will be used for statewide planning for agricultural water demand by the state and counties, so it is important that reasonable rates are established in this plan.

Because the proposed duties are to be applied at the farm-level water meter, it is to be presumed that Inefficiencies in the delivery systems of many of the systems would cause the rates to be even higher at the source meter, which is the point at which CWRM regulates diverted amounts. Flow measurement/metering is a critical data gap and should be programmed into the CIP for each system.

III. <u>Water Conservation and Alternative Water Sources</u> - Emphasis is placed on repair and reconstruction of the irrigation systems, while improvement of the systems to be more efficient is less of a focus. While some supply-side conservation measures are proposed for studied systems, there is little discussion of demand-side programs measures, which is another critical strategy to extend available supplies currently, and in our climate-uncertain future, especially in light of the actual metered consumption at the surveyed farms. Conservation has a great potential to increase water availability and is, in many cases, the most cost-efficient alternative, especially when considering externalities.

There is very little discussion of opportunities to meet future water needs or to replace current use of natural supplies with alternative sources, such as reclaimed water. As CWRM moves to establish measurable instream flow standards and restore mauka to makai flows, planning for alternative sources of water to meet future irrigation needs would be prudent.

IV. Implementation Plan – Of the 14 studied systems, 8 private systems would not allow visual inspection, so a 5-year CIP could not be developed. There are other systems which are partly owned by the State and private entities, and a number of the private system portions also did not allow inspection. Of the systems for which a CIP is developed, there is no criteria to prioritize rehabilitation needs. The Code also requires a long-range plan to manage the systems (HRS 174-C-31(e)(8)). The discussion in Chapter 9 to meet this requirement consists of a number of suggested projects (a laundry list of best practices) that can be implemented by system owners; this may not meet the Code requirement for a long-range management plan, 2019 AWUDP – CWRM Detailed Comments

Executive Summary

- Page xxii, objectives do not mention the Framework
- Page xxiv, Recommended Demand Rates, should expand discussion on the methodology of these recommended gpd/acre figures. Values seem artificially high. The Framework mentions that *"The review of all existing and contemplated agricultural projects shall be based upon water consumption guidelines and water demand unit rates used by the CWRM for the purposes of its water permit application review process."* This implies using IWREDSS, which has not been done here.
- Page xxv, Forecast, the Continued Maintenance scenario water use (734 mgd) seems quite high for 1% growth out to 2035. Current estimates of statewide agricultural use is ~374 mgd (WRPP Table 2-4, Summary of Reported Surface Water Use). Same for Increased Capital Investment scenario. We assume this is a statewide demand forecast, while this AWUDP update only focuses on the unstudied systems from 2004 AWUDP. There seems to be some inconsistency with the scope of this report. The forecast is based on capital investment for maintenance and improvement. Not sure if this is the best driver of agricultural water demand.
- Page xxvi, Development Plan, not sure if this will meet Water Code requirement for a long-range plan to manage the systems.

Chapter 1

- While the beginning of this chapter briefly touches on the Framework, Section 1.2, doesn't discuss meeting Framework requirements in the Goals and Objectives.

Chapter 2

- Tables 1,2,3, would have been good to include an estimated water demand for the IAL tracts.

Chapter 3

- No future estimates of water use given for any of the studied systems.
- Table 5, conversion of reservoir capacity for Kaloko Reservoir should be: 147 acre-ft = 47.9 MG.
- Page 35, second-to-last paragraph, 90.6 MG $\neq$ 287 acre-ft
- Page 38, last incomplete paragraph, the text should clarify that the flows values are for Anahola Stream.
- Table 18 indicates 4,950 feet of active system length, which doesn't match with Table 23 active system length total or Table 24.
- Tables showing land uses within service areas (e.g., Tables 28, 31, etc.) should show how much of it is IAL.
- Table 39, isn't Wainiha on the North Shore of Kauaʻi?
- Table 50, isn't water from Kauknahua stream gravity flow?
- Table 62, How was estimated current water use found? Planning numbers shown in right column. If served by wells, shouldn't we have this on WRIMS?
- Page 89, Assessment of Needs, first sentence, claim there were no leaks in the distribution system. This is unlikely—how do they know this?
- Page 91, Proposed CIP, last bullet, is sinkhole a result of leaking pipe?
- Page 97, Exhibit 26, Kehena and Kohala Ditches mislabeled on the map.

Chapter 4

- Water system inflow (source) measurement device installation should be part of CIP plans for all HDOA-owned systems.
- Page 115, first full paragraph, 150 MG/year is much less than forecasted estimate of 5.3 MGD. Is there an explanation for the difference?
- Page 117, last paragraph, 1.2 billion gallons/year is much less than forecasted estimate of 11.2 MGD. Explanation?
- Page 123, second paragraph, 307.2 MG/year is much less than forecasted estimate of 10 MGD. Explanation?
- Page 126, does not show current demand.
- Page 137, EKIS, is this system still in operation?

Chapter 5

- Page 167, Table 117, label should include Kula region.

Chapter 6

- Section 6.4.2, basing the recommended demands on farm surveys is not the most reliable method. Study lists 92 responses from agricultural park tenants, which would represent statewide water demands. The range of data within each of the agricultural park locations is quite remarkable and some of the results are counterintuitive. Table 128 shows dry season drip irrigation using more water than sprinkler or water hose methods. These anomalies require deeper analysis of why these values were reported. Crop irrigation requirements are equal to the water lost through evapotranspiration minus the gains from rainfall, groundwater contribution and soil moisture. This result can be modeled, and the data gained from the survey should be spot-checked with the model calculation results for reasonableness.
- Crop irrigation requirements vary with location (soil type, rainfall, temperature, solar exposure, etc.) so it is not reasonable to generalize the use of a few crop irrigation requirements for statewide application.
- The disparity of the metered data from the survey and modeled/previous studies suggest that some of the survey participants may be over-irrigating their crops. Especially if these farmers are fallowing 50% of their arable land at any given time. Without knowing the individual irrigation and cultivation practices, it is not reasonable to assume the survey data is appropriate and accurate.

Chapter 7

- Page 216, second full paragraph, is the last sentence true?

Chapter 8

- Page 230, Section 8.3, why wasn't annual NASS data used, was there only 5-year updates?
- The Framework gives guidance on how the demand forecast should be done. This AWUDP update bases the forecast on funding availability, which translates to water availability, instead of other factors, such as any planned/proposed agricultural projects, legislation, new initiatives, emerging markets, etc. Not sure if the funding/water availability is the most dominant driver of agricultural water demand, but the method is explained. If the irrigation systems make more water available, does this ensure that there would be more acreage under cultivation? Previous forecast models look at agriculture at-large statewide. The AWUDP update focuses only on the 14 previously unstudied systems. It is not clear if Table 143 is a forecast of the 14 previously unstudied systems or all irrigation systems.

Chapter 9

- Each systems' Five-Year capital improvement program should include flow measurement/metering.
- Page 245, Long-Range Plan for System Management, this is not a plan but a laundry list of best practices.
- Page 248, Automated water management solutions. Flow measurement/metering should be the first thing the irrigation systems should be doing.
- Page 249, Stormwater Recharge, do we know if this is a reasonable & beneficial use of water? Excess water is taken out of watershed to recharge distant aquifers. This is cited as good for aquifer recharge, but is really a secondary benefit.
- Page 252, Section 9.3, Funding, this is not a funding plan, but a list of funding options.
- Page 250, Reduce Non-revenue loss, improving delivery efficiency is a good practice, but to counter this by saying that seepage loss is a good way to recharge aquifers diminishes the idea of reducing system losses.
- Page 251, Research technological management options, this should include flow measurement and reporting, both source and consumption flow measurement.
- Page 523, not much in this 1-page section.

JOSH GREEN, M.D.
Governor

SYLVIA LUKE
Lt. Governor

PHYLLIS SHIMABUKURO-GEISER
Chairperson, Board of Agriculture

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December 6, 2022

Ms. Suzanne Case, Chairperson
Commission on Water Resource Management
Department of Land and Natural Resources
PO Box 621
Honolulu, HI 96809

Dear Chairperson Case:

SUBJECT: Response to Comments Regarding
December 2019 Agricultural Water Use and Development Plan Update

The Hawaii Department of Agriculture (HDOA) transmitted the December 2019 Agricultural Water Use and Development Plan Update (AWUDP Update) to the Department of Land and Natural Resources (DLNR) on June 10, 2020, for inclusion in the Hawaii Water Plan. The Commission on Water Resource Management (CWRM) posted a Public Hearing Notice on August 14, 2020, hosted public hearings on November 18 and 19, 2020, and accepted comments until December 18, 2020.

The HDOA is appreciative of the review and comments provided by CWRM and the public. The shared commonality between all the commentors and the HDOA, is a collective respect and appreciation for water. The HDOA developed this document to provide a plan and voice for the farmers, ranchers, and other agricultural users in their need for water to support the agricultural industry in Hawaii under current and future conditions.

We have reviewed the comments by CWRM and the public. A response to CWRM comments is included as an Attachment to this letter. In addition, copies of all HDOA responses to commentors are also included for your reference.

The HDOA also prepared a 2021 Revised Edition to the December 2019 AWUDP. The Revised Edition is intended to address specific comments made during the public review period. However, some public comments are beyond the scope of this current document. These comments will be noted and considered for future AWUDP updates. A copy of the public comments and HDOA responses will be included as an Appendix to the Revised Edition.

Thank you again for your comments to the AWUDP Update, as well as your support of agricultural water and its role in the agricultural industry. Please contact Ms. Janice Fujimoto, Agricultural Resource Management Division, at 808-973-9473 with any questions.

Sincerely,

Phyllis Shimabukuro-Geiser

Phyllis Shimabukuro-Geiser
Chairperson, Board of Agriculture

ATTACHMENT 1
Response to CWRM Comments

GENERAL COMMENTS

I. **<u>Comment: Consistency with Code and Framework Requirements</u>** – While the statutory requirements are clearly stated, the Framework elements should also be stated up front. For the majority of the systems, the following information is lacking:

- extent of rehabilitation needed for each system (HRS 174C-31(e)(2))
- future demand forecasts, particularly for lands designated IAL (HRS 174C-31(e)(4))
- criteria to prioritize rehabilitation of the systems (HRS 174C-31-(e)(6))
- system shortfalls and excess capacities (HWP Framework Element 3)
- options for development of additional and alternative water sources (HWP Framework Element 4)
- water conservation programs and measures (HWP Framework Element 5)

We note that the majority of the systems studied in this update are private systems that did not allow visual inspection, and so the extent of rehabilitation needed (and a 5-year implementation plan) could not be developed.

Response: *In the development of the AWUDP, the HDOA focused and prioritized the statutory requirements over the framework elements. As such, the statutory requirements are detailed on pages 1 and 2. The framework objectives are discussed on page 2 and its details are included in Appendix B of the Plan.*

- *To the extent reasonable and feasible the AWUDP provides the rehabilitation assessment for each system. The development plans for private systems are considered proprietary and business confidential information. Therefore, it is the owners/operators' prerogative to share this information for a public document.*

- *Future water demands are shown in Chapter 8. Future demand forecasts for IALs are provided on page 23. Since the use and acreage of IALs is not forecast to change, future water demand is not forecast to change based on current climatic conditions.*

- *Rehabilitation recommendations are prioritized using a good/fair/poor rating system. The prioritization is further explained in the Revision. The priority projects are listed as short-term projects for the system and are typically related to an immediate need. Longer-term projects have less priority or are not needed for immediate corrective action.*

- *Comment noted. The Revision will clarify the findings and identify system shortfalls. It has been determined that there is no excess capacity, as the forecast shows a potential increase in water use if enough funding is available to develop additional lands and improve the distribution systems. If the State of Hawaii has a sustainability goal, more water will be needed to support the growth of agriculture. The expectation is for agriculture to grow over time. Chapter 8 includes the forecast analysis and includes a discussion of the demand given the no action, maintenance option, and increased* *investment in irrigation infrastructure. It was determined that the identification of shortfalls and excess capacity would only represent one snapshot in time and invalidate the forecast analysis and future planning.*

- *Options for development of additional water sources are included in Chapter 5, and alternative water sources are discussed in Chapter 9.2.2.*
- *Chapter 9.2.2 discusses options for water system owners to conserve water.*

Although not visually inspected, the private systems are currently operating and supporting various agricultural communities. They are critical to the agricultural industry. The private system owners/operators are tasked with maintaining their own systems and funding their own improvements. Although rehabilitation plans are not included for all private systems in this AWUDP Update, it should not be categorically assumed that the system owners/operators are not developing plans. Their future plans and project cost estimates are proprietary and business confidential. In addition, as state funds cannot be used for private systems, this information is irrelevant and/or unnecessary for state CIP programming considerations.

II. **<u>Comment: Agricultural water duties</u>** - the recommended planning-level agricultural water demand rates at the farm-level water meter are considerably higher than the duties assigned by the CWRM in other water cases. These duties are based on surveys of actual use at individual farms. Because the duties are based on actual planted acreages, DOA should consider applying IWREDSS to see what computed irrigation makeup water would be needed assuming efficient on-farm water use. (CWRM staff provided the IWREDSS model and training to DOA's consultant.) The proposed duties will be used for statewide planning for agricultural water demand by the state and counties, so it is important that reasonable rates are established in this plan.

Because the proposed duties are to be applied at the farm-level water meter, it is to be presumed that Inefficiencies in the delivery systems of many of the systems would cause the rates to be even higher at the source meter, which is the point at which CWRM regulates diverted amounts. Flow measurement/metering is a critical data gap and should be programmed into the CIP for each system.

Response: *The agricultural water demand rates provided in the Plan are based on averages of actual use data at individual farms. Such data should also be representative of actual planted acreages and reflects the crops and needs of farmers in the survey. As noted in the Plan, actual water demand is dependent on a range of variables, including crop type, elevation, rainfall, and location. The HDOA provides the rate as a planning guideline for farmers. However, it also expects each farmer to know their crops and land to best estimate their farm-specific water demands.*

The AWUDP recommends that the system operators analyze the water use specifically for their system, with consideration of the crops which are or may be grown. Actual water use accounts for the variability in farming techniques and farming customization of the farmer and their crop.

The use of IWREDSS would bias the data toward the goals and objectives of CWRM rather than goals and objectives of the agricultural community. In addition, IWREDSS has not been statistically validated to real-world application and is only a theoretical model. Documents reveal that it may have been validated for farms at Waimanalo, which has moderate rainfall and not indicative to other growing areas and farming techniques. Given the diversity of crops, soils, rainfall and other factors in the state, the use of one farming area does not provide adequate statistical representation for the other farming areas in the State.

We agree. System losses in inefficient delivery systems are not captured in the water rates. Each system is expected to have a different loss rate, and therefore, agree that water flow at the source will be significantly higher. This is recognized in the AWUDP, and one of the recommendations in Chapter 9.2.2 is to study distribution system losses.

HDOA plans to implement a program to collect flow data in all of their systems as funds are made available in water systems. The flow data from non-HDOA systems have been reported by system owners/ operators to CWRM and that data is presented in the AWUDP for the various systems.

III. **Comment: Water Conservation and Alternative Water Sources** - Emphasis is placed on repair and reconstruction of the irrigation systems, while improvement of the systems to be more efficient is less of a focus. While some supply-side conservation measures are proposed for studied systems, there is little discussion of demand-side programs measures, which is another critical strategy to extend available supplies currently, and in our climate-uncertain future, especially in light of the actual metered consumption at the surveyed farms. Conservation has a great potential to increase water availability and is, in many cases, the most cost-efficient alternative, especially when considering externalities.

There is very little discussion of opportunities to meet future water needs or to replace current use of natural supplies with alternative sources, such as reclaimed water. As CWRM moves to establish measurable instream flow standards and restore mauka to makai flows, planning for alternative sources of water to meet future irrigation needs would be prudent.

Response: *We agree that the Plan was developed to maintain the irrigation systems that currently serve our agricultural communities. The Plan does focus on the status of the collection and distribution systems themselves, as their upkeep has the widest reach in affecting farmers. Demand-side programs that are intended to reduce the use of water at each farm, are the purview of each farmer and the manner in which they run their operations. The comment is correct in that the AWUDP focuses on the collection systems and conveyance* *for irrigation water that can serve many farmers, rather than the use at individual farms. The priority is to maintain the flow of water to the farmers, and renovation and improvements are limited to the funding available to the system owners/operators.*

We agree that demand-side programs are important for water conservation. However, it is outside the scope of this document. This document represents the importance of water in sustaining agriculture. Redevelopment of demand side use can be very costly and especially burdensome on farmers as they are struggling to survive.

Alternative water sources are briefly discussed in Chapter 9.2.2 of the AWUDP. It should be noted that the development of alternative water sources and connection of these sources to farms is extremely costly. These costs are especially difficult to bear by farmers who operate on a thin margin.

We recommend that the pursuit of alternative water sources instead be emphasized for residential, commercial, and industrial applications, as they have greater financial resources than the agricultural producers. Agriculture needs the availability of inexpensive water to allow farmers to provide competitive pricing on their goods. In addition, the use of reuse water in farming is likely to adversely impact the product marketability and acceptance by consumers.

IV. **Comment: Implementation Plan** – Of the 14 studied systems, 8 private systems would not allow visual inspection, so a 5-year CIP could not be developed. There are other systems which are partly owned by the State and private entities, and a number of the private system portions also did not allow inspection. Of the systems for which a CIP is developed, there is no criteria to prioritize rehabilitation needs. The Code also requires a long-range plan to manage the systems (HRS 174-C-31(e)(8)). The discussion in Chapter 9 to meet this requirement consists of a number of suggested projects (a laundry list of best practices) that can be implemented by system owners; this may not meet the Code requirement for a long-range management plan,

Response: *The system rating (good/fair/poor) provides the criteria for rehabilitation. The individual system owners are responsible for the system changes and the associated costs. The priority projects for each system are shown as short-term projects*

System owners/operators may not be in a financial position to implement the short-term system needs to keep water flowing, much less the long-range goals. The priority of these short-term projects is to maintain the flow of water to the farmers and continue productive use of the land.

As previously discussed, the private owner/operators' plans are propriety and business confidential. Further, it is their responsibility to fund and implement. In speaking with system owners and farmers in the development of this document, we are aware that they may not even be able to afford their short-term imminent system needs. As such, requiring the implementation of expensive long-term strategies is not in sync with the agricultural *community. Accordingly, the long-range strategies are intended for each system owner to best determine the option that suits their needs and provides the highest return for agriculture.*

DETAILED COMMENTS

Response: Please note that the investigation for this version began in 2015. As such, some of the information provided in this December 2019 document may be dated as it captures our findings at that past point in time. The AWUDP is a living document and is intended for periodic revision in the coming years. Any comments that are not addressed in the document will be noted and considered for future AWUDP updates.

Comments: Executive Summary

- Page xxii, objectives do not mention the Framework

  Response: See above response in the general comments regarding the Framework.

- Page xxiv, Recommended Demand Rates, should expand discussion on the methodology of these recommended gpd/acre figures. Values seem artificially high. The Framework mentions that *"The review of all existing and contemplated agricultural projects shall be based upon water consumption guidelines and water demand unit rates used by the CWRM for the purposes of its water permit application review process."* This implies using IWREDSS, which has not been done here.

  Response: Page xxiv states, "This AWUDP Update expands on this analysis by evaluating water demand from 113 farms growing different crops in various growing regions throughout the state; water demand rates from farms in Kunia, Oahu and published historical demand rates."

  The demand rate is the amount of water that is being used by farmers. Overwatering is expensive, detrimental to crop production, increases disease potential, and causes soil erosion. Overwatering is not in a farmers' best interest.

  IWREDSS may not reflect the actual or future water use required by crops given the area, crop type and climatic condition. If it has not already been done so, IWRDESS should also be validated to address climate change, long-term drought conditions, rising temperatures, etc. Due to these uncertainties in the IWREDSS model, it was not incorporated into the document and actual field data was used, instead.

- Page xxv, Forecast, the Continued Maintenance scenario water use (734 mgd) seems quite high for 1% growth out to 2035. Current estimates of statewide agricultural use is ~374 mgd (WRPP Table 2-4, Summary of Reported Surface Water Use). Same for Increased Capital Investment scenario. We assume this is a statewide demand forecast, while this AWUDP update only focuses on the unstudied systems from 2004 AWUDP. There seems to be some inconsistency with the scope of this report. The forecast is based on capital investment for maintenance and improvement. Not sure if this is the best driver of agricultural water demand.

Response: Comment noted. We understand your question is based on comparison of the 374 mgd rate taken from the WRPP, Summary of Reported Surface Water Use. This rate was considered, but ultimately was not used for the purpose of forecasting since it underestimates agriculture water demand. Some farmers use other sources of agricultural water that are not included in this estimate. In this AWUDP Update, the forecast is based on an estimate of 651 mgd.

To clarify, Chapter 3 focuses on unstudied systems that were not included in the 2004 AWUDP, while Chapter 4 provides updates on the 2004 AWUDP studied systems. However, the forecast and CIP programs looks at all of the agricultural systems studied in both the 2004 AWUDP and the current report. Information from the forecast is used to evaluate water demand on a statewide basis.

Water demand is proportional to agricultural production. To increase agriculture production by system, there will be a corresponding need for increased water flow, and associated investment in additional projects to increase flow efficiency, storage, and source production. The inverse is also true: The lack of investment will reduce irrigation water transmission, decrease agricultural production, and fallow current productive lands. Capital investment in the water systems provides the means for maintaining or increasing agricultural production.

- Page xxvi, Development Plan, not sure if this will meet Water Code requirement for a long-range plan to manage the systems.

Response: This Development Plan was included with the intent of fulfilling the Water Code requirement. It provides long-range plans to manage water systems but presents the plans in a manner that acknowledges and respects the real challenges faced by system owners in their efforts to support agriculture. Water availability is one of many components that enable the success of agriculture.

The immediate CIP requirements for the improvement of the existing irrigation systems are expensive, and system owners/operators are not in a financial position to implement the short-term needs, much less the long-range ones. As such, the menu of long-range strategies is intended for each system owner to best determine the plan that suits them best. For some of the systems in Chapters 3 and 4, long-range plans for system improvements are listed as CIP projects.

In general, long-range funding forecasts generally reflect short-term costs but over extended periods of time. Finite maintenance funds are commonly used to address unplanned events, such as failures after storms. To maintain financial flexibility, system owners/operators may not prepare and adhere to a prescribed CIP plan.

That being said, the budget used in the short-term to maintain the systems would be similar over the next twenty years, with increases for cost of living and inflation. The long-term strategies in the Development Plan may be used to supplement these vital and ongoing system maintenance issues. The AWUDP Update is mindful that no owner/operator can predict where the failures, unplanned and catastrophic events will occur given the age of the facilities.

Comments: Chapter 1

- While the beginning of this chapter briefly touches on the Framework, Section 1.2, doesn't discuss meeting Framework requirements in the Goals and Objectives.
  Response: This comment will be considered in the future AWUDP.

Comments: Chapter 2

- Tables 1,2,3, would have been good to include an estimated water demand for the IAL tracts.

  Response: The data included in these tables are from the information contained in the IAL Decisions and Orders. The operations on the IAL are considered business confidential and proprietary. It is the owner's prerogative to share that information. Each farm has different water needs and may choose to change crops as needed by economic drivers.

Comments: Chapter 3

- No future estimates of water use given for any of the studied systems.
  Response: As stated above, water demand varies. Each farm has different water needs and may choose to change crops as needed by economic drivers. Many of the water systems serve multiple individual farmers. No data was provided in the Decisions and Orders for IAL tracts.

- Table 5, conversion of reservoir capacity for Kaloko Reservoir should be: 147 acre-ft = 47.9 MG.
  Response: This comment is addressed in the Revision.

- Page 35, second-to-last paragraph, 90.6 MG ≠ 287 acre-ft
  Response: This comment is addressed in the Revision.

- Page 38, last incomplete paragraph, the text should clarify that the flows values are for Anahola Stream.
  Response: This comment is addressed in the Revision.

- Table 18 indicates 4,950 feet of active system length, which doesn't match with Table 23 active system length total or Table 24.
  Response: This comment is addressed in the Revision.

- Tables showing land uses within service areas (e.g., Tables 28, 31, etc.) should show how much of it is IAL.
  Response: The land use within the IAL is stated in the document. Table 1 provides a better description of the crops in the IAL.

- Table 39, isn't Wainiha on the North Shore of Kaua'i?
Response: Gage name was presented in the data received from CWRM in 2017. Description of the Gage name is Wainiha Powerhouse Plant.

- Table 50, isn't water from Kaukonahua stream gravity flow?
Response: Data gathering during the interview process indicated a pump was used for this intake.

- Table 62, How was estimated current water use found? Planning numbers shown in right column. If served by wells, shouldn't we have this on WRIMS?
Response: This information is based on HDOA planning guidelines in the 1984 Environmental Impact Statement for the Kahuku Agricultural Park.

- Page 89, Assessment of Needs, first sentence, claim there were no leaks in the distribution system. This is unlikely—how do they know this?
Response: This comment is addressed in the Revision. The statement is revised to state that there are, "No visible and known leaks in the distribution system."

- Page 91, Proposed CIP, last bullet, is sinkhole a result of leaking pipe?
Response: The sinkhole investigation is ongoing.

- Page 97, Exhibit 26, Kehena and Kohala Ditches mislabeled on the map.
Response: This comment is addressed in the Revision.

Comments: Chapter 4

- Water system inflow (source) measurement device installation should be part of CIP plans for all HDOA-owned systems.
Response: HDOA has installed or plans to install flow measurement devices in all of its systems. Those systems are planned to have flow measuring devices installed are in the CIP tables.

- Page 115, first full paragraph, 150 MG/year is much less than forecasted estimate of 5.3 MGD. Is there an explanation for the difference?
Response: The forecasted flow exceeds current capacity. This comment is addressed in the Revision.

- Page 117, last paragraph, 1.2 billion gallons/year is much less than forecasted estimate of 11.2 MGD. Explanation?
Response: The forecasted flow exceeds current capacity. This comment is addressed in the Revision.

- Page 123, second paragraph, 307.2 MG/year is much less than forecasted estimate of 10 MGD. Explanation?
Response: The forecasted flow exceeds current capacity. Noted in Revision.

- Page 126, does not show current demand.
  Response: Forecasted water demand is provided for LHD at 12.5 mgd.

- Page 137, EKIS, is this system still in operation?
  Response: Yes, this system is still in operation.

Comments: Chapter 5

- Page 167, Table 117, label should include Kula region.
  Response: This comment is addressed in the Revision.

Comments: Chapter 6

- Section 6.4.2, basing the recommended demands on farm surveys is not the most reliable method. Study lists 92 responses from agricultural park tenants, which would represent statewide water demands. The range of data within each of the agricultural park locations is quite remarkable and some of the results are counterintuitive. Table 128 shows dry season drip irrigation using more water than sprinkler or water hose methods. These anomalies require deeper analysis of why these values were reported. Crop irrigation requirements are equal to the water lost through evapotranspiration minus the gains from rainfall, groundwater contribution and soil moisture. This result can be modeled, and the data gained from the survey should be spot-checked with the model calculation results for reasonableness.
  Response: Comment noted. This comment will be considered in studies.

- Crop irrigation requirements vary with location (soil type, rainfall, temperature, solar exposure, etc.) so it is not reasonable to generalize the use of a few crop irrigation requirements for statewide application.
  Response: Yes, we agree that there is so much variability that the planning guidance may underestimate water demand in dry areas, and overestimate water demand in very wet climates. However, if applied to a regional planning effort, the water demand should serve to provide planning guidance for water demand for diversified agriculture.

  The AWUDP recognizes that the variability of the water demand and does show a range of water demand by area and crop. Therefore, the AWUDP recommends that the specific agricultural areas perform their own analysis to 1) determine their water needs, and 2) to assist in the re-development of their water systems to serve diversified agriculture. The use of actual water demand reported by multiple farms provides a good indicator that considers the variability of the water demand.

- The disparity of the metered data from the survey and modeled/previous studies suggest that some of the survey participants may be over-irrigating their crops. Especially if these farmers are fallowing 50% of their arable land at any given time. Without knowing the individual

irrigation and cultivation practices, it is not reasonable to assume the survey data is appropriate and accurate.
Response: Comment noted. The converse argument could also be true and the modeled data may result in insufficient watering of the crops. While the HDOA cannot state that over-irrigating never occurs, please note that over-irrigation is not in a farmers' best interest. Overwatering costs more money and is not optimal for crops.

The amount of irrigation is typically tied to the productivity of the crop and how the farmer can maintain maximum productivity of their crops. Over irrigation causes problems and reduced productivity, as stated in the AWUDP. In addition, over irrigation is costly and given the small profit margins for farmers, not in their best interest.

Comments: Chapter 7

- Page 216, second full paragraph, is the last sentence true?
  Response: Yes.

Comments: Chapter 8

- Page 230, Section 8.3, why wasn't annual NASS data used, was there only 5-year updates?
  Response: Yes, only five-year updates are available.

- The Framework gives guidance on how the demand forecast should be done. This AWUDP update bases the forecast on funding availability, which translates to water availability, instead of other factors, such as any planned/proposed agricultural projects, legislation, new initiatives, emerging markets, etc. Not sure if the funding/water availability is the most dominant driver of agricultural water demand, but the method is explained. If the irrigation systems make more water available, does this ensure that there would be more acreage under cultivation? Previous forecast models look at agriculture at-large statewide. The AWUDP update focuses only on the 14 previously unstudied systems. It is not clear if Table 143 is a forecast of the 14 previously unstudied systems or all irrigation systems.
  Response: New State polices and initiatives such as sustainability and food security require the growth of agriculture. If there lacks an adequate supply of inexpensive water to make an agricultural program feasible and profitable, agricultural projects could not begin or exist. The availability of water is vital to the success of an agricultural endeavor. The forecast supports the development of agriculture by removing the water supply constraint.

  Although this AWUPD is focused on agricultural water demand, a broader view is needed to evaluate whether an increase in water will result in an increase of cultivated acreage. The availability of agricultural water is only one component that will drive, or hamper, this growth. Other factors that impact agricultural grown include, but are not limited to, available work force, market demand, and other ancillary costs. The goal for this AWUDP is to allow farmers access to agricultural water, thereby supporting one area of their agricultural business considerations.

  Table 143 is based on all studied irrigation system in both AWUDPs.

Comments: Chapter 9

- Each systems' Five-Year capital improvement program should include flow measurement/metering.
  Response: HDOA plans to implement flow measurement in their systems and the future installation of flow meters in those systems are shown in the CIP.

- Page 245, Long-Range Plan for System Management, this is not a plan but a laundry list of best practices.
  Response: The immediate CIP requirements for these systems are expensive and may not be applicable to all systems. System owners/operators are not in a financial position to implement the short-term needs, much less the long-range ones. As such, the long-range strategies are intended for each system owner to best determine the plan that suits them best.

- Page 248, Automated water management solutions. Flow measurement/metering should be the first thing the irrigation systems should be doing.
  Response: Automated water management solutions have been proven to work well on large farms and not proven feasible on smaller farms, such as many of those in Hawaii. In addition, the amount capital outlay for smaller farms is not feasible for farmers to expend. Therefore, the farmer and the system owners need to determine if this is a workable solution and cost-effective.

- Page 249, Stormwater Recharge, do we know if this is a reasonable & beneficial use of water? Excess water is taken out of watershed to recharge distant aquifers. This is cited as good for aquifer recharge, but is really a secondary benefit.
  Response: This comment will be considered in the future AWUDP.

- Page 252, Section 9.3, Funding, this is not a funding plan, but a list of funding options.
  Response: Each system owner is responsible for the management of their system. The funding options presented in this section offers a mechanism for funding to both state or private entities.

- Page 250, Reduce Non-revenue loss, improving delivery efficiency is a good practice, but to counter this by saying that seepage loss is a good way to recharge aquifers diminishes the idea of reducing system losses.
  Response: The statement in the AWUDP is not incorrect, but this comment will be considered in the future AWUDP.

- Page 251, Research technological management options, this should include flow measurement and reporting, both source and consumption flow measurement.
  Response: HDOA plans to implement a program for flow measurements and CWRM has been provide flow measurement from other water systems. However, this will be noted for future AWUDP studies.

- Page 523, not much in this 1-page section.
  Response: This comment will be considered in the future AWUDP.

General: The Pre-Publication Comments include many detailed CWRM comments about the systems. While this information could not be verified by the AWUP update author, CWRM's input is appreciated. Additional maps were added to Appendix A to show the CWRM alignments.

In addition, it is noted that irrigation system details are subject to additional changes and updates over time. This AWUP Update reflects the status at the time of the investigation. It is intended for future AWUP iterations to revisit and update such information.

DAVID Y. IGE
GOVERNOR OF HAWAII

SUZANNE D. CASE
CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES
COMMISSION ON WATER RESOURCE MANAGEMENT

ROBERT K. MASUDA
FIRST DEPUTY

M. KALEO MANUEL
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AQUATIC RESOURCES
BOATING AND OCEAN RECREATION
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CONSERVATION AND RESOURCES ENFORCEMENT
ENGINEERING
FORESTRY AND WILDLIFE
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DEPARTMENT OF LAND AND NATURAL RESOURCES
DIVISION OF FORESTRY AND WILDLIFE
1151 PUNCHBOWL STREET, ROOM 325
HONOLULU, HAWAII 96813

November 9, 2020

MEMORANDUM

TO: M. Kaleo Manuel, Deputy Director-Water
Commission on Water Resource Management

FROM: David G. Smith, Administrator DGS

SUBJECT: Comments on the 2019 Agricultural Water Use and Development Plan (AWUDP) Update

The Division of Forestry and Wildlife (DOFAW) offers the following comments on the 2019 AWUDP Update. While it is understood that the AWUDP is intended to address projected water demands and prioritize repair, maintenance, and upgrades to existing statewide water systems, it is concerning that DOFAW was not consulted in the drafting of this plan. As stated in the first sentence of the AWUDP executive summary, "water is essential to grow crops and maintain a viable agricultural industry." Yet, there is no mention of forests - the natural "green infrastructure" that creates this essential source of water used by farmers.

DOFAW and the forest reserve system was created in 1903 to help the agriculture, pineapple and sugar cane industries deal with declining water supplies, which were the direct result of deforestation caused largely by feral animals. Since that time, DOFAW's mission has not changed. We continue to be the lead agency responsible for coordinating the protection of forested watersheds for water supply on both public and private lands statewide. The failure of the AWUDP to reference the important role of forests in the production and sustainment of water supplies in the larger picture of food security and local farming is puzzling. It hinders holistic thinking and statewide planning efforts to think about water source as simply the physical pipeline, ditch or reservoir, when in fact, the true "source" of this water is rainfall and mist captured by our forests that flows into aquifers and streams. Forests are critical infrastructure necessary to meet current and future water demands and requirements of Hawaii's diversified agriculture industry, Especially as many State agencies are striving for a "one water" approach to management, we can no longer afford to think of these systems operating in silos.

Most of the existing agricultural water systems are or will be over 100 years old, with many emanating from state DOFAW Forest Reserves. While there is a need to repair and upgrade these water delivery systems and infrastructure, the maintenance and upkeep of our forests – the "green infrastructure" that is the source of all water in the islands - is equally important. This is why DOFAW is actively working with the Department's Land Division and Commission on Water Resource Management (CWRM) to create a watershed cost-share as part of the water lease requirements, pursuant to section 171-58(e) of Hawaii Revised Statutes (HRS). Money contributed by water lessees through the watershed cost-share will be in addition to lease rent and support the management of forests that directly feed the water lease area. DOFAW is investing heavily to protect watersheds statewide and would like to see fees applied to water systems that have ditches and infrastructure originating from DOFAW forest reserve lands. The money generated by these fees would be used to manage the forested watersheds where the intakes and ditches are located. DOFAW would like to involve HDOA in future conversations related to the setting of water rates and fees, collection and enforcement of such a tariff, and the use of expenditures from revenues generated.

The AWUDP talks about capital improvement project (CIP) opportunities or areas identified as important agricultural systems or in need of upgrades. DOFAW currently invests millions of CIP monies into watershed protection fencing in high elevation forests. Since these fences have a direct benefit on future ground and surface water resources, we encourage DOA to communicate more with DOFAW about CIP investments (i.e.: upgrades to pipelines, ditches and reservoirs) so we can better understand the nexus between DOFAW's CIP fences and subsequent impacts on water flow to downstream users over time. Similarly, there is little mention of the repair and maintenance of the roads that lead to many of these ditches and systems. DOFAW manages many of these roads with little injection of capital from any other State or non-State entity.

As managers of the State forest reserves, DOFAW would like to be informed of any work done to the water systems that reside within a forest reserve. DOFAW encourages water system managers to obtain legal easements or access to intakes located within State forest reserves. While DOFAW can issue access permits, a long-term easement issued through Land Division is preferred. Any future land transfers or agreements made between the Department's Land Division and agricultural coalitions should be communicated to DOFAW. This is important because certain agricultural entities have been reluctant to cooperate with DOFAW for access in areas that traverse a forest reserve.

Mahalo for the opportunity to comment.

Sincerely,

DAVID G. SMITH
Administrator

JOSH GREEN, M.D.
Governor

SYLVIA LUKE
Lt. Governor

PHYLLIS SHIMABUKURO-GEISER
Chairperson, Board of Agriculture

MORRIS M. ATTA
Deputy to the Chairperson

State of Hawai'i
DEPARTMENT OF AGRICULTURE
KA 'OIHANA MAHI'AI
1428 South King Street
Honolulu, Hawaii 96814-2512
Phone: (808) 973-9600 FAX: (808) 973-9613

December 6, 2022

Mr. David G. Smith, Administrator
Department of Land and Natural Resources
Division of Forestry and Wildlife
1151 Punchbowl Street, Room 325
Honolulu, Hawaii 96813

Dear Mr. Smith:

SUBJECT: Response to Comments Regarding December 2019 Agricultural Water Use and Development Plan Update

The Department of Agriculture (HDOA) appreciates your review and comments to the December 2019 Agricultural Water Use and Development Plan Update (AWUDP). We appreciate your perspective and insight regarding the forest reserve system, which is an integral part of these water delivery systems.

We have reviewed your comments and provided responses below. The HDOA also prepared a 2021 Revised Edition to the December 2019 AWUDP. The Revised Edition is intended to address specific comments made during the public review period. A copy of the 2021 Revised Edition will be available at: https://hdoa.hawaii.gov/arm/.

Please note that some public comments are beyond the scope of this current document. These comments will be noted and consulted for future AWUDP updates.

Comment: The Division of Forestry and Wildlife (DOFAW) offers the following comments on the 2019 AWUDP Update. While it is understood that the AWUDP is intended to address projected water demands and prioritize repair, maintenance, and upgrades to existing statewide water systems, it is concerning that DOFAW was not consulted in the drafting of this plan. As stated in the first sentence of the AWUDP executive summary, "water is essential to grow crops and maintain a viable agricultural industry." Yet, there is no mention of forests - the natural "green infrastructure" that creates this essential source of water used by farmers.

DOFAW and the forest reserve system was created in 1903 to help the agriculture, pineapple and sugar cane industries deal with declining water supplies, which were the direct result of deforestation caused largely by feral animals. Since that time, DOFAW's mission has not changed. We continue to be the lead agency responsible for coordinating the protection of forested watersheds for water supply on both public and private lands statewide. The failure of the AWUDP to reference the important role of forests in the production and sustainment of water supplies in the larger picture of food security and local farming is puzzling. It hinders holistic thinking and statewide planning efforts to think about water source as simply the physical pipeline, ditch or reservoir, when in fact, the true "source" of this water is rainfall and mist captured by our forests that flows into aquifers and streams. Forests are critical infrastructure necessary to meet current and future water demands and requirements of Hawaii's diversified agriculture industry, especially as many State agencies are striving for a "one water" approach to management, we can no longer afford to think of these systems operating in silos.

Response: Thank you for your comment. We agree about the importance of the forests and our surrounding ecosystem. The importance of the forest system is not limited to agricultural water and applies to the "one water" of the state.

Most of the existing agricultural water systems are or will be over 100 years old, with many emanating from state DOFAW Forest Reserves. While there is a need to repair and upgrade these water delivery systems and infrastructure, the maintenance and upkeep of our forests – the "green infrastructure" that is the source of all water in the islands - is equally important. This is why DOFAW is actively working with the Department's Land Division and Commission on Water Resource Management (CWRM) to create a watershed cost-share as part of the water lease requirements, pursuant to section 171-58(e) of Hawaii Revised Statutes (HRS). Money contributed by water lessees through the watershed cost-share will be in addition to lease rent and support the management of forests that directly feed the water lease area. DOFAW is investing heavily to protect watersheds statewide and would like to see fees applied to water systems that have ditches and infrastructure originating from DOFAW forest reserve lands. The money generated by these fees would be used to manage the forested watersheds where the intakes and ditches are located. DOFAW would like to involve HDOA in future conversations related to the setting of water rates and fees, collection, and enforcement of such a tariff, and the use of expenditures from revenues generated.

Response: This comment is beyond the scope of this AWUDP but may be considered in future documents.

The AWUDP talks about capital improvement project (CIP) opportunities or areas identified as important agricultural systems or in need of upgrades. DOFAW currently invests millions of CIP monies into watershed protection fencing in high elevation forests. Since these fences have a direct benefit on future ground and surface water resources, we encourage DOA to communicate more with DOFAW about CIP investments (i.e.: upgrades to pipelines, ditches, and reservoirs) so we can better understand the nexus between DOFAW's CIP fences and subsequent impacts on water flow to downstream users over time. Similarly, there is little mention of the repair and maintenance of the roads that lead to many of these ditches and systems. DOFAW manages many of these roads with little injection of capital from any other State or non-State entity.

Response: Additional information has been added to Chapter 9.2.2, Additional CIP Projects. Other examples of future plans include the repair and maintenance of roads to irrigation systems for improved access and ease of maintenance.

As managers of the State Forest reserves, DOFAW would like to be informed of any work done to the water systems that reside within a forest reserve. DOFAW encourages water system managers to obtain legal easements or access to intakes located within State Forest reserves. While DOFAW can issue access permits, a long-term easement issued through Land Division is preferred. Any future land transfers or agreements made between the Department's Land Division and agricultural coalitions should be communicated to DOFAW. This is important because certain agricultural entities have been reluctant to cooperate with DOFAW for access in areas that traverse a forest reserve.

Response: Chapter 9.2.3.1 addresses this issue and notes that the lack of maintenance or right of entry agreements is detrimental to the system management. A statement is added to clarify that, "Water system managers/operators are encouraged to work with agencies, such as DOFAW, and other landowners to resolve access issues to maintain these irrigation systems."

Thank you again for your comments to the AWUDP Update, as well as your support of agricultural water and its role in the agricultural industry. Please contact Ms. Janice Fujimoto, Agricultural Resource Management Division, at 808-973-9473 with any questions.

Sincerely,

Phyllis Shimabukuro-Geiser

Phyllis Shimabukuro-Geiser
Chairperson, Board of Agriculture

cc: DLNR, Commission on Water Resource Management

MICHAEL P. VICTORINO
Mayor

JEFFREY T. PEARSON, P.E.
Director

HELENE KAU
Deputy Director

DEPARTMENT OF WATER SUPPLY
COUNTY OF MAUI
200 SOUTH HIGH STREET
WAILUKU, MAUI, HAWAI'I
96793
www.mauiwater.org

November 30, 2020

Ms. Suzanne D. Case, Chairperson
Commission on Water Resource Management
State of Hawai`i Department of Land and Natural Resources
PO Box 621
Honolulu, Hawai`i 96809

Re: Testimony on the Update to the Agricultural Water Use and Development Plan

Dear ~~Chair~~ Case: Suzanne:

The Maui County Department of Water Supply (MDWS) provides the following comments on the proposed update of the Agricultural Water Use and Development Plan (AWUDP).

Utilization of Current Data

The AWUDP update should address the cessation of sugarcane and pineapple monocrops on Maui and short-term to long-term effects since much of the supporting AWUDP information hinges on outdated data in the 2004 AWUDP documents.

The Maui plantation and ditch system information contained in the 2004 AWUDP is significantly outdated (pages 9-10), and should be updated in the 2019 AWUDP to better reflect current and anticipated water demand.

Comprehensiveness of Information

The AWUDP should more comprehensively address the Draft Update to the Maui Island WUDP (2019-2020) issues of: 1) inefficient irrigation systems and irrigation technology; 2) appropriate crops per irrigation requirements and climatic location; and 3) water duties/consumption estimates per crops. Recommended island-wide strategies relating to agricultural irrigation and conservation are summarized in Table 13-1 of the Draft Maui Island WUDP:
https://waterresources.mauicounty.gov/DocumentCenter/View/508/Maui-Island-Water-Use-

and-Development-Plan-Draft-Update

Systems Rehabilitation Plans
The major objective of the AWUDP is to develop a long-range management plan that assesses state and private agricultural water use, supply and irrigation systems. Act 101, SLH 1998 added the AWUDP as a component to the Hawaii Water Plan to ensure that plantation irrigation systems affected by plantation closures would be rehabilitated and maintained for future agricultural use. Based on the provisions of Act 101, SLH 1998, the AWUDP update could more extensively detail: (1) an updated inventory of the irrigation water systems of Maui County; (2) identification of the extent of rehabilitation needed for each system; (3) potential options for subsidization of the cost of repair and maintenance of the government systems; (4) established criteria to prioritize the rehabilitation of the systems, (5) development of a 5-year program to repair the systems, and (6) setup of a long-range plan to manage the systems.

Existing and Future Agricultural Irrigation Demand
The AWUDP should more comprehensively address: 1) assessment of the existing agricultural water irrigation needs of Maui County; 2) development of a range of future agricultural irrigation water needs; 3) identification of existing sources for irrigation water and assessment of any shortfalls or excess capacities in existing irrigation systems, based on the information from the Water Resources Protection Plan (WRPP) and the "Master Irrigation Inventory Plan"; 4) identification of options for development of additional and alternative irrigation water sources; 5) identification of options for conserving irrigation water and/or managing the uses to reduce the total irrigation water demand; and 6) development of strategies encompassing both demand management and resource development options.

Master Irrigation Inventory Plan
The 2019 AWUDP Master Irrigation Inventory Plan should incorporate: 1) Mahi Pono's Agricultural Plan for designated Important Agricultural Lands and 2) adopted Interim Instream Flow Standards (IIFS) as IIFS indirectly dictate how much surface water can be diverted.

Present Water System Profiles
The 2019 AWUDP could include a more thorough description of current supplies, major conveyance facilities and storage reservoirs, re-use programs, and conservation programs that are currently in operation. This description could also include resources to which the State, County, or private agricultural entities have made commitments. The ability of the current system to meet future demands should be thoroughly explored.

Resource Options
The 2019 AWUDP should more comprehensively address resource options including surface-water and ground-water supplies, brackish water, conservation programs for agricultural water users, and reclaimed wastewater for irrigation uses. The Draft Update to the Maui Island WUDP

advocates for implementation of increased use of brackish water for irrigation to conserve potable ground and surface water for domestic and municipal needs. We believe there are significant opportunities for improving efficiency in agricultural irrigation. The AWUDP could provide much needed guidance for the utilization of new technologies and innovative agricultural techniques to preserve water in Hawai`i.

2019 AWUDP Chapter 4 Update of 2004 Irrigation Systems
With consideration to conflicting water needs and agricultural users' dependency on East Maui Irrigation (EMI) system and the Wailuku Water Company, Chapter 4 of the 2019 AWUDP should update these two major irrigation systems.

We appreciate the opportunity to provide testimony and commend the Department of Agriculture in their efforts to update this important plan as it will serve as guidance for agricultural water use in a changing landscape.

Sincerely,

Jeffrey T. Pearson, P.E. Director
BAB

cc: Phyllis Shimabukuro-Geiser, Hawaii Department of Agriculture

JOSH GREEN, M.D.
Governor

SYLVIA LUKE
Lt. Governor

PHYLLIS SHIMABUKURO-GEISER
Chairperson, Board of Agriculture

MORRIS M. ATTA
Deputy to the Chairperson

State of Hawai'i
DEPARTMENT OF AGRICULTURE
KA 'OIHANA MAHI'AI
1428 South King Street
Honolulu, Hawaii 96814-2512
Phone: (808) 973-9600 FAX: (808) 973-9613

December 6, 2022

Ms. Helene Kau, Director
Department of Water Supply
County of Maui
200 South High Street
Wailuku, HI 96793

Dear Ms. Kau:

SUBJECT: Response to Comments Regarding December 2019 Agricultural Water Use and Development Plan Update

The Hawaii Department of Agriculture (HDOA) received the County of Maui, Department of Water Supply's comments to the December 2019 Agricultural Water Use and Development Plan Update (AWUDP). The HDOA is appreciative of your review and comments to this important document. The shared commonality between all the commentors and the HDOA, is a collective respect and appreciation for water.

The investigation for this version began in 2015. As such, some of the information provided in this December 2019 document may be dated as it captures our findings at that past point in time. The AWUDP is a living document and is intended for periodic revision in the coming years.

We have reviewed your comments and provided responses below. The HDOA also prepared a 2021 Revised Edition to the December 2019 AWUDP. The Revised Edition is intended to address specific comments made during the public review period. A copy of the 2021 Revised Edition will be available at: https://hdoa.hawaii.gov/arm/.

Please note that some public comments are beyond the scope of this current document. These comments will be noted and consulted for future AWUDP updates.

- Comment: Utilization of Current Data. The AWUDP update should address the cessation of sugarcane and pineapple monocrops on Maui and short-term to long-term effects since much of the supporting AWUDP information hinges on outdated data in the 2004 AWUDP documents.

  The Maui plantation and ditch system information contained in the 2004 AWUDP is significantly outdated (pages 9-10} and should be updated in the

2019 AWUDP to better reflect current and anticipated water demand.

Response: The AWUDP Update focuses on the condition of existing plantation irrigation systems, water demand, and future agricultural water needs and challenges. Therefore, it recognizes the cessation of both monocrop industries in Hawaii. While the cessation of sugarcane and pineapple monocrops on Maui have certainly affected the agricultural landscape, the Update focuses on current and future water needs. The information on pages 9 and 10 of the 2004 AWUDP show the flow rates during the plantation era. It is intended to provide historical information only.

Further, these industries were supported by Central Maui irrigation water systems, which are currently in ongoing legal disputes. Due to the legal status, system owners/operators did not provide updates on the status of their systems. In future versions of the AWUDP, it may be possible to update the current conditions of these water systems.

- Comment: Comprehensiveness of Information. The AWUDP should more comprehensively address the Draft Update to the Maui Island WUDP(2019-2020} issues of: 1} inefficient irrigation systems and irrigation technology; 2} appropriate crops per irrigation requirements and climatic location; and 3} water duties/consumption estimates per crops. Recommended island-wide strategies relating to agricultural irrigation and conservation are summarized in Table 13-1of the Draft Maui Island WUDP: https:// waterresources.mauicount y.gov/DocumentCent er/View/ 508/ M aui-Island-Water-Use and-Development-Plan-Draft -Update

  Response: The AWUDP is a standalone document for the Hawaii State Water Plan. Similarly, the Maui Island WUDP will be incorporated in the Hawaii State Water Plan, and beyond the scope of this Update and Addendum. The components of the Hawaii Water Plan will provide readers with a more comprehensive perspective. Unfortunately, similar to other water plans, the Maui WUDP seems to imply that the agriculture industry wastes water, which is counterintuitive to the business of agriculture.

- Comment:**Systems Rehabilitation Plans.** The major objective of the AWUDP is to develop a long-range management plan that assesses state and private agricultural water use, supply, and irrigation systems. Act 101,SLH 1998 added the AWUDP as a component to the Hawaii Water Plan to ensure that plantation irrigation systems affected by plantation closures would be rehabilitated and maintained for future agricultural use. Based on the provisions of Act 101, SLH 1998, the AWUDP update could more extensively detail: (1) an updated inventory of the irrigation water systems of Maui County; (2) identification of the extent of rehabilitation needed for each system; (3) potential options for subsidization of the cost of repair and maintenance of the government systems; (4) established criteria to prioritize the rehabilitation of the systems, (5) development of a 5-year program to repair the systems, and (6) setup of a long-range plan to manage the systems.

Response: The 2004 AWUDP and the 2019 AWUDP Update were both prepared in accordance with the above statute. With regards to systems in Maui County, the 2004 AWUDP addressed the Maui Land and Pineapple Pioneer Mill Irrigation System, Molokai Irrigation System, Upcountry Maui Irrigation System, East Maui Irrigation System, and West Maui Irrigation System. The 2019 AWUDP Update provided updates on these systems. All the elements required by the statute are addressed in the document. Future versions of the AWUDP will continue to update these requirements.

- Comment: **Existing and Future Agricultural Irrigation Demand.** The AWUDP should more comprehensively address: 1) assessment of the existing agricultural water irrigation needs of Maui County; 2) development of a range of future agricultural irrigation water needs; 3) identification of existing sources for irrigation water and assessment of any shortfalls or excess capacities in existing irrigation systems, based on the information from the Water Resources Protection Plan (WRPP) and the "Master Irrigation Inventory Plan";4) identification of options for development of additional and alternative irrigation water sources; 5) identification of options for conserving irrigation water and/or managing the uses to reduce the total irrigation water demand; and 6) development of strategies encompassing both demand management and resource development options.

  Response:The above items are covered, to varying extents, throughout the document. For example, Table 144 shows current and future water demand under various investment and growth scenarios. Chapter 5 discusses proposed new irrigation systems, commodity groups with growth potential, and potential expansion in Kula. Chapter 9 discusses long-range development plan projects that system owners could implement, including discussions of reclaimed water, automated water management solutions, and distribution system losses.

- Comment: **Master Irrigation Inventory Plan.** The 2019 AWUDP Master Irrigation Inventory Plan should incorporate: 1) Mahi Pono's Agricultural Plan for designated Important Agricultural Lands and 2) adopted Interim Instream Flow Standards (IIFS) as IIFS indirectly dictate how much surface water can be diverted.

  Response: Comment noted. Incorporation of these comments is beyond the scope of the Revision.

- Comment: **Present Water System Profiles.** The 2019 AWUDP could include a more thorough description of current supplies, major conveyance facilities and storage reservoirs, re-use programs, and conservation programs that are currently in operation. This description could also include resources to which the State, County, or private agricultural entities have made commitments. The ability of the current system to meet future demands should be thoroughly explored.

  Response: The 2004 AWUDP and 2019 AWUDP Update provide an *inventory of select irrigation systems throughout the state, including a brief discussion of the one (1) system that is considering the use of reclaimed water on Oahu. Beyond this inventory of existing irrigation systems and reclaimed water discussion, the other portions of this comment are beyond the scope of this AWUDP Update and its associated Addendum. The primary focus of the 2019 AWUDP was to update the Maui system from the 2004 AWUDP, Unfortunately, the system owners/operators did not want to discuss their systems for the study. The Department hopes that future AWUDP updates will be able to discuss the systems with the owners/operators.*

- Comment: **Resource Options.** The 2019 AWUDP should more comprehensively address resource options including surface- water and ground-water supplies, brackish water, conservation programs for agricultural water users, and reclaimed wastewater for irrigation uses. The Draft Update to the Maui Island WUDP advocates for implementation of increased use of brackish water for irrigation to conserve potable ground and surface water for domestic and municipal needs. We believe there are significant opportunities for improving efficiency in agricultural irrigation. The AWUDP could provide much needed guidance for the utilization of new technologies and innovative agricultural techniques to preserve water in Hawai'i.

  Response: From an agricultural standing, we respectfully disagree with designating brackish water for irrigation. The use of brackish water is only possible for certain salt-tolerant crops,and is detrimental to other crops. In addition, the application of brackish water will result in the overaccumulation of salt in the soil, affecting the viability of the soil itself.

  Further, the introduction of brackish water for irrigation would raise costs of farming to address the new infrastructure requirements, as well as higher water fees. This option will result in compromised agricultural opportunities, cause harm to the economical stability of the industry, and increase the cost of locally grown products. The AWUDP Update contends that the state should support farming efforts, including the availability of irrigation water for agriculture, to promote the state's goals of sustainability and food security.

  Instead, we propose the exploration of alternative water options for commercial and residential water users. These users may be better suited economically to pay for non-essential water uses, such as landscaping. As an option, the County of Maui may also consider the adoption of laws patterned after California, which tie water rates for landscaping into its neighborhood environment, and dictate watering days, times, and durations. These options can achieve the goals of conservation, while still allowing water for food production and agriculture.

- Comment: **2019 AWUDP Chapter 4 Update of 2004 Irrigation Systems.** With consideration to conflicting water needs and agricultural users' dependency on East Maui Irrigation (EMI) system and the Wailuku Water Company, Chapter 4 of the 2019 AWUDP should update these two major irrigation systems.

Response: During the preparation of this AWUDP Update, the EMI system was the subject of ongoing contested case proceedings. An update of the status of these systems is beyond the scope of this Revision.

Thank you again for your comments to the AWUDP Update, as well as your support of agricultural water and its role in the agricultural industry. Please contact Ms. Janice Fujimoto, Agricultural Resource Management Division, at 808-973-9473 with any questions.

Sincerely,

Phyllis Shimabukuro-Geiser
Chairperson, Board of Agriculture

cc: DLNR, Commission on Water Resource Management

Fujimoto, Janice

Subject: FW: [EXTERNAL] Re: Comment for the State Agricultural Water Use and Development Plan

From: Deborah Chai <debchai@yahoo.com>
Sent: Friday, December 4, 2020 2:17 PM
To: DLNR.CW.DLNRCWRM <dlnr.cwrm@hawaii.gov>
Subject: [EXTERNAL] Re: Comment for the State Agricultural Water Use and Development Plan

Dear Commissioners,

I am writing to request enclosures for the lower Hamakua Ditch. I have a small 5 acre parcel in Kalopa Makai. We are not only trying to live a sustainable lifestyle for our family, but also sell our produce at various markets on our Island. With direction from the Department of Agriculture, my husband and son paid for the supplies and provided all the labor to obtain water access to our property. We now have a meter and pay for this water each month.

Our property is on catchment and we cannot get county water. The ditch is critical to the survival of our farm. Many times due to storms, vandalism, and even general repair we have been cut off from this vital resource. We were so relieved to hear that FEMA had agreed to provide a grant to enclose the ditch. This infrastructure would help maintain the integrity of the ditch, reduce the risk of disease, and provide a more reliable source of agricultural water use to farms along the Hamakua Coast. We were dismayed to hear that because a small number of people were concerned about losing the historic nature of the ditch this plan didn't move forward.

So let's consider the historic nature of the ditch - it was to provide water to farmers. These farmers provide food to the community. In order for that to continue to happen sustainably, the ditch needs to be maintained in a manner most effective for this use. The "historic" nature of the ditch will not be preserved in the condition it is in now, and without assistance from the State we could lose this valuable resource all together.

We're currently in a global pandemic where many resources are limited. It may be a long time before we can bring back tourism in a profitable way to our islands. Outer islands are seeing huge increases in shipping costs for goods and services we depend on. We must look to more sustainable practices for and on our Island. Fixing the ditch is a first step. Please do the right thing. Please help the farmers in our community. By maintaining the ditch and providing much needed water to farmers along this coast, you are preserving the history of the ditch.

Mahalo,

Deborah Chai

44-338 Kahawai Road, Honokaa 96727
808-557-9357
On Friday, December 4, 2020, 06:30:08 AM HST, Tim Little <tim.e.little@gmail.com> wrote:

Regarding: State Agricultural Water Use and Development Plan

Dear Commissioners:

I am writing to request enclosure of the waters of the Lower Hamakua Ditch.

Our family farm is in the Kalopa makai area 3 miles east of Honoka'a town. We rely heavily on the Lower Hamakua Ditch (LHD) for irrigation especially in periods of drought and for water demanding crops. We pay for access to the ditch water but that access has been unreliable. We lost access to water for many months after the heavy flooding in March of 2004 damaged and obstructed the LHD with silt. We lost access again for many months after the October 2006 Kiholo Bay earthquake that damaged intake in the Waipio Valley headwaters.

Almost all the LHD dependent farmers were relieved when FEMA agreed to grant $3.9 million to enclose the LHD water in HDPE piping only to have the grant scuttled through the efforts of a small group of politically connected residential property owners. Fearing for their property values they complained loudly that the fully funded enclosure process would defile the "historic" nature of the ditch. Small farmers were given little or no voice as the project was terminated at the behest of the privileged.

We continue to struggle with heavy silting and failure of our irrigation systems due to contamination of the ditch waters by silt intrusion from its open banks. We have struggled with repeated acts of vandalism which damage our water intake and pump at the open LHD itself which is not within the boundary of our property and causes us to have to haul priming pumps and equipment to the site to prime the lines whenever the area is disturbed.

We worry about crops being contaminated and farmers being exposed to leptospirosis from animal waste and carcasses that fall into the open ditch waters. We are aware that two farmers almost lost their lives to contaminated water exposure on Ohau in 2014.

The silting, the vandalism, the water born disease risk, and the State's heavy maintenance costs of the open ditch could all be mitigated by enclosing as much of the ditch as politically possible in cost effective polyethylene pipe.

We feel like we are at the mercy of a handful of powerful gentry who propagandize the Lower Hamakua Ditch as a residential property enhancement when its primary purpose has been for many generations to support agriculture.

We are asking that the DNLR include the enclosure of the Lower Hamakua Ditch in its development plan through as much of its course as can be reasonably negotiated with all stakeholders. We further point out that federal funds were historically set aside for this purpose and the project derailed by a few local politicians not acting in the best interest of the majority of the public who depend on the existence of this vital resource. This project could almost certainly be successfully funded and completed with a negotiated agreement before hand.

Respectfully,

Tim Little
PO Box 1955
Honoka'a, HI 96727
tim.e.little@gmail.com

JOSH GREEN, M.D.
Governor

SYLVIA LUKE
Lt. Governor

PHYLLIS SHIMABUKURO-GEISER
Chairperson, Board of Agriculture

MORRIS M. ATTA
Deputy to the Chairperson

State of Hawai'i
DEPARTMENT OF AGRICULTURE
KA 'OIHANA MAHI'AI
1428 South King Street
Honolulu, Hawaii 96814-2512
Phone: (808) 973-9600 FAX: (808) 973-9613

December 6, 2022

Ms. Deborah Chai
44-338 Kahawai Road
Honokaa, Hawaii 96727

Dear Ms. Chai:

SUBJECT: Response to Comments Regarding December 2019 Agricultural Water Use and Development Plan Update

The Department of Agriculture (HDOA) appreciates your review and comments to the December 2019 Agricultural Water Use and Development Plan Update (AWUDP). We appreciate your comments and commitment to agriculture.

As you noted in your comments, improvements were planned to enclose a portion of the Lower Hamakua Ditch (LHD) system with pipelines. Unfortunately, the Federal Emergency Management Agency (FEMA) elected to allow the funds to lapse and the project was not completed. HDOA irrigation staff provide ongoing maintenance of the ditch in an effort to keep irrigation water flowing in these areas. The AWUDP Update does identify pipeline retrofit as a proposed Capital Improvement Project for the system.

Thank you again for your comments to the AWUDP Update. Please contact Ms. Janice Fujimoto, Agricultural Resource Management Division, at 808-973-9473 with any questions.

Sincerely,

Phyllis Shimabukuro-Geiser

Phyllis Shimabukuro-Geiser
Chairperson, Board of Agriculture

cc: DLNR, Commission on Water Resource Management

December 17, 2020

VIA EMAIL: dlnr.cwrm@hawaii.gov

Commission on Water Resource Management
State Department of Land and Natural Resources
P.O. Box 621
Honolulu, Hawaiʻi 96809

Re: James Kimo Falconer's Testimony re: State of Hawaiʻi Department of Agriculture ("**DOA**") Agricultural Resource Management Division's Agricultural Water Use and Development Plan Update, dated December 2019 ("**2019 Update**")

Dear Commissioners and Staff for the Commission on Water Resource Management:

I urge the Commission to have the 2019 Update returned to the DOA for significant revisions to address deficiencies in the existing modeling for future water demands and the challenges facing the agricultural industry in Hawaiʻi, and advocate for the maintenance and expansion of agriculture in the years to come.

The 2019 Update does not properly analyze, inventory, or study the Honokowai and Honokohau irrigation systems in West Maui. The Honokowai irrigation system serves to make possible the Kaanapali Coffee Farms, a 400-acre farm that is one of the largest coffee farms in the United States and Hawaiʻi. CWRM has previously discussed limiting irrigation water for agriculture by establishing instream flow standards for the Honokowai system or by designating ground and surface water management areas that have the potential of further restricting water for agricultural use in West Maui, including water for the coffee farm. Without significant revisions, the 2019 Update should not be used by the DOA or CWRM as a basis for making decisions regarding water resources in West Maui and/or impacting Kaanapali Coffee Farms.

My Background and Experience

I write as the President of MauiGrown Coffee, Inc., a Hawaiʻi company that I own, which has been marketing and selling coffee grown on the Kaanapali Coffee Farms in West Maui since 2003. My testimony is also informed by my prior experience as a long-time employee of Kaanapali Land Management Corporation ("**KLMC**"), successor to Pioneer Mill Co., Ltd. ("**Pioneer Mill**"). I was the Agricultural Research Director for Pioneer Mill from 1983 to 1999, and the Vice President of Kaanapali Estate Coffee from 1992 to 2001.

The roots of Kaanapali Coffee Farms go back to the late 1980s when Pioneer Mill participated in a University of Hawaiʻi field trial experimenting with coffee varietals in different test plots throughout the state. As a result of the trial, select coffee varieties were found to best suited for growing in West Maui. Based on the results of the trial, in the early 1990s, Pioneer Mill converted approximately 500 acres of sugar cane land for use as a commercial coffee operation. After Pioneer Mill shut down its coffee farm along with its sugar cane operation, KLMC continued to maintain the coffee trees while searching for a partnership that would allow KLMC to keep the land in agriculture. Today, at approximately 400 acres, Kaanapali Coffee Farms is the second largest coffee farm in the United States and in Hawaiʻi. It is the largest coffee farm on Maui, employing approximately 20 full-time workers and additional seasonal workers during the harvesting season. In the past, the coffee farm was watered by the Honokowai and Honokohau irrigation systems. However, the coffee farm is now almost exclusively watered by the Honokowai system, using a drip-irrigation method carried over from the plantation days.

Altogether, for 37 years, I have been an active farmer on land irrigated by waters from the Honokowai and Honokohau irrigations systems. I am one of the more knowledgeable persons on all facets of coffee on Maui and on the sources of water available to irrigate the coffee plants grown on Kaanapali Coffee Farms.

Summary of Comments on 2019 Update

Based on my experience, I offer the following comments on the 2019 Update and respectfully submit that the 2019 Update should be returned to the DOA for further analysis and revisions. My comments are driven by a sense of urgency because the agricultural coffee industry on Maui is facing several existential threats at this time (e.g., coffee borer beetle and coffee leaf rust), and if the lack of water persists, the industry will die. The DOA should strongly advocate on behalf of farmers and the agricultural industry to receive much-needed support and fairness from State agencies.

- Judged by its own objectives and criterion, the 2019 Update does not adequately analyze or give weight to the importance of the Honokohau and Honokowai irrigation infrastructure and the dynamism of the Kaanapali Coffee Farms coffee operations. The limiting factor for agriculture in West Maui is water, not land.

- The 2019 Update's analysis of water demands is deficient because it (1) uses methodologies and inputs that are flawed and deficient, relying on generalized averages taken from a small number of farms rather than recognizing each farm's site-specific challenges and climate conditions; and (2) CWRM's approach to water demand improperly shifts the burden of proof to the farmer to justify water needs that go beyond those set forth in CWRM's IWREDSS model.

- The 2019 Update should vigorously advocate for recognition of public trust status of water used for agriculture.

- The 2019 Update should address the devastating impact of COVID-19 on the State's economy and advocate for the prioritization of projects such as the rehabilitation of the existing Honokohau irrigation system (rather than new major projects) and investment in diversified agriculture.

- The 2019 Update should address and analyze the recent UH study indicating large amounts of fresh water off-shore and the feasibility of tapping into those water sources for agriculture.

- The 2019 Update should assess the impact of the use of re-treated wastewater (R-1 water) on agricultural crops on the marketability and consumer acceptance of crops irrigated by R-1 water, given the apparent inclination of various governmental agencies to substitute R-1 water for non-potable stream and ground water.

Judged by Its Own Objectives and Criterion, the Update Does Not Adequately Analyze or Give Weight to the Importance of the Honokowai and Honokohau Irrigation Systems

The Honokowai irrigation system dates back to the plantation diversion systems in the Lahaina District that began with Pioneer Mill and Maui Land and Pineapple Company ("**ML&P**"). It was Pioneer Mill's second largest diversion system. Today, the gravity-fed Honokowai system leads to the Hanakaʻōʻō Reservoir and Horner Reservoir on KLMC land. Pioneer Mill's most extensive diversion system was the Honokohau irrigation system. KLMC maintains those portions of the Honokohau ditch on KLMC-owned lands or state lands leased by KLMC.

During the time of Pioneer Mill's sugar operation, it was not uncommon for Pioneer Mill to receive 35 MGD from ML&P through the Honokohau system. Currently, however, and for many years, KLMC has been watered almost exclusively by the Honokowai system, with little to no water coming from Honokohau for its farming operations, including the coffee farm. Although certain portions of Honokohau are now in disrepair, if invested in, the system could help substantially to support and expand agriculture in the region.

Although the Honokowai irrigation system continues to water the coffee farm and KLMC's other farming operations, the current flow is much less than half the median flows in 1976. **There is barely enough water to sustain present farming and the farm is stressed under current drought conditions.**

The Honokowai and Honokohau irrigation systems are **essential and necessary** to the continued viability of farming in West Maui. However, the 2019 Update does not meet its own stated objectives with respect to these systems. The November 2020 virtual presentation to the Commission stated that the "objectives" of the 2019 Update were as follows:

- Inventory public and private irrigation water systems
- Identify the extent of rehabilitation needed for each system
- Identify source of water used by agricultural operations, especially IALs
- Identify current and future water needs for agricultural operations, especially IALs
- Develop a 5-year program to repair the systems
- Set up a long-range plan to manage the systems

Rather than meet these objectives for the Honokowai and Honokohau irrigation systems, the 2019 Update instead relies solely on the 2004 Agricultural Water Use and Development Plan Update ("**2004 Update**"). 2019 Update at 147. A lot has changed in the 16 years since the 2004

Update and none of these changes are reflected in the 2019 Update. Slide 5 of the November presentation stated that the 2004 Update "studied" the "Maui Land and Pineapple/Pioneer Mill Irrigation System". Even putting aside the length of time that has passed since then, the 2004 "study" of Honokowai and Honokohau was incomplete and wrong on basic facts.

For example, in discussing the "Maui Land and Pineapple Co./Pioneer Mill Irrigation System," the 2004 Update incorrectly stated that the "sources of water on the western slopes," presumably referring to Honokowai, "have been abandoned." 2004 Update at 63. The Honokowai irrigation system was never abandoned by KLMC or Pioneer Mill.

With respect to identifying water sources, the 2004 Update stated in passing: "In addition to using water from the Honolua Ditch, Pioneer Mill Company developed water from Honokowai Stream and its Amalu and Kapaloa branches in 1898 and 1918. The intakes and high-level groundwater development tunnels, located at approximately 1525-ft elevation, developed an average of over 6 mgd and were used to irrigate Pioneer Mill Company's upper cane fields." Report at 64. The report then stated, erroneously, that "***Amfac/JMB Hawaii***, successor to Pioneer Mill Company (which closed in 1999), no longer uses or maintains these three supplemental sources, its coastal Maui-type shaft sources (ground water) at Honokowai, Kahoma, and Wahikuli, or the Lahainaluna Ditch System south of Wahikuli Reservoir, ***having disposed of its lands which are no longer in agricultural use.***" 2004 Update at 64-65 (emphases added).

However, KLMC, not Amfac/JMB Hawaii, which was a parent entity, is the successor to Pioneer Mill with respect to the lands at Kaanapali. And as stated, KLMC never abandoned or stopped maintaining the Honokowai irrigation system. Currently, during low-flow conditions the water used by KLMC for its agricultural operations in West Maui, including the coffee farm, is almost exclusively *ground* water from two development tunnels: (1) Tunnel 20A on the south side of Kapaloa Stream at elevation of 1700 feet and (2) Tunnel 20B, which is in the Amalu transmission tunnel at an elevation of 1600 feet and discharges water into the north side of Kapaloa Stream. If not for the development tunnels, the ground water would *not* naturally enter the Honokowai Stream channel because there are no high level groundwater compartments below the diversion that are intersected by the stream channel.

The 2004 Update also contained no reference to the land use classification of the agricultural lands watered by the Honokowai and Honokohau systems, despite the fact that much of the land in the West Maui region constitutes "prime" agricultural lands "best suited to produce food, feed, forage, and fiber crops." 2019 Update at 17.

Given its fundamental misunderstandings about ownership and use of the systems, I could not readily discern a concrete, long-range plan to rehabilitate and manage the Honokowai and Honokohau systems in the 2004 Update. Instead, the 2004 Update erroneously stated that "Pioneer Mill Company's parent company is in bankruptcy and other partial owners of the MLP/PMIS have no future plans. ***Consequently, the system's agricultural water uses are of a short-term and interim nature.***" 2004 Update at 66 (emphasis added). By the time the 2004 Update was published, KLMC, Pioneer Mill, and their parent entities had come out of bankruptcy as reorganized entities and continued to maintain diversified agriculture in West

Maui.

The 2004 Update also concluded, with respect to the "long-range management plan," that "an adhoc committee composed of all existing and potential users of the ditch system should be organized to develop the long-range management plan of the MLP/PMIS." 2004 Update at 75. The 2019 Update does not provide an update as to what happened in the intervening 16 years regarding the long-range management plan with respect to the Honokowai and Honokohau (Honolua) systems. In fact, the 2019 Update adds nothing to remedy the deficiencies in the 2004 Update, and does not identify current and future water needs related to the Honokowai and Honokohau (Honolua) ditch systems at all. This omission is notwithstanding that the Honokowai irrigation system serves to make possible one of the largest coffee farms in the United States and Hawai'i; that the land use classifications are consistent with agriculture; that the amount of irrigation water historically available for agriculture from the two systems exceeded on average between 25,000,000 – 30,000,000 gallons per day for agricultural use; and that the end of plantation agriculture made large amounts of prime agricultural land available for other crops.

Measuring the objectives stated in slide 4 of the November 2020 presentation against the work done by DOA in the 2004 and 2019 Updates, I can only conclude that the DOA did not conduct a meaningful study or "inventory" of the Honokohau and Honokowai irrigation systems. *See* Merriam-Webster Online Dictionary (defining "inventory" to mean "itemized list of current assets," "survey of natural resources").

The demand for coffee from Kaanapali Coffee Farms is high. MauiGrown coffee is sold as specialty coffee, meaning it obtains premium prices from the marketplace. There is more demand for the coffee from Kaanapali Coffee Farms than there is supply. There is more available land for coffee than is presently being used. The limiting factor precluding the growth of coffee operations in West Maui is the lack of a reliable source of suitable irrigation water at a reasonable cost.

The 2019 Update should expressly call for the protection, preservation, and enhancement of the Honokowai and Honokohau irrigation systems for farming.

<u>The Update Does Not Adequately Analyze or Give Weight to the Importance of West Maui Agricultural Operations</u>

The 2019 Update also does not recognize the importance of agricultural operations in West Maui, including the 400 acres dedicated to the Kaanapali Coffee Farms. Rather, the 2019 Update seemingly goes out of its way to call out "gentleman's farms" as not fitting within the apparent definition of "farming and agricultural uses." *See* 2019 Update at 193.

When I read the term "Gentleman's Farm," I think, surely that could not refer to the Kaanapali Coffee Farms, the second largest coffee farm in the United States and largest in Maui by far. But to my disbelief, the term has been used previously, within the context of CWRM hearings, to describe the Kaanapali Coffee Farms, with the further implication that the coffee farm was a fake and a sham. I feel the need to continue correcting this mischaracterization of the coffee farm. MauiGrown Coffee and Kaanapali Coffee Farms are bona fide commercial farming businesses, and to label them as gentlemen farms or a sham for expensive housing is insulting. It is deeply demeaning to my livelihood and that of the other individuals employed by the farm. The Maui origin coffee produced here is known worldwide and very unique in the coffee industry.

Yes, part of the coffee farm is located within the Kaanapali Coffee Farms Subdivision (Phase 1). The subdivision consists of four- to seven-acre lots that are sold as unimproved agricultural lots, with certain portions of each lot designated for residential use. The remainder of each lot's acreage is planted in coffee. Kaanapali Coffee Farms uses its own mill to process the coffee grown on its lands. As I've said before in testimony to the Commission, having homes on the property is a business model that provides for a viable agricultural operation, by defraying the costs of creating and furthering a coffee operation. It is a model that, with variants, is commonly used, especially in places like Napa Valley, to balance farming with market housing.

It does not make sense to me to design laws to allow a sustainable model of commercial agriculture while at the same time continuously undermining and demeaning the product based on nothing more than a vague sense that these lots are bought by the wealthy. The bottom line is that the model works, and it could continue to support agriculture in West Maui on a larger scale but for the lack of a reliable source of water.

<u>The 2019 Update's Analysis of Water Demands for Agriculture is Deficient Because (1) the Analysis Uses Flawed Methodologies/Inputs, Relying on Generalized Averages and Not Individual Site and Climate Conditions; and (2) CWRM's Approach to Water Demand Improperly Shifts the Burden to Farmers to Justify Water Needs that Go Beyond CWRM's IWREDSS Model</u>

First, the 2019 Update's analysis of water demands is deficient and inadequate as a tool for planning purposes because it contains information gaps and oversights, relying on generalized averages rather than farmer- and site-specific information and conditions. The November 2020 virtual presentation to the Commission included a slide called "Sample Variations in Water Demand," copied below.

Sample Variations in Water Demand

(Table 124 – Summary of Average Daily Crop Water Demand, Lower Hamakua Ditch, Kukuihaele to Paauilo (gpd/acre), DOA 1999)

	Crop Water Demand Below 500 feet		Crop Water Demand Above 500 feet	
Rainfall	50%	80%	50%	80%
Banana	2,211	3,236	1,425	1,964
Coffee	1,471	2,079	852	1,296
Papaya	1,471	2,079	852	1,296
Macadamia nut	1,140	1,578	562	992
Foliage/flowers	1,808	2,655	1,140	1,600
Truck crops	1,140	1,578	562	992
Reference Crop	1,500	2,100	900	1,350
Effective Daily Rainfall (inches)	*0.11*	*0.09*	*0.13*	*0.10*
(gpd/acre)	2,986	2,443	3,530	2,715

The 2019 Update explains: "**In the late 1990s**, the State of Hawaii, Department of Agriculture and its partners developed watershed plans for several irrigation systems in the state. The Lower Hamakua Ditch (LHD) Watershed Plan and Final Environmental Impact Statement computed water demand by crop, which was based on pan evapotranspiration results. **Table 124 presents**

the various crop irrigation requirements for crops grown below the 500-foot elevation and above the 500-foot elevation in the Kukuihaele to Pa`auilo area." 2019 Update at 183 (emphases added).

In viewing this table created based on plans from the 1990s and without any consultation with me, it struck me that the identified "crop water demand" for coffee would not even provide enough water today to meet the permanent wilting point threshold for coffee trees at our coffee farm. The failure to develop solid empirical data generated from one of the largest coffee farms in Hawaiʻi is an unfortunate symptom of reaching conclusions on the basis of completely inadequate evidence. Yet, this failure has huge consequences for farmers who then have to rebut the presumption of accuracy attributed to the erroneous and incomplete work done by those planners who rely on faulty data. It cannot be over-emphasized that each farm faces particular and unique challenges arising from individual site and climate conditions. There is no such thing as a generalized farm or crop. It is misguided to rely on generalized averages taken from a small number of farms to create water demand rates that will be broadly and sweepingly applied. Ironically, this concept is partially recognized at slide 24 of the November presentation for "Aquaculture, taro, and other wet crops" where the water demand is described as "**Dependent on crop and location**." In fact, this is true for all crops. As a result, this fact should be recognized for all crops and all farms, with water demand rates then being established farm by farm.

Second, the 2019 Update's analysis of water demand rates is deficient because it does not recognize that CWRM's approach to assessing water demands improperly shifts the burden to the farmer to justify water needs that go beyond CWRM's model. The 2019 Update identifies "water demand rates" for "statewide planning for agricultural water demand," and states that these "planning levels" are subject to specific site conditions and husbandry practices. 2019 Update at xxiv. However, CWRM's model for estimating crop irrigation requirements is not based on specific site conditions facing a particular farmer. Rather, the 2019 Update states that CWRM has been relying on the Irrigation Water Requirement Estimation Decision Support System ("**IWREDSS**")—"an Arc-GIS-based numerical simulation model" developed for CWRM—to estimate irrigation requirements for individual farmers seeking allocated water. 2019 Update at 184. These requirements are determined based on an 80 percent rainfall frequency (drought rate of one in five years). *Id.* at 185. The IWREDSS model is not based on specific site conditions facing a particular farmer, and lacks the specificity, experience, and empirical expertise gained by the individual farmer working on that farmer's unique farm. The model is outdated, unyielding, and inflexible.

For example, the 2019 Update states that under CWRM's IWREDSS model, farmers "cannot exceed the moving annual total" calculated by the model "**at any time**." 2019 Update at 185. "Therefore, if rainfall is less than the 80 percent rainfall frequency or the drought periods are longer than assumed, the applicant **can easily exceed the annual allocation or will need to reduce the amount of acreage farmed to stay within the moving annual water allocation**." *Id.* (emphasis added). For crops like coffee that rely on planted trees that take years to reach maturity, having insufficient water and losing mature, fruit-bearing trees would endanger the farm's survival.

CWRM's approach to water demand shifts the burden to farmers to justify the need for more water than the IWREDSS model predicts. This approach is wrong, and the 2019 Update should point this out. In the minutes of the July 21, 2020 CWRM meeting discussion of the 2019 Update, I read questions from some of the Commissioners suggesting that farmers surveyed by the DOA were overstating their water needs or are seeking to grow "thirsty" crops that are not appropriate for the area. I have not seen any evidence of this. Although the Commissioners' questions appeared to put the burden on farmers to "make better use of their water" if "they want higher allocations," most farmers and operators do not have the funds necessary to improve and maintain the necessary water delivery infrastructure. As DOA staff stated during the July 21 meeting, "I'd rather see the Commission make a push to try to get funds to help these farmers and system operators get funding to fix their systems, rather [than] pinning them into a corner where they may not have the ability to address them and not have the financial means, then they don't have any water to irrigate their crops."

The 2019 Update should take a position and advocate on behalf of farmers. Specifically, the Update should state that if there is a difference between CWRM's water demand model and the farmer's real life experience on unique farmland, the model should bear the burden of proof. Adherence to CWRM's current model as establishing the presumptive need for water for planning purposes means that DOA and CWRM are planning for adverse results.

The 2019 Update Should Vigorously Advocate for Recognition of Public Trust Status of Water Used for Agriculture

Under Hawaii's Constitution, Article XI, Section 3, we are called to "conserve and protect agricultural lands, promote diversified agriculture, increase agricultural self-sufficiency and assure the availability of agriculturally suitable lands."

The 2019 Update concludes with a statement that "[a]griculture is an essential component for the state to achieve its goal of sustainability and a diversified economy. The agricultural industry relies on these water systems to deliver inexpensive water to meet and expand agricultural production." 2019 Update at 253. The Update continues, "The investment into these agricultural water systems is the key to provide adequate water to continue to grow diversified agriculture. As the saying goes, … ***without water there is no agriculture*** …, which is the reason these agricultural water systems were originally constructed – and why they need to be maintained for another 100 years." 2019 Update at 253 (bold emphasis added).

It is clear to me that the Honokowai and Honokohau irrigation systems conserve, protect, and promote the public interest by supporting our agricultural lands and advancing many benefits, including sustainability, self-sufficiency, food security, economic diversity, job growth, aquifer recharge, wildfire suppression, and bringing life to the land. Indeed, the 2004 Update recognized that an "important aspect" of the irrigation system in West Maui was "its history of providing the scenic greenery of sugarcane and pineapple fields on the slopes of West Maui, a tourist industry attraction. Without irrigation, brown slopes will mar this popular visitor setting." 2004 Update at 66.

However, currently the public trust doctrine does not include water used for agriculture as a public trust use. There is much support for such recognition. The State Water Code recognizes that it "shall be liberally interpreted to obtain *maximum beneficial use* of the waters of the State for purposes such as domestic uses, aquaculture uses, irrigation and other ***agricultural uses***[.]" HRS § 174C-2 (emphasis added). Other statutes recognize: "The people of Hawaii have a substantial interest in the health and sustainability of agriculture as an industry in the State." HRS § 205-41. But the lack of recognition of agriculture as a public trust use continues to stand in the way of providing adequate support for the agricultural industry in Hawaiʻi. Again, water is the limiting factor in West Maui, not the lack of land. There is demand for Hawaiʻi agriculture, and support in public opinion for "farmers," but not enough support from the State. The DOA should vigorously advocate in the 2019 Update for recognition of public trust status of water used for agriculture.

<u>The 2019 Update Should Address the Impact of COVID-19</u>

The 2019 Update should be revised to take into account the profound impact of COVID-19 on the state and local planning processes. Obviously the pandemic has wreaked havoc on the State's economy. Maui's economy is particularly dependent on tourism, and it will likely take years to recover. My understanding is that state/county tax revenues decreased significantly due to the pandemic, and it has been reported that state budgets will be facing deep cuts.

In light of this economic crisis, it makes the most sense for government agencies to spend money on agricultural water projects that provide the best rate of return. The 2019 Update should advocate for prioritizing the rehabilitation of existing water systems like the Honokohau system over new infrastructure projects. The Honokohau system could have a greater geographic reach if properly rehabilitated.

The 2019 Update should also strongly advocate for state agencies to prioritize investment in diversified agriculture at this time. The pandemic has exposed the need to diversify our economy, especially in Maui. The wider public support for sustainability, self-sufficiency, food security, and job growth align with strong support for diversified agriculture.

<u>The 2019 Update Should Address and Analyze Recent Studies Indicating Large Amounts of Fresh Water Off-Shore</u>

It was recently reported in national media that scientists associated with the University of Hawaiʻi at Manoa, among others, published a research paper showing that within the rock of Hawaiʻi Island below the waves, there are underground rivers of fresh water flowing 2-1/2 miles out into the ocean. *See* Matt Kaplan, *Hawaii's Fresh Water Leaks to the Ocean Through Underground Rivers*, New York Times (Nov. 25, 2020). "In total, these rivers appear to contain enough fresh water to fill about 1.4 million Olympic swimming pools." *Id.* Dr. Eric Attias, a postdoctoral researcher at the University of Hawaiʻi who led the study, said that the discovery could be relevant to other islands as well, including Maui, and "could well mean that the water challenges faced by islanders all over the world might soon become a lot less challenging." *Id.*

These new findings could clearly have a profound impact on water use and allocation in the State. The 2019 Update should address and analyze the study and examine the impact of its findings on supplying water for agriculture in Hawaiʻi.

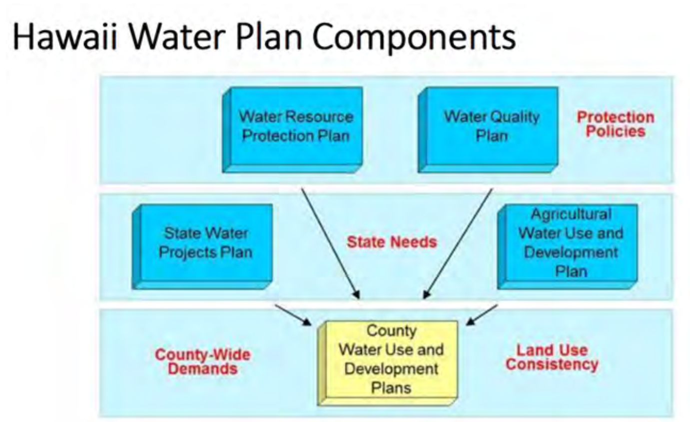
The 2019 Update Should Assess the Impact of R-1 Water on Marketability and Consumer Acceptance of Agricultural Crops

The 2019 Update states that "[r]eclaimed water from WWTP can be considered for use on agricultural lands for certain irrigation purposes, subject to government regulations." 2019 Update at 247. Various governmental agencies at this time appear inclined to substitute reclaimed wastewater (R-1 water) for non-potable stream and ground water. In light of this apparent trajectory, the 2019 Update should be revised to include a thorough, evidence-based study or assessment of the impact of the use of R-1 water on the marketability and consumer acceptance of agricultural crops irrigated by R-1 water.

For example, the use of any R-1 water, regardless of treatment method, will erase the opportunity for any "organically certified" farming and presents large challenges to the marketability of crops, including coffee, that aspire to premium positions in the marketplace. I am not aware of any studies by the same governmental agencies advocating for the use of R-1 water on marketability or consumer acceptance of agricultural crops irrigated with R-1 water. Before making retreated wastewater a significant part of the DOA's plan to maintain and expand agriculture in Hawaiʻi, these impacts should be studied.

Conclusion

I note that the DOA's presentation on the 2019 Update stated that the Agricultural Water Use and Development Plan addresses "State Needs," in contrast to the "Protection Policies", "County-Wide Demands" and "Land Use Consistency" components of the planning process:



The 2019 Update should be revised to truly meet the needs of agriculture in the State, by accurately identifying the needs, and acting to protect the industry and provide real opportunities for agriculture to succeed in Hawaiʻi. Talking points about supporting farmers and local agriculture, of sustainability and self-sufficiency, should become action points.

The 2004 Update stated that the Plan "focuses on transforming former plantation systems to diversified agriculture use, as well as maintaining systems already devoted to diversified agriculture use." 2004 Update at iii. The report recognized that "**With large amounts of prime agricultural lands and irrigation systems** made available for conversion to diversified agriculture by plantation closures in the 1990s, **the State has an unparalleled opportunity to strengthen and expand Hawaii's diversified agriculture industry**." *Id.* (emphasis added). That was 16 years ago. In my opinion, the State has not made use of the "unparalleled opportunity" created by the old plantation irrigation systems like that of Honokowai and Honokohau in West Maui. Instead, CWRM has discussed limiting irrigation water for agriculture even further by establishing in-stream flow standards and designating ground and surface water management areas.

There is a real opportunity to develop coffee in West Maui as a sustainable and self-sufficient player in Hawaii's economy. The chairperson of the Hawai'i Board of Agriculture recently told the Maui news that "**Coffee is one of Hawaii's signature crops**, of which production was estimated to be $54.3 million in 2019." MauiNow, *USDA Confirmed Coffee Leaf Rust on Coffee Plants on Big Island* (Nov. 11, 2020), https://mauinow.com/2020/11/11/usda-confirmed-coffee-leaf-rust-on-coffee-plants-on-big-island/.

The lack of land has been an issue in the past, but now the limiting factor to the coffee industry in West Maui is water. I believe that we are at a crossroads for the continued viability of the coffee industry here. We are already facing unprecedented threats from the coffee berry borer that has infested farms throughout the Big Island and has been found on Maui. And more recently, coffee leaf rust, "one of the most devastating pests of coffee plants," was found on Maui and the Big Island. *Id.* But most fundamentally, we need water to sustain and grow the industry. Without enough water and investment by the State and this Commission, the industry will die. We cannot continue with the status quo and expect the industry to continue or to thrive in any manner. To adequately address the nature of the challenges, the 2019 Update needs to be returned to the DOA for significant revisions before it is used as the baseline for important decision-making for years to come.

Thank you for your consideration of my testimony.

Very truly yours,

James Kimo Falconer

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December 6, 2022

Mr. James Kimo Falconer
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Dear Mr. Falconer:

SUBJECT: Response to Comments Regarding December 2019 Agricultural Water Use and Development Plan Update

The Hawaii Department of Agriculture (HDOA) received your comments to the December 2019 Agricultural Water Use and Development Plan Update (AWUDP Update). The HDOA is appreciative of your thorough review and comprehensive comments to this important document. The shared commonality between all of the commentors and the HDOA, is a collective respect and appreciation for water. In response to specific comments obtained in the public comment period, the HDOA prepared a 2021 Revised Edition to the December 2019 AWUDP. A copy of the 2021 Revised Edition will be available at: https://hdoa.hawaii.gov/arm/.

We have reviewed your comments and provide the responses below. Although your comments are beyond the scope of this revision, they are included in an Appendix to the Revised Edition. In addition, your comments will be considered in future AWUDP Updates.

- Comment: Judged by its own objectives and criterion, the 2019 Update does not adequately analyze or give weight to the importance of the Honokohau and Honokowai irrigation infrastructure and the dynamism of the Kaanapali Coffee Farms coffee operations. The limiting factor for agriculture in West Maui is water, not land.

  Response: Comment noted. The West Maui water system's importance as highlighted in the 2004 AWUDP.

- Comment: The 2019 Update's analysis of water demands is deficient because it (1) uses methodologies and inputs that are flawed and deficient, relying on generalized averages taken from a small number of farms rather than recognizing each farm's site-specific challenges and climate conditions; and (2) CWRM's approach to water demand improperly shifts the burden of proof to the farmer to justify water needs that go beyond those set forth in CWRM's IWREDSS model.

Response: The AWUDP Update emphasizes the acknowledgment of each farm's site-specific challenges. Chapter 6 highlights the differences in water demand based on a variety of factors, such as climate, elevation, crop type, and irrigation method. The average water demand in planning rates in Table 130 show that demand rates vary by situation. These demand rates are planning considerations based on surveys of farms throughout the state, but do not preclude an individual farmer or system owner/operator from determining their own individual needs.

Your comments on the IWREDSS model used by CWRM, (and not taken into consideration in the AWUDP) is constent with other farmers who spoke about this issue..

- Comment: The 2019 Update should vigorously advocate for recognition of public trust status of water used for agriculture.

  Response: This is beyond the scope of this project.

- Comment: The 2019 Update should address the devastating impact of COVID-19 on the State's economy and advocate for the prioritization of projects such as the rehabilitation of the existing Honokohau irrigation system (rather than new major projects) and investment in diversified agriculture.

  Response: Comment noted. This document was prepared prior to the introduction of COVID-19 into our state. The effects of COVID-19 are beyond the scope of this document.

- Comment: The 2019 Update should address and analyze the recent UH study indicating large amounts of fresh water off-shore and the feasibility of tapping into those water sources for agriculture.

  Response: Comment noted. The AWUDP recognizes that new water sources and intakes will be needed. Therefore, if this is a feasible water source for your system this source of water is valuable to your system, then you should use it. Further research on this matter is beyond the scope of this project.

- Comment: The 2019 Update should assess the impact of the use of re-treated wastewater (R-1 water) on agricultural crops on the marketability and consumer acceptance of crops irrigated by R-1 water, given the apparent inclination of various governmental agencies to substitute R-1 water for non-potable stream and ground water.

  Response: Comment noted. A discussion of reclaimed water as an alternate water source is described in Section 9.2.2, but does not address the marketability and consumer acceptance concerns mentioned in your comment.

Thank you again for your comments to the AWUDP Update, as well as your support of agricultural water and its role in the agricultural industry. Please contact Ms. Janice Fujimoto, Agricultural Resource Management Division, at 808-973-9473 with any questions.

Sincerely,

Phyllis Shimabukuro-Geiser

Phyllis Shimabukuro-Geiser
Chairperson, Board of Agriculture

cc: DLNR, Commission on Water Resource Management

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Honoring our roots.
Preserving our spirit.

December 17, 2020

VIA FEDEX AND EMAIL

Commission of Water Resource Management
State Department of Land and Natural Resources
P.O. Box 621
Honolulu, Hawaii 96809

Re: Public Testimony on Hawai'i State Department of Agriculture Agricultural Water Use and Development Plan, 2019 Update

I. INTRODUCTION

The following information and comments are submitted on behalf of Kaanapali Land Management Corp. ("**KLMC**") pursuant to the Department of Land and Natural Resources ("**DLNR**") News Release (the "**News Release**") dated September 30, 2020, regarding the Commission on Water Resource Management's ("**Commission**" or "**CWRM**") "Public Hearings Scheduled for Input on the Agricultural Water Use and Development Plan" held on November 18 and 19, 2020 (the "**Hearings**"). The purpose of such Hearings was to solicit input on the update prepared in December, 2019 (the "**2019 Update**") by the Hawai'i State Department of Agriculture ("**DOA**") to the Agricultural Water Use and Development Plan ("**AWUDP**"). The News Release states that written testimony will be accepted by CWRM until December 18, 2020.

The AWUDP is one of five parts of the Hawai'i Water Plan (the "**HWP**") that is assembled by CWRM pursuant to statutory directive in the State Water Code (the "**Code**"), to guide CWRM as a long-term planning tool for water resource management. Prepared by DOA, the AWUDP inventories and examines state water resources, including water infrastructure systems and assesses them with a view to providing support to the continuation and development of agriculture in Hawaii. The 2019 Update is the first update of the AWUDP prepared by DOA since the update that it adopted in 2004 (the "**2004 Update**"). With respect to the West Maui water systems, the 2004 Update provides more detail in certain respects than the 2019 Update and will be referenced herein as needed.

KLMC submits this testimony to provide CWRM and DOA with the benefit of its farming experience as it relates to the 2019 Update and water resources generally in West Maui.

The 2019 Update should be revised before it can become the planning document needed to chart the future course for water and agriculture on West Maui. In some

instances, KLMC asks that the 2019 Update be revised to address what KLMC considers to be errors and flaws in connection with the calculation of water demand rates and forecasts. In other instances, KLMC asks for revisions to address oversights. As part of any revision, the 2019 Update needs to consider the economic devastation caused by COVID and promote the expansion of West Maui agriculture as part of its planning perspective. Finally, the 2019 Update should be revised to consider the role that the Honokohau ditch system now plays and how it can participate in an expanded and more efficient distribution of irrigation waters to promote state policy goals while contributing to a reset of the Maui economy. The following points, some already well-known and acknowledged in the 2019 Update, warrant particular attention:

- **KLMC has a significant farming footprint on West Maui, utilizing an irrigation system that the company has utilized for over 100 years.** Operating the largest coffee farm on West Maui and the second largest in the State, and also supporting other crops and grazing, KLMC is a model of the type of farm that the State should promote to develop more diversified agriculture. KLMC's primary sources of irrigation water for its current operations are development wells located in the Honokowai valley. However, these wells provide a limited quantity of water and thus KLMC's ability to grow its agricultural footprint is constrained. See Section II, infra. The 2019 Update fails to acknowledge the continuing use of this system.

- **A substantial amount of prime farmland is now available for the promotion and expansion of agriculture, including much of the former sugar and pineapple lands in West Maui (which includes the land farmed by KLMC).** See Section III, infra. The 2019 Update fails to assess these opportunities properly and the 2019 Update needs to be revised to acknowledge and provide more planning guidance based on the benefits that can flow from these lands.

- **Continued support of agriculture provides many benefits to the citizens and economy, both locally and statewide.** This is recognized and promoted by many government and non-government organizations and supports the statutory and constitutional recognition of agriculture as an important state priority. See Section IV, infra. The 2019 Update fails to adequately tie these policy considerations to the specific needs of farmers or to examine the agricultural value of the lands in West Maui.

- **Water is critical to the success of agriculture.** The 2019 Update fails to properly take into account the critical importance of reliable irrigation water flows to arid regions of the State, such as the prime agricultural areas of West Maui, underplaying the risk to farmers of drought conditions in these areas. Cost considerations favor the continued use of existing, gravity feed water transmission systems, such as the Honokohau ditch system and the Honokowai system utilized by KLMC, over development of new infrastructure, to make sure that these critical water needs are satisfied. See Section V, infra.

- **The 2019 Update fails to acknowledge or consider the important role that the Honokohau ditch system can play in as a reliable source of supply for irrigation waters and its distribution of water to agricultural lands between Kapalua and Lahaina. A number of factual statements made in the 2019 Update or 2004 Update concerning the system, and KLMC's relationship to it, are incorrect.** These errors should be addressed and corrected. There are potential users for this water who could help satisfy the goals of the 2019 Update to 1) provide a comprehensive plan to protect and increase the agricultural water resources available to the diversified agriculture industry; and 2) maintain and improve the agricultural water systems in the State of Hawaii to support an economically viable diversified agricultural industry. See Section VI, infra. The 2019 Update needs to be revised to correctly assess and recognize the importance of the Honokohau Ditch system as an important source of agricultural water, and the primary source of agricultural water for West Maui.

- **The 2019 Update is methodologically flawed, and incorrectly uses shortcuts to determine water demand rates that do not adequately take into account needs of specific crops, local site conditions, drought risk and husbandry practices. Moreover, the rates used are in most cases too low even on an average basis to provide volumes consistent with maximizing yields and avoiding crop losses.** See Section VII, infra. The data is old, incomplete and not relevant to the irrigation needs for crops in arid climate zones. The 2019 Update needs to be revised by collecting additional data that takes into account these zones. In addition, using an assumption of 1 year of drought out of 5 and not providing enough water to weather those years is a major flaw of the 2019 Update.

- **While the 2019 Update recites the current legal framework around which water decisions are made, it should advocate for an enhanced legal status for agricultural water in light of other stated policy goals. Agricultural use of water is squarely within the public interest and its role in implementing public policy goals reinforces that notion.** The 2019 Update repeatedly alludes to various policy goals to support agriculture expressed by various government agencies and political leaders, some of which have been set down by statute. Without adequate water, these policies amount to empty promises. DOA, CWRM and other agencies need to actively promote agricultural use of waters to achieve these policy goals. The Hawai'i Supreme Court has articulated the boundaries of the "public trust doctrine" relating to the waters of Hawaii. A compelling argument can be made that water for agricultural irrigation should be accorded similar priority. See Section VII.C., infra.

- **Because the modeling of current water demand is flawed the forecast of future demand is also flawed to the extent it uses the same numbers.** See Section VII.E. infra. The regression analysis that projects a future growth rate also raised questions that need to be examined before the 2019 Update is adopted.

- **The impact of COVID-19 on the economy of Hawaii generally and Maui in particular means that planned growth, certainly pre-COVID, must**

be reassessed because the baseline projections are based on circumstances that have radically changed. Until the impacts of COVID-19 and slowing population growth are considered, the 2019 Update will rest on faulty premises. Moreover, any water demands not taking into account the factors noted above cannot form the basis for sound water planning for agricultural purposes. The 2019 Update was prepared prior to the COVID-19 outbreak, it fails to take these facts and circumstances into account. See Section VIII.A., infra. These impacts are so profound that the 2019 Update needs to be revised to take them into account.

- **Recent marine electrical imaging studies of the Island of Hawai'i suggest that there may be significant nearshore and offshore submarine reservoirs of freshwater connected to the aquifers of the Island of Maui (and other volcanic islands) which could mean that the sustainable yields of the aquifers in West Maui are significantly understated.** This would further support the continued use of existing irrigation systems, such as the Honokohau Ditch system, for agriculture. It could also support the further development of secondary sources, such as wells, that would be utilized only during drought conditions. See Section VIII.B., infra. Again, if the pressure on domestic water supplies might be reduced by significant additional supplies, the allocation of surface and ground water for agricultural irrigation should be less problematic.

II. KLMC's FARMING OPERATIONS AND IRRIGATION SYSTEM

KLMC (formerly known as Kaanapali Development Corp.) is an affiliate of Pioneer Mill Company, LLC ("**Pioneer Mill**", formerly known as Pioneer Mill Company, Limited). KLMC was formed to own, manage and improve Pioneer Mill's land in the Kaanapali area of West Maui. Pioneer Mill and its affiliates, including KLMC, have been engaged in agricultural operations on West Maui for over 150 years. For purposes of this testimony, KLMC shall be deemed to include any of its subsidiaries that are engaged in farming operations. Today, these operations (the "**KLMC Farming Operations**") include one of the largest coffee farms in the United States (and the second largest coffee farm in Hawai'i), cultivation of fruit trees and other crops, cattle and goat grazing, and small farms.

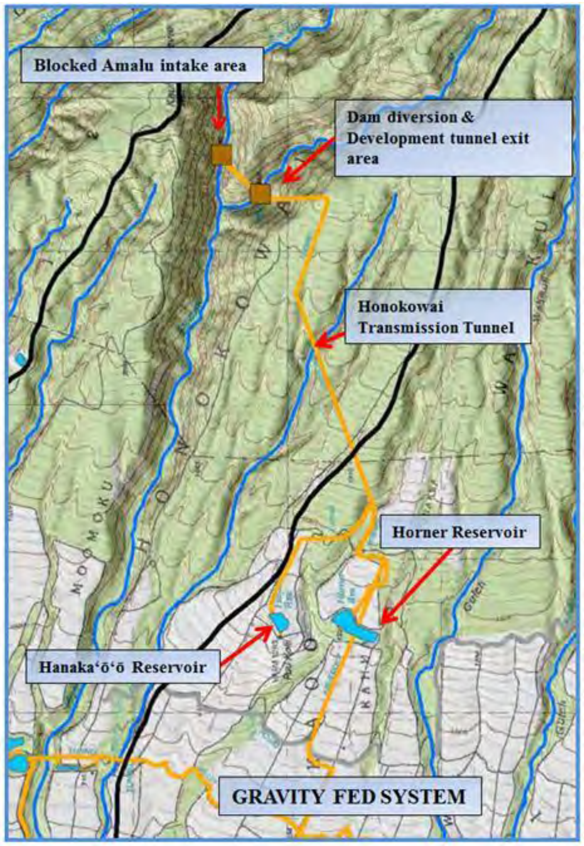
The KLMC Farming Operations currently include both farming on its own lands and also contractual relationships to farm lands owned by successor landowners to KLMC who have purchased lots in KLMC-developed subdivisions that comprise a portion of the coffee farm (the "**Ag Lots**"). The cultivated portions of the Ag Lots are leased by the lot owners to the development's lot owner's association, which in turn contracts with KLMC to cultivate, manage, and maintain the farming areas, and to harvest, process and market the coffee crop for sale to third parties as milled green coffee. KLMC undertakes these services in addition to farming the coffee and other crops grown on its own lands.

Among the customers for KLMC's coffee is MauiGrown Coffee, LLC ("**MauiGrown Coffee**"), which is owned by Kimo Falconer who provided oral testimony at the Hearings. MauiGrown Coffee purchases green coffee from KLMC, roasts it and sells it to the public through his storefront business in Lahaina. Most of the remainder of the green coffee produced by the coffee farm is sold to other roasters in Hawaii for the same purpose, although some is exported to the mainland and internationally. Mr. Falconer was formerly an employee of Pioneer Mill and KLMC and has been involved in KLMC Farming Operations since the early 1980's. He was instrumental in converting former sugar plantation acreage to coffee for Pioneer Mill in the late 1980's and turning the new coffee farm into a commercial operation. Mr. Falconer continues to assist KLMC on a consulting basis in all aspects of the KLMC Farming Operations as they pertain to coffee.

Historically, beginning in the late 19th century, Pioneer Mill, together with adjacent large landowners such as Maui Land & Pineapple Company, Inc. ("**MLP**") developed an extensive system of water development, diversion and transmission infrastructure for the purpose of providing irrigation water to crops throughout West Maui. These crops, mostly sugar and pineapple, once covered almost the entire arable lands between what is now Kapalua and Ukumehame.

Today, KLMC Farming Operations rely primarily on ground water sourced from two development tunnels (the "**Honokowai Development Tunnels**") constructed by Pioneer Mill in the Honokowai Valley prior to 1920. This ground water is supplemented sporadically by stream water from the Kapaloa Stream, which is a tributary of the Honokowai Stream (collectively, the Kapaloa Stream and the Honokowai Stream are referred to herein as the "**Honokowai Stream**") that manages to reach the diversion at the entrance to KLMC's transmission tunnel downstream from the Honokowai Development Tunnels. From such transmission tunnels, the collected water (the "**Honokowai Water**") is first diverted to reservoirs on KLMC land and then enters KLMC's extensive irrigation system to distribute the Honokowai Water as needed by the KLMC Farming Operations. KLMC has previously commented in great detail about the Honokowai Stream and Honokowai Development Tunnels through written testimony (the "**KLMC Honokowai IFSAR Testimony**") provided to CWRM on October 9, 2019, in response to the Commission's draft of the Instream Flow Standard Assessment Report, Island of Maui Hydrologic Unit 6010, Honokowai, DRAFT PR-2019-01, dated June 2019 (the "**Draft IFSAR Report**").

The graphic on the following page shows the Honokowai Water system (the Honokohau Ditch crosses KLMC land at the bottom of this graphic).



With respect to the lands now owned or farmed by KLMC, KLMC historically obtained water as a secondary source from the Honokohau Ditch system (the "**Honokohau Ditch**") which is the most extensive water transmission system in West Maui, and comprises development tunnels, stream diversions, transmission tunnels, ditches, siphons and reservoirs, which was completed in 1913 (replacing an earlier ditch system) and originates at the Honokohau Stream (the "**Honokohau Stream**"). Currently, the Honokohau Ditch has the capacity to provide non-potable water from the Honokohau stream in the north to the Kahoma stream in the south. The primary sources for the Honokohau Ditch are intakes in the Honokohau Stream (the "**Honokohau Intake**") the Kaluanui Stream (the "**Kaluanaui Intake**") and the Honolua Stream (the "**Honolua Intake**"). (Historically, the Honokohau Ditch continued past Kahoma, transmitting water augmented from other streams as far south as Ukumehame. For a good history of the construction and early use of the West Maui ditch systems, see C. Wilcox, "Sugar Water: Hawaii's Plantation Ditches", at 122-137, which can be found at: https://books.google.com/books?id=6lZO0HSgF7UC&pg=PA137&lpg=PA137&dq=honokohau+ditch+history&source=bl&ots=ZMaikZHdG_&sig=ACfU3U2YlxtH3I0IMhuSigV67hSHLe9LJA&hl=en&sa=X&ved=2ahUKEwjl2bmyp63tAhV_RzABHcHuDfo4ChDoATASegQICRAC#v=onepage&q=honokohau%20ditch%20history&f=false.) While the Honokohau Intake continues to operate, the Kaluahaui Intake and Honolua Intake have each been closed.

A map of the current Honokohau Ditch system, reproduced from the 2004 Update, is shown on the next page.

Currently, the coffee farm comprises over 400 acres and KLMC cultivates other crops on its lands in addition to providing grazing lands for cattle and goats. A significant portion of its lands remain fallow however, due to lack of water. The KLMC Farming Operations employ 20 people full time and additional people on a part-time basis primarily during the harvest season. MauiGrown Coffee provides employment for additional people at the company store. Today, the volume of water transmitted by the Honokohau Ditch is far below its historic average and is insufficient to provide any meaningful water to the KLMC Farming Operations, as it had in the past, which negatively impacts KLMC during drought conditions by stressing the plants and constraining yields. Water is the limiting resource that prevents KLMC from expanding its agricultural footprint on its lands.

III. HISTORY AND TRAJECTORY OF AGRICULTURE

In 1980, according to the DOA, there were 350,830 acres in crop production, 85 percent of which was tied to sugar and pineapple. By 2015, total crop acres dropped to 151,830, which amount included the 38,800 acres of sugar farmed by HC&S in central Maui. HC&S went out of production in 2016. Of the remainder, seed corn accounted for 23,728 acres, commercial forestry for 22,864 acres, and macadamia nuts for 21,545, the last two of these primarily attributed to the Island of Hawai'i. These crops are primarily for export. Pasture use between 1980 and 2015 decreased over 30% from 1.1 million acres to 761,430 acres. "Statewide Agricultural Land Use Baseline 2015", DOA 2016, available at https://hdoa.hawaii.gov/wp-content/uploads/2016/02/StateAgLandUseBaseline2015.pdf ("**DOA Baseline 2015**"), at 4, 20. Hawai'i reached its high water mark in terms of acres in active agricultural production during the plantation era and now, with that era gone, "there is a surplus of agricultural land and water in the state that could be deployed for more intensive agriculture use". DOA Baseline 2015 at 4.

While much of the remaining acreage in crops is oriented toward export outside of Hawai'i, and much of this is located on the Island of Hawai'i, there is a recent trend toward smaller farms growing a variety of crops mostly for sale and consumption within the state. For purposes of these comments, while diversified crops have in the past typically meant to include only a variety of leaf and root vegetables, the term "**Diversified Agriculture**" herein shall be the same as used by DOA in the 2019 Update: "all agricultural crops in the State of Hawai'i". 2019 Update, at 10. Livestock, consisting primarily of cattle, sheep and goats, both for dairy and meat production ("**Livestock**") are grazed on range and pastureland, or on small private parcels, in various parts of the state. Livestock grown for local consumption also includes chickens raised for egg production and honey bees. **Substantially all of the KLMC Farming Operations consist of Diversified Agriculture and Livestock grazing for local consumption within the State.**

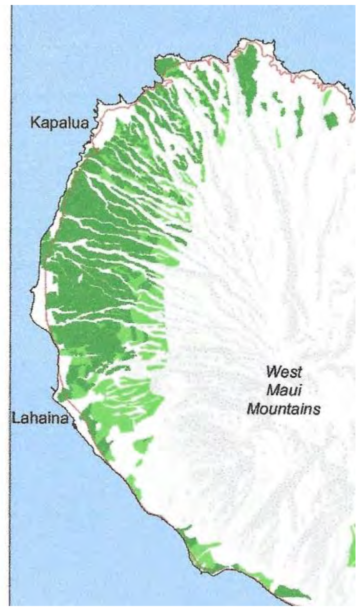
Between 2012 and 2017, the total number of farms in Hawai'i increased from 7,000 to 7,328, according to the U.S. Department of Agriculture ("**USDA**") but the value of farm industry output fell 15% from $661 million to $564, which reflects the shift from larger commercial farming to small local farms. Almost all of the growth in farms numbers is attributable to small farms on less than 10 acres. Most of the new farms are engaged in Diversified Agriculture or raising Livestock. There is also a trend toward selling produce directly to consumers rather than wholesale to local grocers and retailers, utilizing roadside stands, retail stores or farmer's markets. See, A. Gomes, "Big Shifts Hit Hawaii Farm Landscape", Honolulu Star-Advertiser, April 22, 2019, which can be found at https://hfbf.org/big-shifts-hit-hawaii-farms-landscape/.

Until the 1990s in West Maui, where KLMC operates, Pioneer Mill and MLP accounted for a combined 14,000 acres of sugar and pineapple production, which are now gone and new agriculture has been slow to reemerge, with "[m]uch of the former cropland reverting to dry grass and shrubs that flush green after the rain and periodically burn off in wild fires". DOA Baseline 2015, at 60. Since MLP is not currently involved in active agriculture, the only current remaining agricultural ventures of any size are the KLMC Farming Operations.

The State of Hawaii has a number of different classification systems for agricultural land; the 2019 Update discusses three of them: (1) Agricultural Lands of Importance to the State of Hawai'i ("**ALISH**"), (2) Land Capability Classification ("**LCC**"), and (3) Important Agricultural Lands ("**IAL**"). See 2019 Update at 16-23. The 2019 Update did not provide any of this information relative to the Honokohau Ditch and should be revised to include it.

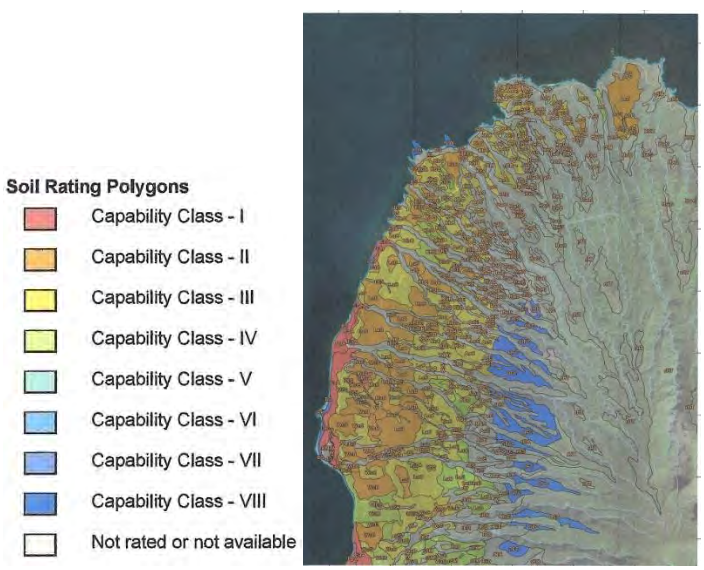
Land is designated as IAL in compliance with statute. Currently, the only area designed as IAL on Maui is the former Alexander & Baldwin sugar plantation land in Central Maui. Id., at 23. That does not mean that other land on Maui cannot be designated as IAL. The ALISH system designates agricultural land in 3 categories: (1) Prime, (2) Unique or (3) Other. Id., at 16-17. The

ALISH map for Maui can be found at https://files.hawaii.gov/dbedt/op/gis/maps/mau_alish_large.pdf and is reproduced below, together with an expanded map showing only the West Maui region:



As is apparent from the map, a major portion of the lands in the West Maui area serviced by the Honokohau Ditch system are "Prime" agricultural lands according to ALISH, meaning that it is "land best suited to produce food, feed, forage, and fiber crops". 2019 Update, at 17.

The LCC classifications for the soils in the relevant West Maui region, assuming the availability of irrigation, is shown in the map below which was downloaded (and cropped) from the USDA National Resources Conservation ("**NRCS**") website at https://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx.



It can be seen from the map that, not only is much of the agricultural land serviced by the Honokohau Ditch system Prime under the ALISH classification system, but the underlying soils are generally in capability classes I, II or III. Clearly, the lands are suitable for the promotion of Diversified Agriculture in the areas serviced by the Honokohau Ditch.

As stated above, a portion of the KLMC Farming Operations consist of Ag Lots that have been sold to private owners but "are planted in coffee and provides the owner with a selected house site, a managed coffee landscape, and an income for their production. This blend offers a model for opportunities elsewhere in the State." DOA Baseline 2015, at 60. This structure is materially different from a "gentleman farm" concept where a lot buyer maintains agricultural zoning for land by planting a few trees or vegetables, or grazing a few head of Livestock, mostly for personal consumption. See 2019 Update, at 230. By maintaining a significant portion of its development land in commercially managed farms, an Ag Lot development such as Ka'anapali Coffee Farms supports local employment and helps to subsidize the farming activity, thereby supporting continued agriculture in Hawai'i.

IV. BENEFITS OF DIVERSIFIED AGRICULTURE

The trend toward Diversified Agriculture and Livestock for local consumption in Hawai'i, as practiced by KLMC, provides a number of benefits to the people of Maui and Hawai'i generally and the local economy in particular and is clearly in the public interest. The 2019 Update fails to address the impacts of COVID and its devastation of the Maui economy and how increased water supplies and increased agricultural activity can be promoted through a reassessment of future water needs in light of these COVID impacts.

A. Sustainability

Legally, "the term sustainable agriculture means an integrated system of plant and animal production practices having a site-specific application that will, over the long term:

- satisfy human food and fiber needs;
- enhance environmental quality and the natural resource base upon which the agricultural economy depends;
- make the most efficient use of nonrenewable resources and on-farm resources and integrate, where appropriate, natural biological cycles and controls;
- sustain the economic viability of farm operations; and
- enhance the quality of life for farmers and society as a whole."

Subchapter I: Findings, Purposes, and Definitions, U.S. Code, Title 7, Chapter 64-Agricultural Research, Extension and Teaching, Available at GPO Access:

http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=browse_usc&docid=Cite:+7USC3103 (8/23/07). DOA refers instead to the Webster definition of sustainability as it pertains to agriculture: "of, relating to, or being a method of harvesting or using a resource so that the resource is not depleted or permanently damaged". 2019 Update, at 204 (footnote 40).

In general, it is easy to see how a transition to smaller, local farms, growing crops or raising livestock for local consumption satisfies at least some of these attributes, when compared to larger conventional farms. While the economic viability of smaller farms is a tenuous enterprise, the use of shared resources and infrastructure, best agricultural practices and, where appropriate, public and private subsidies help to achieve the sustainability of individual farms and agriculture generally. Farmers are benefited by achieving wages and profits that sustain their lives over the longer term and society is benefitted by improvements to the local economy and food options.

DOA appears to agree. It states: "A good first step toward achieving statewide sustainability is to develop a sustainable agricultural industry, both in resources and economics. … If farmers are to be expected to provide quality and consistent commodities, they must have an adequate and stable water supply for their crops, especially during severe weather conditions." 2019 Update, at 204.

B. Food Security and Self-Sufficiency

DOA recognizes that the concept of "import replacement" has long been discussed in Hawai'i. However, progress has been slow. See 2019 Update, at 206-207, 225. Included in the issues that could help to promote "import replacement" were reducing costs by encouraging larger farms with increased functional specialization, and developing low-cost irrigation water. Id., at 206. DOA's recap of a 2008 University of Hawai'i paper on the subject, which advocated a doubling of consumption of Hawai'i-grown food products, concludes with the observation that "this forecast assumed that there were available resources and infrastructure to double production". Id., at 207. Presumably, this largely refers to the availability of adequate irrigation water and the means to deliver that water to the land.

Commenting on the USDA's report of an increase in the number farms in its most-recent 5-year statewide census of agriculture, "Gov. David Ige commented on the snapshot of Hawaii agriculture by promoting the need to grow more food for local consumption. 'These numbers should reinvigorate all efforts to continue to increasing Hawaii's food security and self-sufficiency' ". See, "Big Shifts Hit Hawaii Farm Landscape", supra.

Hawai'i has always been largely dependent on imports for the mainland or internationally for its food supply, importing 85-90% of its food. As an isolated outpost in the middle of the Pacific, this dependency is a source of risk for the state's inhabitants, making them "particularly vulnerable to natural disasters and global event[s] that might disrupt shipping and the food supply". See "Increased Food Security and Food Self-Sufficiency Strategy", Office of Planning Department of Business Economic Development & Tourism in Cooperation with the Department of Agriculture, State of Hawaii, October 2012, ("**Office of Planning 2012 Food Strategy**"), available at https://files.hawaii.gov/dbedt/op/spb/INCREASED_FOOD_SECURITY_AND_FOOD_SELF_SUFFICIENCY_STRATEGY.pdf , at 2.

The Office of Planning 2012 Food Strategy identifies three objectives for food security and self-sufficiency: (1) Increase Demand for Locally Grown Foods, (2) Increase Production of Locally Grown Foods, and (3) Provide Policy and Organizational Support to Meet Food Self-Sufficiency Needs. Id., at 18, 23, and 34. It sets forth a number of policy statements and action items to achieve these goals and identifies numerous government and non-government organizations that are tasked with or participate in their implementation. These objectives are repeated by DOA on page 205 of the 2019 Update. DOA is designated as a lead or assisting organization for many of these action items.

With respect to water, the policy statements in the Office of Planning 2012 Food Strategy, focus on the need to maintain, upgrade and repair state irrigation systems and former plantation agriculture irrigation infrastructure, recognizing that "agricultural lands and irrigation system action recommendations are inter-related and inter-dependent". Among the items that are assigned to DOA (and CWRM), is the completion of the AWUDP, which is the subject of this testimony. Id., at 24-25.

The Maui Island Plan, General Plan 2030 ("**Maui General Plan**"), was adopted in 2012. It can be found at https://www.mauicounty.gov/DocumentCenter/View/84686/Whole-Maui-Island-Plan-Book?bidId=. Among its "key highlights" is "Protection of Maui's Small Towns and Rural Character. Outside of growth areas development will be limited to preserve our agricultural lands and open space." Maui General Plan, at ES-2. While, due to lower than expected population growth since 2012 and economic disruptions caused by the COVID-19 pandemic, the Maui General Plan is likely already out of date, it does recognize that "[I]ncreasing local consumption of Maui agricultural goods is a long-term opportunity for stabilizing and expanding agriculture. Besides economic benefits to farmers, substituting locally-produced food for imports could allow Maui to become more self-sufficient." Maui General Plan, at 4-16.

C. Diversification of the Economy

The Office of Planning 2012 Food Strategy also recognized that "[I] ncreasing food self-sufficiency will keep money circulating in Hawaii's economy rather than supporting agribusiness in other states or countries. It will help to diversify Hawaii's economy." Office of Planning 2012 Food Strategy, at 2.

Even before the invasion of COVID-19, each of the State of Hawai'i and Maui County recognized the need to reduce their dependence on tourism and diversify the economy into other areas.

For example, in 2016, the County of Maui Mayor's Office of Economic Development, in partnership with Maui Economic Development Board, released its Comprehensive Economic Development Strategy ("**CEDS**"), which can be found at https://www.mauicounty.gov/DocumentCenter/View/106485/OED-CEDS-Report?bidId=. "Among the major challenges Maui County faces in economic development are diversification of the economy; increasing the number and proportion of living wage jobs; …". CEDS, at 5. Agriculture is identified as one of eight industries for which priority goals for diversification were set by the CEDS, including the need to "assure reliable, adequate and affordable water sources for all ag ventures". CEDS, at 50.

Two objectives of the Maui General Plan are to "[m]aintain or increase agriculture's share of the total island economy" and "[e]xpand diversified agriculture production at an average annual rate of 4 percent". Maui General Plan, at 4-19, 4-20.

The Draft West Maui Community Plan ("**DWMCP**"), which was updated June 2020 but does not appear to have taken into account the impact of COVID-19, can be found at https://wearemaui.konveio.com/draft-west-maui-community-plan. It identifies at least two policies that recognize the importance of agriculture in fostering the goal of economic opportunity: (1) "[s]upport agriculture that provides jobs, improves soil health, is less water intensive, and provides food and products for local markets", and (2) "[s]upport agriculture that is small-scale or self-subsistence farming". DWMCP, at 56. Agriculture is one of 14 land use designations specified in the DWMCP and covers by far the largest area shown on the included community plan map. DWMCP, at 70, 86-87.

If West Maui truly plans to maintain a significant agricultural component for its future economy, water resources need to be allocated to farming areas for them to be successful. While small-scale farms comprise a portion of the KLMC Farming Operations and contribute to food security, they (and subsistence farms) generally are not money-making enterprises and contribute little to the local economy, because they do not provide jobs or spend significant money at other local businesses. The promotion of commercial-scale farming, on the other hand, such as KLMC's coffee and Diversified Agriculture ventures, have the capacity to help grow and diversify the local economy in a positive way.

D. Job Growth

According to an October 2019, Kiplinger article Hawaii was projected to be one of the 10 worst states for job growth for 2019 and 2020. D. Payne, "10 States with the Slowest Rates of Job Growth, 2020", Kiplinger, October 17, 2019. Then the pandemic hit, turning job growth significantly negative. Maui County's unemployment rate rose from 2.2% in March, 2020, to 34.6% in April 2020 and has since eased downward to 23.6% in September 2020. U.S. Bureau of Labor Statistics, “Kahilui-Wailuku-Lahaina Area”, October 2020, at: https://www.bls.gov/regions/west/hi_kahului_msa.htm. It will take many years for the rate to revert to anything close to the rate seen before the COVID-19 pandemic decimated Maui’s economy.

As stated above, KLMC’s Farming Operations provide employment for 20 full-time employees and a number of part-time employees on a seasonal basis. These jobs are in peril if KLMC cannot obtain sufficient water to continue operations. Conversely, to the extent that agriculture can be expanded in West Maui in a manner that is commercially viable, more job opportunities will be created as well. Avoiding the loss of jobs is just as important as growing the number of job opportunities. Providing farmers on West Maui with reliable, adequate and affordable water sources will help preserve and create local jobs that are especially needed over the next few years.

E. Wildfire Suppression

Wildfires have become commonplace in Hawaii. Most fires start in “unmanaged nonnative grasslands and shrublands, which have dramatically expanded with declines in Hawaii’s agricultural “footprint” by more than 60% since the 1960s.” C. Trauemicht, “Recent Maui Fires Require Proactive Statewide Response”, Honolulu Civil Beat, October 28, 2019, which can be found at: https://www.civilbeat.org/2019/10/recent-maui-fires-require-proactive-statewide-response/. In 2018, there were 627 wildland fires statewide, including one that impacted lands owned by KLMC. Since the beginning of 2019 in West Maui, fires in January 2019 in Olowalu, April 2019 near the Kapalua Airport, October 2019 above Kahana Ridge (which burned about 1000 acres), September 2020 between the Kapalua Airport and KLMC’s lands (blackening approximately 550 acres), and October, 2020 in Kahoma Valley.

Fires such as these could be minimized through the greening of fallow agricultural lands or the grazing of Livestock, which would reduce the amount of dry vegetation on former plantation acreage. The expansion of the agricultural footprint on West Maui would assist in this effort. Moreover, due to the abandonment or closure of reservoirs in West Maui, there is not a sufficient source of fresh water available to firefighters to battle these blazes and they typically use helicopter drops of ocean water to bring fires under control. The use of ocean water is harmful to the soil and due to its salt content and can make future agriculture in those areas problematic.

While a bill has been introduced that would support reutilizing these reservoirs for fire suppression, it is not clear that this can be done without management of the reservoirs by landowners who have no financial attachment to them. Rehabilitating reservoirs in the context of supporting and expanding commercial agriculture, and providing a ready source of irrigation water for such purpose would also serve the twin goals of reducing the fallow dry acreage and providing a source of fresh water near these lands for fire suppression. See, generally, Staff, "Three bills would impact life in West Maui", Lahaina News, February 13, 2020, which can be found at: https://www.lahainanews.com/news/local-news/2020/02/13/three-bills-would-impact-life-in-west-maui/.

F. Aesthetic Enhancement

While the foregoing benefits of supporting existing and future agriculture on Maui are directly related to the business, another benefit of replanting fallow lands is the enhanced aesthetic value of the greening of the hillsides above the settled areas of the state. In fact, the DOA website, at https://hdoa.hawaii.gov/chair/boa/, states that the "Department is dedicated to the preservation and productive use of agricultural resources so as to assure a healthy and adequate food supply for Hawaii's people, providing employment, maintaining a favorable balance of trade, and *preserving the aesthetic quality of the Islands* [emphasis added]".

With tourism being a major factor in the economy of West Maui, the beautification of the hillsides by providing managed crop and grazing lands versus fallow scrublands enhances the appeal of this area and thus enhances the visitor experience. With respect to the Honokohau Ditch system, the 2004 Update, stated that "the State's interest is based on the agricultural water needs of surrounding State lands and the need to continue scenic greenery on West Maui's western slopes for the tourism industry". 2004 Update, at 66. Of course, since the 2004 Update did not acknowledge any remaining private agriculture on West Maui, it confined its comments to State lands, but the comment applies equally to private agricultural lands.

V. IMPORTANCE OF WATER/WATER NEEDS

A. Importance of Water for Agriculture

"If agriculture on Maui is to be economically viable, the State and County will need to ensure that farmers have access to sufficient supplies of affordable water." Maui General Plan, at 4-17. Without water, crops don't grow. Without crops, there is no food. In Hawai'i, agriculture exists in a variety of locations and environments. But, the lion's share of plantation farming was conducted in regions on the leeward side of islands, where the rainfall was less and sunshine was maximized. This provided for healthier yields and more crop cycles. In order to provide needed water for crops in these advantaged locations, extensive irrigation systems were developed to transport water from rainier areas to sunnier ones.

In West Maui, substantially all agriculture was, and continues to be, conducted in these sunny regions, including the KLMC Farming Operations. The 2019 Update "reaffirms that agricultural water systems (irrigation systems) are the most important infrastructural requirement to expand Hawai'i's diversified agriculture industry; and that irrigation water supply should be reliable and adequate to meet the current and future water requirements of Hawai'i's diversified agricultural industry … achieving the state's goals of agricultural growth, economic diversity, and sustainability." 2019 Update, at 4. KLMC agrees with this assessment and also with the stated goals of the 2019 Update: "to 1) provide a comprehensive plan to protect and increase the agricultural water resources available to the diversified agriculture industry; and 2) maintain and improve the agricultural water systems in the State of Hawaii to support an economically viable diversified agricultural industry". Id.

B. Consequences of Drought

Rainfall is seasonal in Hawaii, particularly on the leeward side of each island. During the "dry season" between April and October, most areas not at significant elevations experience abnormally dry conditions. In addition, some areas may experience prolonged drought periods even during "rainy seasons". According to the National Integrated Drought Information System, the portion of West Maui that includes the Honokohau Ditch and the Honokowai Water systems is currently in the D2-Severe Drought classification. This data can be found at: https://www.drought.gov/drought/states/hawaii. Among the consequences of severe drought is that "crop or pasture loss likely". Id.

As an arid area on the leeward side of Maui, West Maui has experienced at least moderate drought conditions at times during most of the last 20 years. Drought has become an important enough issue in Hawaii that CWRM adopted a Hawaii Drought Plan in 2000, the most-recent update of which was prepared in 2017 and can be found at https://files.hawaii.gov/dlnr/cwrm/planning/HDP2017.pdf.

While irrigation water is important at various times during the growing cycle for any crop, loss of water during drought periods can result in significant economic loss. While crop loss insurance can cover some of this for a given year, this will not typically suffice where there is permanent damage to the farms, such as loss of grazing lands or fruit or nut bearing trees. Most small farmers growing Diversified Agriculture products will not be able to afford crop insurance.

C. Cost Considerations

No matter what crop is being produced, or at what scale, the cost of irrigation water can make the difference between a farmer's success or failure. Farms in Hawaii generally have three options (other than hoping for rain) for sourcing irrigation water (1) county potable water systems, (2) private wells, and (3) diversions from stream beds. The first option infringes on the domestic water supplies and is poor use of water that has been treated for human consumption. Private wells are expensive to drill and operate. That is why, dating back over 100 years, agriculture in Hawaii has largely depended on gravity feed systems that transport stream water or high level ground water from the source to the point of need.

While gravity feed systems are not without cost, once the infrastructure is in place the variable cost of maintenance is relatively minor. The Honokohau Ditch and Honokowai Water systems each divert primarily high level ground water from development tunnels and represent the lowest cost option for farmers on West Maui. In keeping with the goals of the 2019 Update stated above, the use of these systems should be maximized to ensure a viable diversified agricultural industry can be maintained and grow in West Maui.

D. Components of 2019 Update

The main components of the 2019 Update include (1) an inventory of water systems not inventoried by the 2004 Update (which earlier inventories are relied upon in the 2019 Update), (2) development of capital improvement programs for these water systems, (3) updated water demand forecasts, and (4) a proposal for a development plan to meet existing and future water needs. 2019 Update, at 4-5. So, in essence, the purpose of the 2019 Update is to assess the potential supply of irrigation water and ensure that it is sufficient to meet the expected demand for irrigation water.

The water system of interest to KLMC and West Maui generally is the system identified in the 2019 Update as the "Maui Land and Pineapple Co./Pioneer Mill Irrigation System" ("**MLP/PMIS**"), and the infrastructure providing Honokowai Water. The MLP/PMIS originally consisted of three ditch systems that are all included in the definition of Honokohau Ditch used in this testimony.

VI. IMPORTANCE OF THE HONOKOHAU DITCH

A. Historical Use/Capacity; Description in AWUDP

Historically, the central stem of the Honokohau Ditch transported water drawn from many of the valleys in West Maui, including delivering water to the Wahikuli and Crater Hill reservoirs above Lahaina Town where it could be stored and redirected northward at lower elevations or directed further to the south to Launiupoko. The Wahikuli and Crater Hill reservoirs have since been decommissioned. DOA Baseline 2015, at 62. Unless this portion of the system is rehabilitated, the functional southern limit of the Honokohau Ditch is the Kahoma Valley.

The 2004 Update adequately describes the construction, scope and early history of the Honokohau Ditch, but makes a number of assertions concerning the use and condition of that system and the so-called "western slopes" sources, meaning the Honokowai Water system, that were incorrect then and are incorrect now.

- The 2019 Update categorizes the Honokohau Ditch as managed by the Agricultural Development Corporation ("ADC"), when it should be classified as a private system. 2019 Update, at 3. "The ADC oversees and assists in the management of water systems which are transitioning from the plantation era to diversified agriculture." 2019 Update, at 245. The agricultural lands in West Maui are certainly transitioning to Diversified Agriculture, and the ADC may manage the relatively minor portion of the system that exists on State lands, but this portion has no associated agriculture today. The system is primarily managed by MLP and KLMC.

- By 2004, when the 2004 Update was released, KLMC and Pioneer Mill (and their parent entities) had emerged from bankruptcy as reorganized entities and continued to engage in Diversified Agriculture on some of their land in West Maui. See 2004 Update, at 66, 75.

- The "sources of water on the western slopes", essentially referring to the Honokowai Water system, was never at any time abandoned by KLMC or Pioneer Mill and continued to serve as the primary source of irrigation water for KLMC's Farming Operations. See 2004 Update, at 63, 66. Thus the MLP/PMIS should have continued to include the Honokowai Water system in its assessment.

- KLMC, not Amfac/JMB Hawaii, which was a parent entity, is the successor to Pioneer Mill with respect to the lands at Kaanapali, and it never stopped maintaining the Honokowai Water system. See 2004 Update at 64.

- In addition, the uses of irrigation water from MLP/PMIS in the 1980s was not confined to the uses described in the 2004 Update, but was also used by Pioneer Mill (and later KLMC) to irrigate crops, including its remaining sugar fields and its newly-established coffee farm, which is still in business. See 2004 Update, at 64. Later, KLMC continued to use the Honokohau Ditch as a secondary source of irrigation water for its makai fields until reliable water stopped flowing to it during the past few years. (According to Table 113 of the 2019 Update, significant water flowed to KLMC through the Honokohau Ditch during the years 2012-2014. 2019 Update, at 154. Even so, KLMC continues to use the Honokohau Ditch as a mechanism for transporting water to certain portions of its land, and it has never abandoned or stopped using the Honokohau Ditch on the portions it owns.)

Water flowing into the Honokohau Ditch does not comprise only surface water, as suggested by the DOA Baseline 2015, but also ground water that is produced by development tunnels and that utilize stream beds for transmission between the mouth of the development tunnels and the diversions/intakes that deposit water directly or indirectly into the Honokohau Ditch for distribution to users to the south. See, generally, KLMC Honokowai IFSAR Testimony.

The 2019 Update relies upon the 2004 Update for its description and assessment of the Honokohau Ditch and Honokowai Water systems, augmenting it only to recognize that a portion of the system at Wahikuli is now owned by West Maui Land Company ("**WMLC**"), and the potential to reconnect the system to the south to provide a water source for lands owned (or previously developed) by WMLC and Kamehameha Schools Bishop Estate ("**KSBE**"). This portion of the 2019 Update references Map 125, which is supposed to show the West Maui/Pioneer Mill Irrigation system alignment of the Honokohau Ditch system through these lands, but shows a different ditch system instead. 2019 Update, at 152 and Map 125. In addition, Table 113 shows no flow data for Honokowai, but that is not because there was no water being used from the Honokowai Water system during those years, but only because no readings were taken.

B. Rehabilitation and Maintenance of Honokohau Ditch

According to the DOA Baseline 2015, "MLP continues to manage several stream intakes in Honolua and Honokohau Valleys and the Honokohau Ditch, which were once the backbone of the region's water delivery system." DOA Baseline 2015, at 60. However, this is only partially true, since KLMC maintains those portions of the Honokohau Ditch that exist on KLMC lands and also on such portions that exist on state land that has been leased by KLMC. MLP never managed portions of the ditch to the south of Mahinahina. The Honokohau today delivers water to support the Kapalua resort and also transmits water to the County Water Department at Mahinahina. Id. While the KLMC portion of the Honokohau Ditch system is operable, KLMC has received no meaningful water from MLP though the ditch for the past few years.

While the geographic scope of the Honokohau Ditch system is smaller than during the plantation days, since it currently is in disrepair from the former Wahikuli Reservoir and southward, the system can still deliver water to a large portion of West Maui and should still be considered an important regional water system.

"As with most infrastructure issues, agricultural water systems require ongoing investment and maintenance to insure their viability… The legacy of plantation era surface water collection and delivery systems is a valuable part of today's agricultural heritage. Many of these systems could never be rebuilt, regardless of price" Id. at 84.

The 2004 Update assessed the condition of those portions of the MLP/PMIS system that it chose to include and provided a list of proposed capital improvement projects ("**CIP**") and maintenance projects. It did not revise these for the 2019 Update and they are woefully out-of-date. Nevertheless, it is important for DOA to revisit this and make proposals based on current facts. Otherwise, because Chapters 4 and 5 of the 2019 Update do not contain any current proposed projects that impact the MLP/PMIS system (or any other system in the area), KLMC does not comment on those chapters.

Last winter, MLP commenced a series of major repairs to the Honokohau Ditch, to restore damage caused by hurricanes Lane and Olivia in late 2018. Mostly, these repairs were to the intake area in the Honokohau Valley, but also to some of the siphons and access roads. See, L. Imada, "ML&P begins repairs to Honokohau Stream ditch system", Maui News, December 5, 2019, which can be found at: https://www.mauinews.com/news/local-news/2019/12/mlp-begins-repairs-to-honokohau-stream-ditch-system/ . Apart from these repairs, we recommend that DOA and CWRM consider the following:

- Reconstruction of the Wahikuli Reservoir and provide for the reuse of the Crater and/or "New" reservoirs
- Replacement of the Wahikuli Ditch with pipelines, laterals and control valves
- Repair or replace the Mahinahina Weir
- Repair of Honokowai and Wahikuli Stream siphons and associated siphon boxes
- Rehabilitation of the Honolua intake
- Line the 140 Reservoir
- Repair open ditch sections as needed

Responsibility for maintenance of these systems will depend on the facts. For example, KLMC continues to maintain the Honokowai Water system because it exists almost entirely on land that it owns or manages. The Honokohau Ditch system could be maintained in a number of ways. Landowners could maintain those portions that exist on their land. The incentive for doing so, however, would depend on whether the landowners are receiving adequate irrigation water from the system. Landowners could enter into a contract for the delivery of water, which would include an allocation of maintenance costs. This might raise technical issues concerning priorities, metering or failure to deliver water. Finally, as suggested in the 2004 Update, the State could create an entity to manage and maintain the Honokohau Ditch, such as an irrigation cooperative, which would raise the same issues as a contract and also other issues concerning ownership, easements and resolution of disputes. See 2004 Update, at 67.

Chapter 9 of the 2019 Update includes a general discussion of the development plan presented (consisting of the CIPs and other projects listed in the discussions of the individual systems in Chapters 4 and 5). While no projects are included for the Honokohau Ditch, we nevertheless have comments on this discussion.

KLMC is generally in agreement with some of the statements in support of agriculture that DOA makes:

- KLMC agrees that current rules and regulations for reservoirs, dams and instream flow affect the amount of water supplied to farms and may impede the rehabilitation or growth of affected systems – and, by extension, Diversified Agriculture. See 2019 Update, at 242.

- KLMC acknowledges, as does DOA, that "the State of Hawaii's goals, which require an increase in agricultural production, crop diversity, and economics, include:

    - Diversifying the economy;

    - Sustainability and self-sufficiency; and

    - Support of diversified agriculture"

  2019 Update, at 246.

- While KLMC agrees that the installation of automated irrigation systems may bring the benefits described (See 2019 Update, at 248, 251), the disadvantages should also be considered, such as (1) cost, especially for smaller farms, (2) potential job losses, and (3) reduction of aquifer recharge.

- KLMC agrees that distribution loss studies should be undertaken to ensure that sufficient water is allocated to agricultural lands. See 2019 Update, at 248. However, for reasons stated earlier in this testimony, there are benefits to aquifer recharge caused by these losses that may, on balance, make them less problematic, other than to the extent the farmer is paying for water that is not being applied to the crops or receives insufficient irrigation water because of such losses. Generally, it should be up to the landowner to manage system losses on its own land. Providing other infrastructure for aquifer recharge should also be considered if there is sufficient excess water and funding available. See 2019 Update at 249-250.

- KLMC agrees with the concepts suggested by DOA to "meet the state's goals and provide economic stability to the agriculture industry". See 2019 Update at 251.

C. System Capacity/Current and Future Needs

In 2002, MLP estimated the capacity of the Honokohau Stream intake to divert water into the Honokohau Ditch at 60-65 MGD. See R. Fontaine, "Availability and Distribution of Base Flow in Lower Honokohau Stream, Island of Maui", USGS Water-Resources Investigations Report 03-4060, 2003 ("**USGS 03-4060**"), at 21. Historically, the average flow in the Honokohau Ditch was closer to 20MGD, according to the 2019 Update. 2019 Update, Table 113, at 153. This is somewhat lower than the time-series data for the period 193-2000 computed by USGS, which arrived at an average discharge of 24.7 MGD but a median of 19 MGD. USGS 03-4060, at 25. About 1 MGD of this amount was historically redirected into Honokohau Stream through the "taro gate" that was used to water the taro crops in the valley. USGS 03-4060, at 27. The development tunnels in the Honokohau Valley account for about 4MGD of flow. USGS 03-4060, at 24. The average stream flow above the development tunnels is about 25.3 MGD and the median is about 15.5 MGD. USGS 03-4060, Table 11, at 26.

If 13 MGD could be permitted to be diverted into the intake on a consistent basis, with 1MGD diverted through the taro gate, additional water would flow downstream from the diversion about 80% of the time. USGS 03-4060, Table 10, at 26, (utilizing a conversion rate of 1MGD to 1.547 cu.ft./sec). This does not take into account additional ground water inflow or runoff into the stream below the development tunnels. This flow amount would serve to maximize the utility of the Honokohau Stream as a water source while at the same time providing water for the kalo farmers in the Honokohau Valley as well as sufficient excess for the maintenance of biota and the aesthetics of natural stream flow. If Honolua Intake and/or Kaluanaue Intake were reopened to contribute water to the Honokohau Ditch, additional waters could become available for agricultural use. **We strongly recommend that DOA and CWRM include such an analysis in the AWUDP.**

Current nonstream uses of water flowing into the Honokohau Ditch total approximately 4.6 MGD, as noted below. See, Imada, supra. Other agricultural users could utilize an increased volume of water to expand Diversified Agriculture in West Maui.

1. MLP

MLP currently only diverts irrigation water into the Honokoahu Ditch for use in its Kapalua Development, other than the amount that is redirected into the valley through the taro gate. This amounts to 0.9 MGD for the golf courses and 1.0 MGD for the remainder of the resort.

MLP owns significant agricultural lands that are currently fallow and could be used for agriculture, by the company itself, by leasing the land to third parties for agriculture or hiring contract farmers. The amount of additional water needed would depend on the scope of any agriculture that is initiated.

2. Maui County Department of Water Supply ("DWS")

DWS currently uses about 2.5 MGD for its Mahinahina water treatment plant, filtering the water to include in the County's domestic water system. The

County plans to complete two ground water wells to augment the Honokohau Ditch water and provide for future growth. The first well will be in Kahana and is expected to draw 0.96 MGD from the Honolua Aquifer; the second well will come later and be drilled mauka of the Mahinahina plant, drawing about 0.672 MGD from the Honokowai Aquifer. See, K. Cerizo, "County moves to take wells from exploratory to full production", The Maui News, July 24, 2019, which can be found at https://www.mauinews.com/news/local-news/2019/07/county-moves-to-take-wells-from-exploratory-to-full-production/. The construction of these wells makes it unlikely that the County would require additional water from the Honokohau Ditch in the foreseeable future. This is especially true since the COVID-19 pandemic has resulted in the delay or cancellation of planned projects, such as the project that the Employee Retirement System of the State of Hawaii ("**ERS**") had planned for the redevelopment of a portion of the current Kaanapali Resort golf courses. See, A. Gomes, "State retirement fund abandons plan for Maui golf course redevelopment", Honolulu Star Advertiser, November 1, 2020, found at: https://www.staradvertiser.com/2020/11/01/hawaii-news/retirement-fund-abandons-plan-for-maui-golf-course-redevelopment/. This development would have included a hotel and 150 to 250 condominiums, which would have added to potable water demands in West Maui. Id.

3. The Department of Hawaiian Homelands ("DHHL")

DHHL recently abandoned its planned Honokowai community and has restarted the planning effort. See, Staff, "DHHL withdraws plans for massive Honokowai Master Plan development", Lahaina News, December 12, 2019, which can be found at https://www.lahainanews.com/news/local-news/2019/12/12/dhhl-withdraws-plans-for-massive-honokowai-master-plan-development/. DHHL has reserved approximately 2.1 MGD of water from the Honokowai Aquifer to irrigate the agricultural component of these lands. While it could develop wells for this purpose, because of the location of this development it makes far more sense for DHHL to obtain this water from the Honokohau Ditch system. The Honokohau Ditch runs adjacent to portions of the DHHL lands both to the north and south of the Honokowai Valley.

4. KLMC

As noted above and in more detail in the KLMC Honokowai IFSAR Testimony, KLMC uses the Honokowai Water system as its main source of irrigation water. Historically, until recently, KLMC also obtained water from the Honokohau Ditch sourced from the intakes on that system. This water had been used as a secondary source when Honokowai Water was inadequate. Because the KLMC Farming Operations are currently water constrained, and because KLMC would work to increase the agricultural footprint on its lands, it could use a significant additional allocation of Honokohau Ditch water. This would help accomplish all of the goals of Diversified Agriculture noted elsewhere in this testimony.

5. Other State Lands

While the DHHL Honokowai Project is in the planning stages, other lands owned by State agencies in the vicinity of the Honokohau Ditch that are now fallow could be replanted in crops. Some of this land lies between KLMC's land an Wahikuli. Historically, Pioneer Mill leased much of this land for sugar cultivation. Most of it is not in the path of development in any reasonable timeline and thus will remain unused unless repurposed. As with MLP, the State could lease the land or hire contract farmers. DHHL also intends to have a small agriculture component in its Leiali'i development, near Lahaina. This area could receive Honokohau Ditch water if the Wahikuli Ditch is rehabilitated or reconstructed. Again, the amount of water required for these lands would depend on the facts.

6. Others

Other users currently account for 0.2 MGD of Honokohau Ditch water, primarily for small parcels adjacent to MLP lands. If there remains sufficient Honokohau Ditch water after accommodating the upstream users mentioned above, so that the Wahikuli Reservoir and other associated improvements could be profitably rebuilt, then there is the potential for downstream agricultural users such as WMLC and KSBE to be able to increase their agricultural footprints. It would make sense in this case to revisit the ability to divert additional Kahoma and/or Kanaha Stream water to augment this supply.

D. Aquifer Recharge

"The amount of recharge available to enter the aquifers is the volume of rainfall, fog drip, and irrigation water that is not lost to runoff or evapotranspiration or stored in the soil." USGS Report FS 126-00, "Ground Water in Hawaii", 2000. "Overall irrigation rates have been steadily decreasing since the 1970s, when large-scale sugarcane plantations began a conversion from furrow to more efficient drip irrigation methods and a reduction in the amount of acreage dedicated to sugarcane production." P. Young, Images of Old Hawai'i, "Irrigation-enhanced Recharge", June 7, 2016. Nevertheless, even drip irrigation contributes to ground water recharge and an increase in the agricultural footprint of West Maui would help increase recharge rates. To the extent that water is moved from aquifers with larger excess capacity to aquifers with less excess capacity, such as occurs with the Honokohau Ditch, there is an opportunity to benefit the overall water management of the region. The 2019 Update should consider this opportunity.

E. DHHL Aquifer Allocation

As stated above, DHHL has reserved approximately 2.1 MGD of water from the Honokowai aquifer. Some of this allocation may be attributed to the Mahinahina Well to be drilled by DWS, but the remainder would likely be for irrigation water for the agricultural component of DHHL's Honokowai planned development. Virtually none of this development could be irrigated from surface or high-level ground water within the Honokowai aquifer because (1) there is no existing irrigation system that could transport this water to the development, (2) the Honokowai stream and other streams within the Honokowai aquifer are not perennial streams at lower elevations, and (3) substantially all of the water developed by the Honokowai Water system is used by KLMC for its farming operations and the entire irrigation system is on private land owned by KLMC.

According to DWS, the Honokowai Aquifer has an estimated sustainable yield of 6.0 MGD. While this number may be understated in part due to the recent research that suggests that Hawaiian aquifers may extend beneath the ocean floor, under current estimates this aquifer may become fully committed in the future due to the aquifer's proximity to more concentrated development. Conversely, the Honolua and Honokohau Aquifers, which can each be serviced by the Honokohau Ditch, have estimated sustainable yields of 8 MGD and 9 MGD, respectively. While there is some significant pumpage from the Honolua Aquifer (though less on a percentage basis relative to sustainable yield than Honokowai) there is currently none from the Honokohau Aquifer. See, County of Maui, Department of Planning, "West Maui Community Plan – Water Technical Resources Paper", October 15, 2018, at 6, found at: https://westmaui.wearemaui.org/technical-resource-papers-water. Given the excess capacity of these aquifers and the ability of the Honokohau Ditch system to deliver irrigation water directly to DHHL's Honokowai lands, it would be to the benefit of DHHL and all other users of water in West Maui to move DHHL's water allocation to either the Honolua or Honokowai Aquifer. The 2019 Update should suggest this reallocation.

VII. MODELING WATER DEMAND

A. Water Demand for Diversified Agriculture Generally

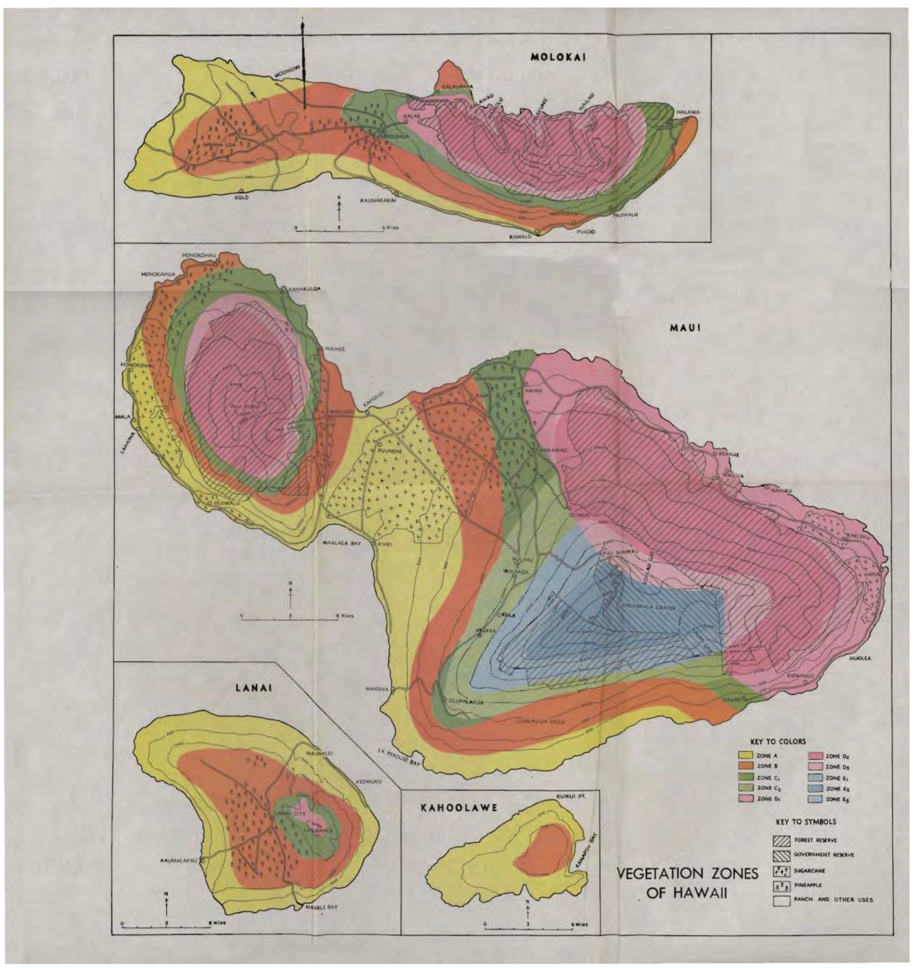
The 2019 Update refers to "water demand" as "water use as measured at the farm's boundary or water meter", before subtracting system losses and non-irrigation uses. 2019 Update at 168. It does so because this is the amount of water that needs to be allocated to the user. KLMC agrees with this definition.

DOA reviewed 8 different studies of water use for various dates between 1953 and 2011 (the "**Historical Studies**") in an attempt to get a handle on average and maximum water requirements (on a monthly or daily basis). In addition, in 2014, it conducted research on 113 farms and engaged informal discussions with other farmers, ranchers, system managers and other stakeholders (the "**Farmer Survey**"). See 2019 Update, at 170-190. DOA also acknowledged (by conducting its analysis differently) that the average recommended water demand determined by the 2004 Update, was flawed. 2019 Update at 2019. Nevertheless, DOA included this study among those that it examined to determine an agricultural water demand planning rate ("**AWDPR**") for diversified agriculture (for acreage that is 50% or 100% planted) and irrigated pastures (assuming acreage that is 100% planted), as shown in its Table 130. Id., at 194.

While the main takeaway from this is that the results of these studies provide data with extremely wide variations, KLMC makes the following specific comments:

1. Ripperton and Hosaka Vegetation Zones ("R&H Zones")

The R&H Zones for each island are based on elevation, climate, soil and vegetation and are separated into 5 categories. The map for Maui is reproduced below:



2019 Update, at 176. The agricultural lands of West Maui that would likely be serviced by the Honokohau Ditch are included in either Zone A or Zone B, which are the two most arid zones. The DOA and CWRM (and the 2019 Update) should take this fact into account in determining site specific water allocations for farms in this area. The KLMC Farming Operations are primarily conducted in Zone A.

Each of the Historical Studies are problematic when applied more broadly to farms in arid regions that require water, particularly those in Zone A.

- The 1956 and 1959 Historical Studies examined by DOA relate to the Waimānalo Irrigation System, which is on the windward side of Oahu and includes lands primarily in Zones C and D. Because these areas can expect much more natural rainfall than occurs in Zones A and B, the lower reported water demands of these studies should be irrelevant when examining water demand rates for West Maui.

- While the reported water demand for the Kailau and Kāne`ohe farms in 1953 is higher than Waimānalo, those farms are likewise in Zones C and D.

- Kahuku Farms, at the northernmost point of Oahu, is primarily in Zone B.

- The sugarcane study from 1995 examined the irrigation requirements for a crop that is no longer grown anywhere in Hawai'i, and thus shouldn't be relevant (despite the higher water demand rates).

- The 1999 study of water demand in the vicinity of the Lower Hāmākua Ditch, on the windward side of the Island of Hawai'i, deals with lands that are entirely within Zone D. How this study can have any relevance to agriculture on the leeward side of Maui is unknown.

- The study of average water demand undertaken for the 2004 Update examined farms in the Lālamilo area, served by the Waimea Irrigation System near the town of Waimea on the Island of Hawai'i. This area appears to be in Zone C. Again, higher elevations and more rainfall.

- The 2011 study relative to Upper Kula Farms and Lower Kula Farms, relates to lands in Zone C (with possibly some in Zone B) for Lower Kula, and Zones C or E for Upper Kula. Even with drought, the higher elevations suggest that water demands will not be as high because of significantly lower average temperatures.

While it is possible for drought conditions to exist even at higher elevations during unusual weather, based on the foregoing, it appears that DOA's reliance on past studies, at least as they pertain to water demand in drier parts of the islands, is misplaced.

2. IWREDSS Model

DOA also has taken into account the Irrigation Water Requirement Estimation Decision Support System ("**IWREDSS**"), which is "an Arc-GIS-based numerical simulation model", developed for CWRM by Ali Fares, Ph.D. ("**Dr. Fares**"), who is a Professor of Water Security at Prairie View A&M University, in Prairie View, TX. See 2019 Update, at 184. CWRM has been relying on the IWREDSS model to estimate irrigation requirements for individual farmers seeking allocated water. These requirements are determined based on an 80 percent rainfall frequency (drought rate of one in five years). Id., at 185.

No data is provided in the 2019 Update relative to the IWREDSS model, so it is not possible to ascertain whether any data from the model was used to arrive at DOA's AWDPRs, though it does not appear from the narrative that the IWREDSS model was incorporated into the numbers. However, it appears that CWRM's water allocation method in effect assumes crop failure every fifth year, at least with respect to a portion of the farmer's crop. For certain types of crops, such as coffee, macadamia nuts or bananas, that rely on planted trees that take years to reach maturity, the prospect of having insufficient water and losing mature, fruit-bearing trees would have a profound impact on the profitability of the farm. No mention is made in the 2019 Update about this consideration and KLMC is concerned that overreliance on the IWREDSS model would result in under-allocation of irrigation water to farms that are particularly at economic risk for drought.

3. 2014 Farmer Survey

The final information that DOA considered in its determination of AWDPR is the data it collected from its Farmer Survey. KLMC believes that this information may be more relevant to agriculture in West Maui because it at least included some feedback relative to farms in R&H Zones A and B. However, as stated above, most Kula farms are in Zone C or above, which would account for the lower average water usage there (far outside the water demand ranges of the Keāhole, Moloka'i and Mililani areas also reported for R&H Zones A or B, but some farms surveyed could be in Zone C or higher in Moloka'i and Mililani depending on the farms selected). See, 2019 Update, Table 129, at 189.

Regardless of foregoing and the reliability of the numbers presented, the data presented does show that the average water needs of farmers is significantly higher in the dry season that the wet season. 2019 Update, Table 127, at 188. One would expect farms in dry areas such as R&H Zones A or B to require the dry season amounts for most of the year, since those areas are not augmented with much rainfall even during the wet season. For Maui, however, since only farms in Kula were considered for the formal portion of the Farmer Survey, the numbers presented in Table 127 are significantly understated relative to what the actual experience would be in West Maui where the KLMC Farming Operations are located.

4. Recommended AWDPRs

All in all, KLMC does not find the methodology used to develop the AWDPRs to be persuasive and believes that the actual planning rates should be significantly higher, particularly relative to farms in R&H Zones A or B, such as those in West Maui.

- The numbers used to compute averages is highly dependent on the location of the farms selected. Thus, it cannot be said (2019 Update, at 188) that "[t]he dry season monthly averages range from 161,500 to 442,800 gallons per acre for most of the state, excluding Kaua'i". The Kaua'i farms chosen were in R&H Zone C, which would naturally translate to lower water demand. If farms had been chosen in different zones, water demand would likely have approximated needs for farms elsewhere in the state for those same zones. It would have made more sense for DOA to collect data by zone and compute averages for each zone rather than lumping them all together.

- The data presented does not discriminate by type of crop. It is also suspected that many of the farms surveyed are small, without extensive irrigation systems, although this is unknown. This could skew the results when compared with larger commercial operations.

- While rainfall numbers are presented, it would make sense to adjust those numbers for the average temperature at the chosen locations, since obviously hotter areas need more irrigation water than cooler ones.

- The DOA appears to have simply averaged the results from the Farmer Survey, the Historical Studies and metered results from farms in the Kunia O'ahu area, which are in R&H Zones B or C. Based on this, DOA arrives at an average of 3,946 gpd/acre, based on 50% planted area, and rounded this down to 3,900 gpd/acre to establish its AWDPR, and did the same for dry season usage rates to establish an AWDPR for drought conditions of 8,100 gpd/acre. These amounts are doubled for farm acreage that is 100% planted. 2019 Update, at 190-194. Because of the problems outlined above with respect to the numbers input, KLMC believes that the AWDPR amount is unreliable.

- The DOA does acknowledge that “it should be noted that for dry periods throughout the year or during drought conditions, water demand is higher to account for the lack of rainfall”. 2019 Update, at 182. This is clearly the case for agricultural land in Zone A. Also, the DOA concedes that “water use varies by many factors, and a one-size-fits-all approach should not be applied in every agricultural endeavor”. Id., at 193. With that in mind, we think it is error to take an “average” and use it as a starting point, where the average includes many dissimilar farms and climates.

- This discussion says that it does not apply to “gentleman farms”. It is unclear what DOA means by this term or what would be included or not included when specific farms are examined, but it clearly cannot apply to the KLMC Farming Operations, which are among the largest on Maui, notwithstanding that some of the farms exists on Ag Lots owned by third parties.

B. Water Demand for Specific Crops

The DOA in Chapter 7 of the 2019 Update attempts to establish water demand rates for specific crops by relying on the 2004 Update’s water use guidelines (which as stated above) were based on data taken from a single area on the Island of Hawaii (see 2004 Update, at 159-162). While this data may have relevance to farms with similar topography, soil, rainfall and average temperature, it has little relevance to Diversified Agriculture in dry areas such as West Maui. Moreover, as respects the KLMC Farming Operations, which emphasize coffee production, no data is presented for coffee at all. 2019 Update, at 196.

Likewise, when comparing the 2004 Update’s numbers to the Farmer Survey amounts, on a per crop basis, no indication is made as to the location of each farm whose numbers are incorporated into the data for any particular crop. This makes the use of this data for a real assessment of irrigation needs for individual crops highly suspect. Id.

Conversely, KLMC acknowledges and does not disagree with DOA’s general analysis of environmental factors, although we find the comments concerning what may occur with the availability of food supplies from other parts of the world to be quite speculative. See 2019 Update, at 197-203. In particular, the DOA points out that during “zero (0) rainfall events, irrigation water must supply the total water need for the crop”. 2019 Update, at 198. While this may seem obvious, it is a normal condition in the arid but fertile leeward areas of the islands, such as West Maui, which can go for months without rain at lower elevations. In addition, we agree with DOA’s statement that “for all crops, evenly distributed water supply (rainfall or irrigation) is conducive to optimal growth". Id. This supports, among other things, the notion that backup irrigation sources are important to agricultural success. So, DOA concludes that "[i]f agriculture is to survive, the availability of agricultural commodities in the market needs to be dependable. In addition, if the State's policies continue to trend toward sustainability and food security, the importance of available water during drought conditions is even more critical." Id., at 200.

C. Support for Agriculture in the Law

KLMC has no specific comments at this time on the general discussion of the current legal framework provided by DOA. See 2019 Update at 207-219. With respect to the status of agriculture, and water for agriculture, under the laws of Hawai'i, however, KLMC cites the following relevant laws and decisions:

- The state water resources trust as articulated by the Hawai'i Supreme Court "embodies a dual mandate of 1) protection and 2) maximum reasonable and beneficial use." *In re Water Use Permit Applications*, 94 Hawai'i 97, 139, 9 P.3d 409, 451 (2000) (hereinafter "***Waiahole I***").

- Per Haw. Rev. Stat. § 174C-2:

  "The state water code shall be liberally interpreted to obtain **maximum beneficial use** of the waters of the State for purposes such as domestic uses, aquaculture uses, **irrigation and other agricultural uses**, power development, and commercial and industrial uses." (Emphasis added).

- Article XI, § 3 of the Hawai'i State Constitution provides:

  "**The State shall conserve and protect agricultural lands, promote diversified agriculture, increase agricultural self-sufficiency and assure the availability of agriculturally suitable lands.** The legislature shall provide standards and criteria to accomplish the foregoing." (Emphasis added).

- "The people of Hawaii have a substantial interest in the health and sustainability of agriculture as an industry in the State." HRS § 205-41.

- "[T]he state water resources trust acknowledges that private use for 'economic development' may produce important public benefits and that such benefits must figure into any balancing of competing interests in water[.]" Waiahole I, 94 Hawai'i at 138, 9 P.3d at 450.

- In Waiahole I, the Hawai'i Supreme Court agreed with CWRM that, "as a general matter, water use for diversified agriculture on land zoned for

> agriculture is consistent with the public interest." Waiahole I, 94 Hawai'i at 162, 9 P.3d at 474. "**Such use fulfills state policies in favor of reasonable and beneficial water use, diversified agriculture, conservation of agricultural lands, and increased self-sufficiency of this state.**" Id. (citing Haw. Const. art. XI, §§ 1 & 3; HRS § 174C-2(c)) (emphasis added). "The public has a definite interest in the development and use of water resources for various reasonable and beneficial public and private offstream purposes, including agriculture[.] Id.at 141, 9 P.3d at 453.

Given the foregoing policy pronouncements in the State Constitution, its statutes and the seminal Supreme Court case on the subject, it is clear that there is recognition of the importance of agriculture and irrigation water to the state and that such uses are in the public interest. While the Supreme Court declined to include agriculture among the uses protected by it in articulating the "public trust doctrine" for water, it is clear that it nevertheless recognized agriculture as an important use for water and that it recognized many of the same benefits of Diversified Agriculture that we identify in this testimony.

It is incumbent on DOA and CWRM to recognize and promote agricultural irrigation water consistent with these constitutional, statutory and judicial pronouncements and to recognize the allocation of water for this purpose is in the public interest and serves compelling policy goals that have been articulated by state, county and local governments. Nowhere are these interests better served than to utilize these goals to support the expansion of Diversified Agriculture in West Maui and to provide the irrigation water necessary to do so.

D. Characteristics of West Maui and Factors Affecting Demand

As stated above, almost all of the agricultural land in West Maui that can be served by the Honokohau Ditch system lies within R&H Zones A or B, meaning that it is drier and hotter than average and needs a reliable supply of irrigation water. (The KLMC Farming Operations lie primarily in Zone A.) It has a materially different climate than the Kula farms surveyed by DOA to model water needs on Maui. The lion's share of such West Maui land is Prime under the ALISH grading system and rests in LCC soil capability classes I, II or III. While that area has not been classified as IAL, it is clearly important agricultural land and could deserve such a classification. It is an area where, with proper policies and government support, the state could help realize its goals for diversified agriculture.

E. Recommended Agricultural Forecast

Chapter 8 of the 2019 Update attempts to forecast agricultural water demand going forward 5 and 20 years from the 2015 baseline date. While KLMC does not have data on how the 2020 results have come out, it is possible that they are materially lower than the forecast. In any event, the 2019 Update's forecast should not be relied upon because:

- the determination of the average water demand rate of 3,400 gpd/acre was flawed (this same number was used by DOA in its land-based model and thus it is also wrong),
- forecasts of population growth made as a basis for planning have proved to be overstated, and;
- changed circumstances during the past year due to the economic devastation caused by the COVID-19 pandemic will likely push the timeline for most investments forward by many years.

DOA admits that "the correlation of land area to water demand is also complicated by the assumption that all crops have the same water demand". 2019 Update, at 227. It also states that "[e]ach agricultural water system will have a water demand rate based on the climate, soil, crop diversity and farming techniques used by the individual farmer". Id., at 229. So, relying on any state or even island-wise average, when so many variables play into actual water demand, is speculative, and won't be useful for farm areas that are not "average".

The citation to a Mink and Yuen study of farmers in Kula is instructive in that the study confirmed the obvious, that farmers would grow more crops and expect better yields if they had more water. 2019 Update, at 233. KLMC argues above that it would also do the same.

The linear regression analysis presented also raises a few questions that should be reexamined by DOA in order to ensure that the output can be relied upon for planning purposes:

- It is not clear that the value data provided in Table 137 is in real dollars and if not, then the values in the later years will be overstated compared to the earlier ones and the assumed growth rate in terms of water demand would thus also be overstated.
- Also the high trend line for the 1997-2012 dataset does not seem from our perspective to have enough data points to suggest that the trend line should continue at the same growth rate going forward. There are many reasons that the growth rate between 2007 and 2012, for example, showed a rapid increase, since the amount of Diversified Agriculture started at a very low number in 1997. This could be due to a number of one-time or short-term events, such as the rapid rise and then moderation of the seed corn industry. In fact, we already know that this trend line is wrong because the

> value of farm industry output fell 15% to $564 million in 2017 from the 2012 amount. Gomes, "Big Shifts Hit Hawaii Farm Landscape", supra. All of this leads to DOA assuming an average growth rate going forward (from 2015) of 0.6% per year. While KLMC thinks that such a growth rate may be achievable if adequate water is made available, it does not fall naturally from the numbers presented.

The agricultural land use tables presented on pages 234-236 of the 2019 Update suffer from the fact that the year that these numbers represent is not stated. For West Maui, it unknown how DOA obtained a cultivated acreage amount of 6,320 acres, since KLMC believes that it has been over 20 years since that much acreage was cultivated in West Maui. If that is true for the other areas as well, the number of cultivated acres is overstated and the number of available acres is understated. Regardless, using numbers that old for the purpose of making a forecast projecting trends from the present is problematic.

Finally, the 2019 Update arrives at a recommended forecast of water demand based on three different scenarios for capital investment and maintenance of water systems: "1) no action, 2) maintained water systems, and 3) large capital investment." Id., at 236. While DOA used an assumed demand rate of 3,400 gpd/acre for the land-based model, it used the numbers derived from its recommended AWDPRs derived earlier in the report (7,800 gpd/acre for field crops and 3,900 gpd/acre for diversified crops, assuming crop rotation and a 50% system loss) for this forecast. It uses its assumed 0.6% annual agricultural growth rate. Id.

We have discussed above why these amounts cannot be used for crops that, because of climate, husbandry or other factors, do not fit neatly within these averages. In fact, the DOA acknowledges that the "forecasts provide a guide to water demand, as the actual demand varies based on farmer practices, soil type, crop type, intensification, diversity, climate, politics, transportation costs, fuel and energy costs, market variability, consumer demand, etc." – a lot of variables. Id., at 241. Also, "[u]nfortunately, a lack of agricultural statistics hampers the development of an accurate baseline for agricultural water demand in 2015". Id., at 236.

So, while the three scenarios show a difference in the forecast trends that might be recognized by common sense, the actual numbers are so speculative that they should not be used for planning purposes. Also, while some areas may need substantial new investment to grow, other areas have significant available land to grow Diversified Agriculture with existing systems, ongoing maintenance and possibly some incremental investment to improve storage and distribution infrastructure. The Honokohau Ditch would fall into this latter category. The 2019 Update should include a reassessment of systems like Honokohau Ditch consistent with their value for serving the state's goals for Diversified Agriculture.

VIII. 2020 DEVELOPMENTS

The 2019 Update was released in December of 2019. Two significant developments have occurred since the release of the report that could have a meaningful impact on the report's conclusions. Given the importance of these developments, the 2019 Update should be revised with them in mind before being incorporated into the Hawai'i Water Plan.

A. COVID-19

The most obvious development is the emergence and continuation of the COVID-19 pandemic. COVID-19 has caused untold health crises, economic devastation and personal suffering to people all over the United States and across the world. Hawai'i, given its dependence on the tourism industry, has been among the hardest hit states. In October, 2020, Hawai'i had the nation's highest unemployment rate, at 14.3%. See U.S. Bureau of Labor Statistics Economic News Release, USDL-20-2132, November 20, 2020, available at: https://www.bls.gov/news.release/laus.nr0.htm. See also, HNN Staff, "Hawaii's unemployment rate highest in the nation for second month", HawaiiNewsNow, November 20, 2020, which can be found at: https://www.hawaiinewsnow.com/2020/11/20/hawaiis-unemployment-rate-highest-nation-second-consecutive-month/. On Maui, the news is even worse, with a rate of 22.5% in October. Id.

While the state has recently relaxed its travel restrictions in order to attempt to revive the dormant hospitality sector, it will still take many years for Hawaii's economy to return to the level enjoyed in 2019. This is even more true for Maui, which is more dependent on tourism than the other islands. Based on 3rd quarter 2020 numbers, civilian unemployment for the State was 13.9%, but this number is overly optimistic, because the labor force also contracted by 5.1% from the year-ago quarter. See, Hawaii Department of Business, Economic Development and Tourism ("**DBEDT**"), Quarterly Statistical & Economic Report, Executive Summary, 4th Quarter 2020 ("**DBEDT 4Q Summary**"), at 3-5, 12, available at https://files.hawaii.gov/dbedt/economic/data_reports/qser/qser-2020q4-es.pdf. If it is assumed that the civilian labor force had stayed constant, adjusted only for the percentage change in the population for 2020 (-0.1%), the actual unemployment rate would be approximately 18.2%. On Maui, the civilian labor force contracted by 7.0% over the same period, so if it is assumed that the civilian labor force only changed by the estimated change in the population (0.48%), then the actual unemployment rate of Maui would be approximately 27.1%.

State and County tax receipts overall were down dramatically in 2020, although income tax receipts were up mostly because of payment of 2019 taxes and 2020 estimated taxes based on prior years' income. See DBEDT 4Q Summary, at 3. Given the severe reduction in business activity, it should be expected that income taxes collected in 2021 will be significantly below the 2020 amounts, while other types of taxes will experience a modest rebound in line with slowly improving economic conditions. While the GDP for the entire country is projected to decrease by 3.7% for 2020, and increase by 4.0% in 2021, in Hawaii the 2020 GDP decrease is expected to be 11.2% and only increase by 2.1% in 2021. Id., at 5. It will take until 2025, at least, for the economy to recover to 2019 levels in terms of employment and GDP. As a consequence, with tax revenues down and the government needing to redeploy assets to COVID relief, the governor is looking to make substantial budget cuts, of $600 million in 2021, asking state departments to trim budget between 10-20%. See HNN Staff, "Gov. Ige looks to trim $600 million from state's budget", HawaiiNewsNow, November 30, 2020, available at https://www.hawaiinewsnow.com/2020/11/30/gov-ige-seeking-trim-million-fro-states-budget/.

Therefore, the State should look to spend dollars on agricultural water projects that provide the best cost/benefit profile. This would suggest that major new projects be deferred and emphasis be placed on rehabilitating existing systems, particularly those, like the Honokohau Ditch system where (1) there is the prospect of significant additional acreage, (2) the system is largely functional, (3) the system includes significant portions on private lands, and (4) water diversions through the system can be increased consistent with state priorities. The 2019 Update does not do this and any reexamination of projects with a view toward prioritizing should favor Diversified Agriculture and provide the most water for irrigation of agricultural lands possible.

B. Possible Extension of Aquifers Below the Ocean Floor

In November 2020, scientists associated with the University of Hawaii at Manoa, Frontier Geosciences, Universiti Malaysia Terengganu, and the Scripps Institution of Oceanography, University of California at San Diego, published a research paper that suggests that conventional hydrogeologic model for onshore aquifers may be missing significant pools of fresh water in nearshore and offshore formations. See, Attias, Thomas, Sherman, Ismail and Constable, "Marine electrical imaging reveals novel freshwater transport mechanism in Hawai'i", Science Advances, November 25, 2020, which can be found at https://advances.sciencemag.org/content/6/48/eabd4866. While research was done on the nearshore and offshore formations in the vicinity of Hualalai on the Island of Hawai'i, the authors identified five other volcanic islands, including the Island of Maui, that "present hydrogeological layered formations analogous to the submarine multilayer formation" that the authors revealed in the vicinity of Hualalai. Id., at 6. The authors believe that their findings support global-scale applicability to volcanic islands generally.

While this study "reveals a novel mechanism that transports substantial volumes of freshwater from onshore aquifer to deep submarine aquifer offshore", it is new and was confined to one volcanic island. Id. If it is true that substantial amounts of freshwater do exist in nearshore and offshore formations surrounding any of the islands of Hawaii, but particularly in regions where the onshore aquifers have relatively low sustainable yields, this could be a game changer for the future of water in Hawaii, and would support additional transport of surface water for agricultural uses.

IX. CONCLUSION

In its conclusion to the 2019 Update, DOA states that “[a]griculture is an essential component for the state to achieve its goal of sustainability and a diversified economy. The agricultural industry relies on these water systems to deliver inexpensive water to meet and expand agricultural production. … As the saying goes, … without water there is no agriculture … which is the reason these agricultural water systems were originally constructed – and why they need to be maintained for another 100 years.” 2019 Update, at 253. KLMC agrees with these statements.

The “public trust doctrine” as articulated by the courts, does not include agriculture as a public trust use, but it should, and the DOA should advocate for this position. At a minimum, there is ample support in the State’s Constitution, statutes and policy pronouncements, that support of agriculture is in the public interest and that water resources should be managed for maximum benefit. As stated in the State Water Code:

Per Haw. Rev. Stat. § 174C-2:

> The state water code shall be liberally interpreted to obtain ***maximum beneficial use*** of the waters of the State for purposes such as domestic uses, aquaculture uses, irrigation and other ***agricultural uses***, power development, and commercial and industrial uses. (Emphasis added).

In order to best support the State’s stated policy goals of supporting and promoting Diversified Agriculture, DOA and CWRM need to make sure that sufficient water is provided to farmers who need it and that secondary sources are taken into consideration.

The 2019 Update fails to properly assess the Honokohau Ditch system in its current state and has made a number of assertions concerning the ownership, use and condition of the system that are not accurate. The Honokohau Ditch system is the most important source of irrigation water in West Maui. While it isn’t the primary system used by KLMC Farming Operations, it constitutes and important secondary source for existing crops and a necessary source to expand operations on additional land. Other landowners in West Maui that own significant agricultural lands, including DHHL, would require irrigation water from the Honokohau Ditch system to grow their footprint of Diversified Agriculture. The 2019 Update needs to be revised to consider this system and the benefits that can flow from it.

The 2019 Update fails to properly assess the water demands tied to agriculture because the methodology does not use enough data points or take into account the varied factors that would be considered in arriving at reliable water demand numbers at a specific location. Some of the data used is too old to be of use. In particular, use of 80% numbers for drought demand may work in some locations at cooler locations, but would mean significant crop losses at warmer locations. The DOA admits that the numbers don't take much of this into account, but it uses them anyway. The DOA should withdraw the 2019 Update, reexamine the methodology used to determine water demand and adjust it accordingly.

The DOA and CWRM have an opportunity to help revitalize an industry that is important to the State and to local citizens on each island. The Hawaii Water Plan, including the AWUDP component, need to provide for the opportunity to get this done. The benefits of Diversified Agriculture are many, and include:

1. Sustainability
2. Food Security and Self Sufficiency
3. Economic Diversification
4. Job Growth
5. Wildfire Suppression
6. Aesthetic Enhancement

Finally, the 2019 Update should be revised to take into account the profound impact that COVID-19 has imposed on the state and local planning processes. Projects will be deferred or eliminated, and those that are chosen to go forward will inevitably be based on an assessment of cost versus benefit. The State has already recognized that the promotion and development of Diversified Agriculture, can help solve some of the problems that were exposed as the pandemic has evolved. Moreover, if it is true that the islands of Hawaii have more fresh water aquifer capacity than previously thought, the pressure to divert irrigation water for other purposes could be greatly ameliorated. The DOA and CWRM should examine the recent research concerning nearshore and offshore fresh water reservoirs and determine whether to modify their planning criteria based on their conclusions.

KLMC appreciates the opportunity to comment on the 2019 Update.

Sincerely,

Richard Helland
Vice President
Kaanapali Land Management Corp.

JOSH GREEN, M.D.
Governor

SYLVIA LUKE
Lt. Governor

PHYLLIS SHIMABUKURO-GEISER
Chairperson, Board of Agriculture

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December 6, 2022

Mr. Richard Helland, Vice President
Kaanapali Land Management Corp.
275 Lahainaluna Road
Lahaina, Hawaii 96761

Dear Mr. Helland:

SUBJECT: Response to Comments Regarding December 2019 Agricultural Water Use and Development Plan Update

The Hawaii Department of Agriculture (HDOA) received your comments to the December 2019 Agricultural Water Use and Development Plan Update (AWUDP). The HDOA is appreciative of your thorough review and comprehensive comments to this important document. The shared commonality between all of the commentors and the HDOA, is a collective respect and appreciation for water.

The investigation for this version began in 2015. As such, some of the information provided in this December 2019 document may be dated as it captures our findings at that past point in time. The AWUDP is a living document and is intended for periodic revision in the coming years.

We have reviewed your comments and provided responses in the Attachment. The HDOA also prepared a 2021 Revised Edition to the December 2019 AWUDP. The Revised Edition is intended to address specific comments made during the public review period. A copy of the 2021 Revised Edition will be available at: https://hdoa.hawaii.gov/arm/.

Please note that some public comments are beyond the scope of this current document. These comments will be noted and consulted for future AWUDP updates. All the public comments will be included as an Appendix to the Revision. In addition, a copy of your comments and these responses will be forwarded to the County of Maui Department of Water Supply for their consideration and reference.

Thank you again for your comments to the AWUDP Update, as well as your support of agricultural water and its role in the agricultural industry. Please contact Ms. Janice Fujimoto, Agricultural Resource Management Division, at 808-973-9473 with any questions.

Sincerely,

Phyllis Shimabukuro-Geiser
Chairperson, Board of Agriculture

cc: DLNR, Commission on Water Resource Management
Department of Hawaiian Home Lands
County of Maui, Department of Water Supply

ATTACHMENT
RESPONSE TO COMMENTS

I. INTRODUCTION

The following information and comments are submitted on behalf of Kaanapali Land Management Corp. ("**KLMC**") pursuant to the Department of Land and Natural Resources ("**DLNR**") News Release (the "**News Release**") dated September 30, 2020, regarding the Commission on Water Resource Management's ("**Commission**" or "**CWRM**") "Public Hearings Scheduled for Input on the Agricultural Water Use and Development Plan" held on November 18 and 19, 2020 (the "**Hearings**"). The purpose of such Hearings was to solicit input on the update prepared in December, 2019 (the "**2019 Update**") by the Hawai'i State Department of Agriculture ("**DOA**") to the Agricultural Water Use and Development Plan ("**AWUDP**"). The News Release states that written testimony will be accepted by CWRM until December 18, 2020.

The AWUDP is one of five parts of the Hawai'i Water Plan (the "**HWP**") that is assembled by CWRM pursuant to statutory directive in the State Water Code (the "**Code**"), to guide CWRM as a long-term planning tool for water resource management. Prepared by DOA, the AWUDP inventories and examines state water resources, including water infrastructure systems and assesses them with a view to providing support to the continuation and development of agriculture in Hawaii. The 2019 Update is the first update of the AWUDP prepared by DOA since the update that it adopted in 2004 (the "**2004 Update**"). With respect to the West Maui water systems, the 2004 Update provides more detail in certain respects than the 2019 Update and will be referenced herein as needed.

KLMC submits this testimony to provide CWRM and DOA with the benefit of its farming experience as it relates to the 2019 Update and water resources generally in West Maui.

The 2019 Update should be revised before it can become the planning document needed to chart the future course for water and agriculture on West Maui. In some instances, KLMC asks that the 2019 Update be revised to address what KLMC considers to be errors and flaws in connection with the calculation of water demand rates and forecasts.In other instances, KLMC asks for revisions to address oversights. As part of any revision, the 2019 Update needs to consider the economic devastation caused by COVID and promote the expansion of West Maui agriculture as part of its planning perspective. Finally, the 2019 Update should be revised to consider the role that the Honokohau ditch system now plays and how it can participate in an expanded and more efficient distribution of irrigation waters to promote state policy goals while contributing to a reset of the Maui economy. The following points, some already well-known and acknowledged in the 2019 Update, warrant particular attention:

- **KLMC has a significant farming footprint on West Maui, utilizing an irrigation system that the company has utilized for over 100 years.** Operating the largest coffee farm on West Maui and the second largest in the State, and also supporting other crops and grazing, KLMC is a model of the type of farm that the State should promote to develop more diversified agriculture. KLMC's primary sources of irrigation water for its current operations are development wells located in the Honokowai valley. However, these wells provide a limited quantity of water and thus KLMC's ability to grow its agricultural footprint is constrained. See Section II, infra. The 2019 Update fails to acknowledge the continuing use of this system.

Response: Comment noted. Chapter 4 of the document was to update the changes to the system as it was initially studied in the 2004 AWUDP. HDOA's understanding is that the wells were in operation circa 2004, and there were no significant changes documented to the wells. All reported flows from the system reported to CWRM are provided in Table 113 and 114. HDOA agrees that the system is important to agriculture. Future AWUDPs will revisit the system. Unfortunately, as the system is a privately owned system, HDOA's role in development of the system is very limited.

- **A substantial amount of prime farmland is now available for the promotion and expansion of agriculture, including much of the former sugar and pineapple lands in West Maui (which includes the land farmed by KLMC).** See Section III, infra. The 2019 Update fails to assess these opportunities properly and the 2019 Update needs to be revised to acknowledge and provide more planning guidance based on the benefits that can flow from these lands.

Response:The AWUDP Update focuses on the condition of irrigation systems, water demand, and future agricultural water needs and challenges. The HDOA agrees that productive use of prime farmland in West Maui, as well as other underutilized agricultural lands, should be pursued. As the system is a private system, we are not in a position to develop planning for the system, however, system management and other improvements are suggested in Chapter 9, Section 9.2 for your consideration.

- **Continued support of agriculture provides many benefits to the citizens and economy, both locally and statewide.** This is recognized and promoted by many government and non-government organizations and supports the statutory and constitutional recognition of agriculture as an important state priority. See Section IV, infra. The 2019 Update fails to adequately tie these policy considerations to the specific needs of farmers or to examine the agricultural value of the lands in West Maui.

Response: The HDOA understands the importance and necessity of water for the continued survival of agriculture, regardless of policy and priority. The development of the AWUDP as a stand-alone document of the Hawaii State Water Plan shows the significance of water to agriculture. The AWUDP Update underscores the importance of irrigation water, the value of the existing irrigation systems, and the differing water demand needs of farmers throughout the state.

HDOA's policy considerations for the support of agriculture in the state may be found in the HDOA's Report on the Strategic Plan to Double Local Food Production and Exports by 2030. While this Plan does not focus on West Maui lands, the principals and policies are relevant and comprehensive.

- **Water is critical to the success of agriculture.** The 2019 Update fails to properly take into account the critical importance of reliable irrigation water flows to arid regions of the State, such as the prime agricultural areas of West Maui, underplaying the risk to farmers of drought conditions in these areas. Cost considerations favor the continued use of existing, gravity feed water transmission systems, such as the Honokohau ditch system and the Honokowai system utilized by KLMC, over development of new infrastructure, to make sure that these critical water needs are satisfied. See Section V, infra.

Response: The use of existing gravity flow systems are essential to the delivery of water to agricultural areas. Thus, the need for increased CIP funding to ensure the longevity of the systems and to increase the systems efficiency is highlighted.

The AWUDP Update acknowledges that cost concerns associated with maintaining and improving irrigation infrastructure. While the Update does make suggestions for improvements and development, it is ultimately the decision of the irrigation owner/operator in how to invest in their water infrastructure.

- **The 2019 Update fails to acknowledge or consider the important role that the Honokohau ditch system can play in as a reliable source of supply for irrigation waters and its distribution of water to agricultural lands between Kapalua and Lahaina. A number of factual statements made in the 2019 Update or 2004 Update concerning the system, and KLMC's relationship to it, are incorrect.** These errors should be addressed and corrected.There are potential users for this water who could help satisfy the goals of the 2019 Update to 1) provide a comprehensive plan to protect and increase the agricultural water resources available to the diversified agriculture industry; and 2) maintain and improve the agricultural water systems in the State of Hawaii to support an economically viable diversified agricultural industry. See Section VI, infra. The 2019 Update needs to be revised to correctly assess and recognize the importance of the Honokohau Ditch system as an important source of agricultural water, and the primary source of agricultural water for West Maui.

Response: Comment noted, however, as this is a private system the maintenance and improvements are determined by the owners/operators. Future AWUDP studies will revisit the system to document significant changes to the system, as HDOA recognizes the importance of this system to agriculture.

- **The 2019 Update is methodologically flawed, and incorrectly uses shortcuts to determine water demand rates that do not adequately take into account needs of specific crops, local site conditions, drought risk and husbandry practices. Moreover, the rates used are in most cases too low evenon an average basis to provide volumes consistent with maximizing yields and avoiding crop losses.** See Section VII, infra. The data is old, incomplete and not relevant to the irrigation needs for crops in arid climate zones. The 2019 Update needs to be revised by collecting additional data that takes into account these zones. In addition, using an assumption of 1 year of drought out of 5 and not providing enough water to weather those years is a major flaw of the 2019Update.

Response: The water demand rates reflect a more robust methodology than the original 2004 AWUDP. The argument that water demand rates differ by crop, local site conditions, drought risk, and husbandry practices is true and was intended to be conveyed in the Update. The rates in the 2019 AWUDP Update are intended as planning guidelines, and should not be applied for *every agricultural endeavor. Farm-specific rates are ideal in determining water demand. As recommend in the AWUDP, each system should conduct their own site-specific water plan to determine crop type, water demand and improvements. These site-specific water plans could be incorporated in future AWUDP's if available.*

The variability of water demand by crop, area, etc. has been discussed in many previous studies and highlighted in Section 7.1 in this study and in the 2004 AWUDP.

Extreme weather events are considered and thus suggestions are provided in Chapter 9. Again, detailed analysis of each system due to impacts from climate change and other factors should be performed by the system owner/operator, and beyond the scope of this 2019 AWUDP Update and its associated Revision.

- **While the 2019 Update recites the current legal framework around which water decisions are made, it should advocate for an enhanced legal status for agricultural water in light of other stated policy goals. Agricultural use of water is squarely within the public interest and its role in implementing public policy goals reinforces that notion.** The 2019 Update repeatedly alludes to various policy goals to support agriculture expressed by various government agencies and political leaders, some of which have been set down by statute. Without adequate water, these policies amount to empty promises. DOA, CWRM and other agencies need to actively promote agricultural use of waters to achieve these policy goals. The Hawai'i Supreme Court has articulated the boundaries of the "public trust doctrine" relating to the waters of Hawaii. A compelling argument can be made that water for agricultural irrigation should be accorded similar priority. See Section VII.C., infra.

Response: Thank you for your support of agricultural water and its role in the agricultural industry. The AWUDP is prepared within the legal framework, and is intended to be a voice that represents the water needs of the agricultural industry in the Hawaii Water Plan.

- Because the modeling of current water demand is flawed the forecast of future demand is also flawed to the extent it uses the same numbers. See Section VII.E. infra. The regression analysis that projects a future growth rate also raised questions that need to be examined before the 2019 Update is adopted.

Response: The water demand computations are to provide an overall planning guidance for agriculture water demand throughout the state. The AWUDP suggests that system owners/operators develop their own plan to meet their specific needs, crop, farming techniques, micro-climates, etc. These specific improvements or studies may not be applicable to other systems in the state. In addition, state funds cannot be used to make improvements to privately owned systems.

- The impact of COVID-19 on the economy of Hawaii generally and Maui in particular means that planned growth, certainly pre-COVID, must be reassessed because the baseline projections are based on circumstances that have radically changed. Until the impacts of COVID-19 and slowing population growth are considered, the 2019 Update will rest on faulty premises. Moreover, any water demands not taking into account the factors noted above cannot form the basis for sound water planning for agricultural purposes. The 2019 Update was prepared prior to the COVID-19 outbreak, it fails to take these facts and circumstances into account. See Section VIII.A., infra.These impacts are so profound that the 2019 Update needs to be revised to take them into account.

Response: The impact of COVID-19 has been a struggle for our state. As acknowledged in your comment, this 2019 Update was prepared prior to the COVID-19 epidemic. The effects of COVID-19 are beyond the scope of this 2019 AWUDP Update and its associated Revision.

- **Recent marine electrical imaging studies of the Island of Hawai'i suggest that there may be significant nearshore and offshore submarine reservoirs of freshwater connected to the aquifers of the Island of Maui (and other volcanic islands) which could mean that the sustainable yields of the aquifers in West Maui are significantly understated.** This would further support the continued use of existing irrigation systems, such as the Honokohau Ditch system, for agriculture. It could also support the further development of secondary sources, such as wells, that would be utilized only during drought conditions. See Section VIII.B., infra. Again, if the pressure on domestic water supplies might be reduced by significant additional supplies, the allocation of surface and ground water for agricultural irrigation should be less problematic.

Response: This AWUDP focuses on the importance and maintenance of existing irrigation systems. The evaluation of nearshore and offshore submarine reservoirs is beyond the scope of this 2019 AWUDP Update and its associated Revision. As stated in Chapter 9, the development of new water sources should be explored. Any information you can share will be considered for inclusion in future AWUDP Updates.

II. KLMC's FARMING OPERATIONS AND IRRIGATION SYSTEM

KLMC (formerly known as Kaanapali Development Corp.) is an affiliate of Pioneer Mill Company, LLC ("**Pioneer Mill**", formerly known as Pioneer Mill Company, Limited). KLMC was formed to own, manage and improve Pioneer Mill's land in the Kaanapali area of WestMaui. Pioneer Mill and its affiliates, including KLMC, have been engaged in agricultural operations on West Maui for over 150 years. For purposes of this testimony, KLMC shall be deemed to include any of its subsidiaries that are engaged in farming operations. Today, these operations (the "**KLMC Farming Operations**") include one of the largest coffee farms in the United States (and the second largest coffee farm in Hawai'i), cultivation of fruit trees and other crops, cattle and goat grazing, and small farms.

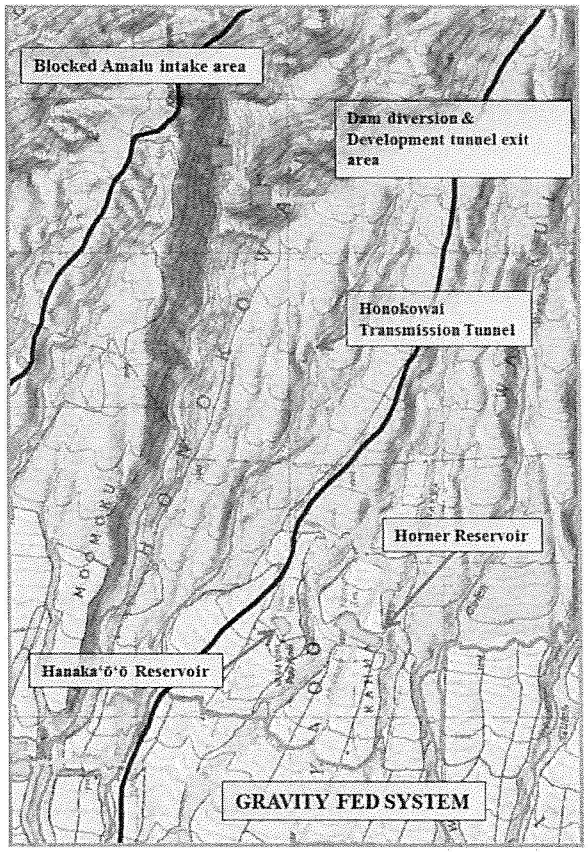
The KLMC Farming Operations currently include both farming on its own lands and also contractual relationships to farm lands owned by successor landowners to KLMC who have purchased lots in KLMC-developed subdivisions that comprise a portion of the coffee farm (the "**Ag Lots**"). The cultivated portions of the Ag Lots are leased by the lot owners to the development's lot owner's association, which in turn contracts with KLMC to cultivate, manage, and maintain the farming areas, and to harvest, process and market the coffee crop for sale to third parties as milled green coffee. KLMC undertakes these services in addition to farming the coffee and other crops grown on its own lands.

Among the customers for KLMC's coffee is MauiGrown Coffee, LLC ("**MauiGrown Coffee**"), which is owned by Kimo Falconer who provided oral testimony at the Hearings. MauiGrown Coffee purchases green coffee from KLMC, roasts it and sells it to the public through his storefront business in Lahaina. Most of the remainder of the green coffee produced by the coffee farm is sold to other roasters in Hawaii for the same purpose, although some is exported to the mainland and internationally. Mr. Falconer was formerly an employee of Pioneer Mill and KLMC and has been involved in KLMC Farming Operations since the early 1980's. Hewas instrumental in converting former sugar plantation acreage to coffee for Pioneer Mill in the late 1980's and turning the new coffee farm into a commercial operation. Mr. Falconer continuesto assist KLMC on a consulting basis in all aspects of the KLMC Farming Operations as they pertain to coffee.

Historically, beginning in the late 19^{th} century, Pioneer Mill, together with adjacent large landowners such as Maui Land & Pineapple Company, Inc. ("**MLP**") developed an extensive system of water development, diversion and transmission infrastructure for the purpose of providing irrigation water to crops throughout West Maui. These crops, mostly sugar and pineapple, once covered almost the entire arable lands between what is now Kapalua and Ukumehame.

Today, KLMC Farming Operations rely primarily on ground water sourced from two development tunnels (the "**Honokowai Development Tunnels**") constructed by Pioneer Mill in the Honokowai Valley prior to 1920. This ground water is supplemented sporadically by stream water from the Kapaloa Stream, which is a tributary of the Honokowai Stream (collectively, the Kapaloa Stream and the Honokowai Stream are referred to herein as the "**Honokowai Stream**") that manages to reach the diversion at the entrance to KLMC's transmission tunnel downstream from the Honokowai Development Tunnels. From such transmission tunnels, the collected water (the "**Honokowai Water**") is first diverted to reservoirs on KLMC land and then enters KLMC's extensive irrigation system to distribute the Honokowai Water as needed by the KLMC Farming Operations. KLMC has previously commented in great detail about the Honokowai Stream and Honokowai Development Tunnels through written testimony (the "**KLMC Honokowai IFSAR Testimony**") provided to CWRM on October 9, 2019, in response to the Commission's draft of the Instream Flow Standard Assessment Report, Island of Maui Hydrologic Unit 6010, Honokowai, DRAFT PR-2019-01, dated June 2019 (the "**Draft IFSAR Report**").

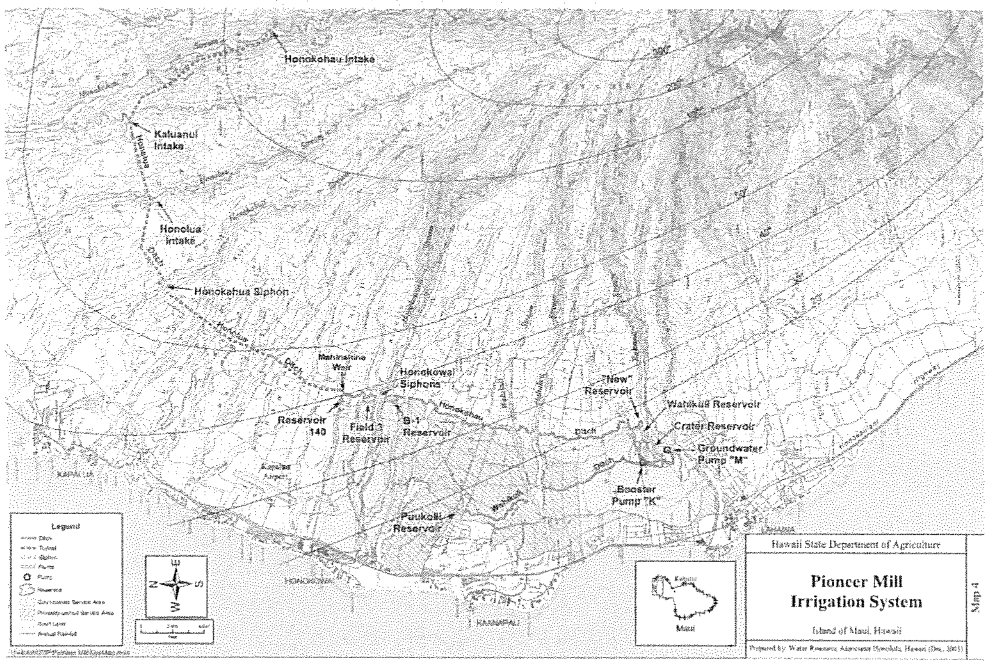
The graphic on the following page shows the Honokowai Water system (the Honokohau Ditch crosses



KLMC land at the bottom of this graphic).

With respect to the lands now owned or farmed by KLMC, KLMC historically obtained water as a secondary source from the Honokohau Ditch system (the "**Honokohau Ditch**") whichis the most extensive water transmission system in West Maui, and comprises developmenttunnels, stream diversions, transmission tunnels, ditches, siphons and reservoirs, which wascompleted in 1913 (replacing an earlier ditch system) and originates at the Honokohau Stream(the "**Honokohau Stream**"). Currently, the Honokohau Ditch has the capacity to provide non-potable water from the Honokohau stream in the north to the Kahoma stream in the south. The primary sources for the Honokohau Ditch are intakes in the Honokohau Stream (the"**Honokohau Intake**") the Kaluanui Stream (the "**Kaluanaui Intake**") and the Honolua Stream(the "**Honolua Intake**"). (Historically, the Honokohau Ditch continued past Kahoma,transmitting water augmented from other streams as far south as Ukumehame. For a good historyof the construction and early use of the West Maui ditch systems, see C. Wilcox, "Sugar Water:Hawaii's Plantation Ditches", at 122-137, which can be found at: https://books.google.com/books?id=6lZO0HSqF7UC&pg=PA137&lpg=PA137&dq=honokohau+ditch+history&sou rce=bl&ots=ZMaikZHdG_&sig=ACfU3U2YlxtH3I0IMhuSigV67hSHLe9LJA&hl=en&sa=X&ved=2ahUKEwjl2b myp63tAhV_RzABHcHuDfo4ChDoATASeqQICRAC#v=onepage&q=honokohau%20ditch%20history&f=false.) While the Honokohau Intake continues to operate, the Kaluahaui Intake and Honolua Intake haveeach been closed.

A map of the current Honokohau Ditch system, reproduced from the 2004 Update, isshown on the next page.



Currently, the coffee farm comprises over 400 acres and KLMC cultivates other crops on its lands in addition to providing grazing lands for cattle and goats. A significant portion of its lands remain fallow however, due to lack of water. The KLMC Farming Operations employ 20 people full time and additional people on a part-time basis primarily during the harvest season. Maui Grown Coffee provides employment for additional people at the company store. Today, the volume of water transmitted by the Honokohau Ditch is far below its historic average and is insufficient to provide any meaningful water to the KLMC Farming Operations, as it had in the past, which negatively impacts KLMC during drought conditions by stressing the plants and constraining yields. Water is the limiting resource that prevents KLMC from expanding its agricultural footprint on its lands.

Response: *Thank you for the information about KLMC. These comments are included in an Appendix to the Revision.*

III. HISTORY AND TRAJECTORY OF AGRICULTURE

In 1980, according to the DOA, there were 350,830 acres in crop production, 85 percent of which was tied to sugar and pineapple. By 2015, total crop acres dropped to 151,830, which amount included the 38,800 acres of sugar farmed by HC&S in central Maui. HC&S went out of production in 2016. Of the remainder, seed corn accounted for 23,728 acres, commercial forestryfor 22,864 acres, and macadamia nuts for 21,545, the last two of these primarily attributed to the Island of Hawai'i. These crops are primarily for export. Pasture use between 1980 and 2015 decreased over 30% from 1.1 million acres to 761,430 acres. "Statewide Agricultural Land Use Baseline 2015", DOA 2016, available at https://hdoa.hawaii.gov/wp-content/uploads/2016/02/StateAgLandUseBaseline2015.pdf (**"DOA Baseline 2015"**), at 4, 20. Hawai'i reached its high water mark in terms of acres in active agricultural production during the plantation era and now, with that era gone, "there is a surplus of agricultural land and water in the state that could be deployed for more intensive agriculture use". DOA Baseline 2015 at 4.

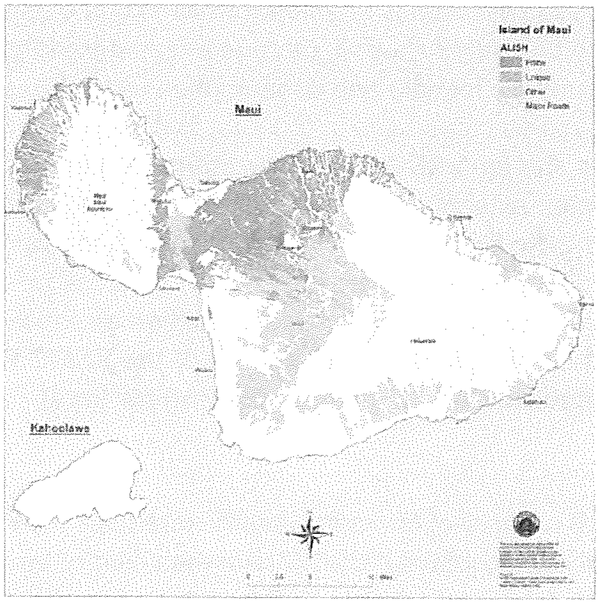
While much of the remaining acreage in crops is oriented toward export outside of Hawai'i, and much of this is located on the Island of Hawai'i, there is a recent trend toward smaller farms growing a variety of crops mostly for sale and consumption within the state. For purposes of these comments, while diversified crops have in the past typically meant to include only a variety of leaf and root vegetables, the term "**Diversified Agriculture**" herein shall be the same as used by DOA in the 2019 Update: "all agricultural crops in the State of Hawai'i". 2019 Update, at 10. Livestock, consisting primarily of cattle, sheep and goats, both for dairy and meat production ("**Livestock**") are grazed on range and pastureland, or on small private parcels, in various parts of the state. Livestock grown for local consumption also includes chickens raised for egg production and honeybees. **Substantially all of the KLMC Farming Operations consist of Diversified Agriculture and Livestock grazing for local consumption within the State.**

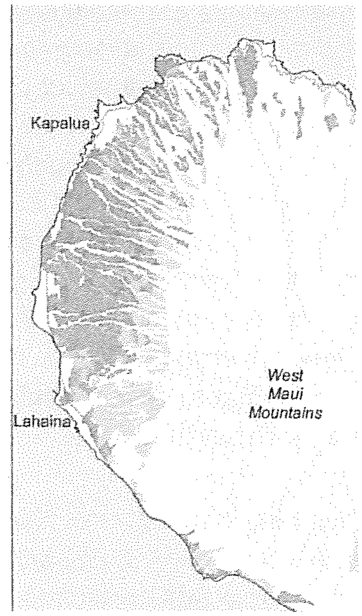
Between 2012 and 2017, the total number of farms in Hawai'i increased from 7,000 to 7,328, according to the U.S. Department of Agriculture ("**USDA**") but the value of farm industry output fell 15% from $661 million to $564, which reflects the shift from larger commercial farming to small local farms. Almost all of the growth in farms numbers is attributable to small farms on less than 10 acres. Most of the new farms are engaged in Diversified Agriculture or raising Livestock. There is also a trend toward selling produce directly to consumers rather than wholesale to local grocers and retailers, utilizing roadside stands, retail stores or farmer's markets. See, A. Gomes, "Big Shifts Hit Hawaii Farm Landscape", Honolulu Star-Advertiser, April 22, 2019, which can be found at https://hfbf.org/big-shifts-hit-hawaii-farms-landscape/.

Until the 1990s in West Maui, where KLMC operates, Pioneer Mill and MLP accounted for a combined 14,000 acres of sugar and pineapple production, which are now gone and new agriculture has been slow to reemerge, with "[m]uch of the former cropland reverting to dry grass and shrubs that flush green after the rain and periodically burn off in wild fires". DOA Baseline 2015, at 60. Since MLP is not currently involved in active agriculture, the only current remaining agricultural ventures of any size are the KLMC Farming Operations.

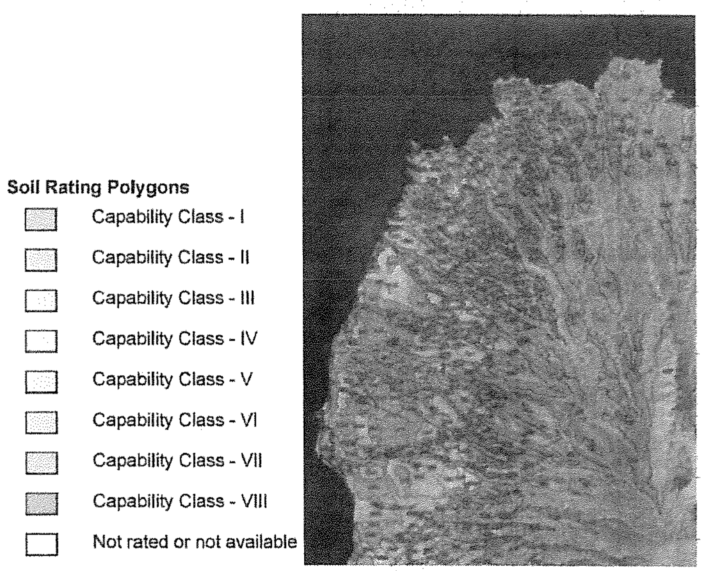
The State of Hawaii has a number of different classification systems for agricultural land; the 2019 Update discusses three of them: (1) Agricultural Lands of Importance to the State of Hawai'i ("**ALISH**"), (2) Land Capability Classification ("**LCC**"), and (3) Important Agricultural Lands ("**IAL**"). See 2019 Update at 16-23. The 2019 Update did not provide any of this information relative to the Honokohau Ditch and should be revised to include it.

Land is designated as IAL in compliance with statute. Currently, the only area designed as IAL on Maui is the former Alexander & Baldwin sugar plantation land in Central Maui. Id., at 23. That does not mean that other land on Maui cannot be designated as IAL. The ALISH system designates agricultural land in 3 categories: (1) Prime, (2) Unique or (3) Other. Id., at 16-17. The ALISH map for Maui can be found at https://files.hawaii.gov/dbedt/op/gis/maps/mau_alish_large.pdf and is reproduced below, together with an expanded map showing only the West Maui region:





As is apparent from the map, a major portion of the lands in the West Maui area serviced by the Honokohau Ditch system are “Prime” agricultural lands according to ALISH, meaning that it is “land best suited to produce food, feed, forage, and fiber crops”. 2019 Update, at 17.



The LCC classifications for the soils in the relevant West Maui region, assuming the availability of irrigation, is shown in the map below which was downloaded (and cropped) from the USDA National Resources Conservation (“**NRCS**”) website at https://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx.

It can be seen from the map that, not only is much of the agricultural land serviced by the Honokohau Ditch system Prime under the ALISH classification system, but the underlying soils are generally in capability classes I, II or III. Clearly, the lands are suitable for the promotion of Diversified Agriculture in the areas serviced by the Honokohau Ditch.

As stated above, a portion of the KLMC Farming Operations consist of Ag Lots that have been sold to private owners but "are planted in coffee and provides the owner with a selected house site, a managed coffee landscape, and an income for their production. This blend offers a model for opportunities elsewhere in the State." DOA Baseline 2015, at 60. This structure is materially different from a "gentleman farm" concept where a lot buyer maintains agricultural zoning for land by planting a few trees or vegetables, or grazing a few head of Livestock, mostly for personal consumption. See 2019 Update, at 230. By maintaining a significant portion of its development land in commercially managed farms, an Ag Lot development such as Ka'anapali Coffee Farms supports local employment and helps to subsidize the farming activity, thereby supporting continued agriculture in Hawai'i.

Response: *Thank you for the information about KLMC and agricultural lands. These comments are included in an Appendix to the Revision.*

IV. BENEFITS OF DIVERSIFIED AGRICULTURE

The trend toward Diversified Agriculture and Livestock for local consumption in Hawai'i, as practiced by KLMC, provides a number of benefits to the people of Maui and Hawai'i generally and the local economy in particular and is clearly in the public interest. The 2019 Update fails to address the impacts of COVID and its devastation of the Maui economy and how increased water supplies and increased agricultural activity can be promoted through a reassessment of future water needs in light of these COVID impacts.

A. Sustainability

Legally, "the term sustainable agriculture means an integrated system of plant and animal production practices having a site-specific application that will, over the long term:

- satisfy human food and fiber needs;
- enhance environmental quality and the natural resource base upon which the agricultural economy depends;
- make the most efficient use of non-renewable resources and on-farm resources and integrate, where appropriate, natural biological cycles and controls;
- sustain the economic viability of farm operations; and
- enhance the quality of life for farmers and society as a whole."

Subchapter I: Findings, Purposes, and Definitions, U.S. Code, Title 7, Chapter 64-Agricultural Research, Extension and Teaching, Available at GPO Access: http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=browse_usc&docid=Cite:+7USC3103 (8/23/07). DOA refers instead to the Webster definition of sustainability as it pertains to agriculture: "of, relating to, or being a method of harvesting or using a resource so that the resource is not depleted or permanently damaged". 2019 Update, at 204 (footnote 40).

In general, it is easy to see how a transition to smaller, local farms, growing crops or raising livestock for local consumption satisfies at least some of these attributes, when compared to larger conventional farms. While the economic viability of smaller farms is a tenuous enterprise, the use of shared resources and infrastructure, best agricultural practices and, where appropriate, public and private subsidies help to achieve the sustainability of individual farms and agriculture generally. Farmers are benefited by achieving wages and profits that sustain their lives over the longer term and society is benefitted by improvements to the local economy and food options.

DOA appears to agree. It states: "A good first step toward achieving statewide sustainability is to develop a sustainable agricultural industry, both in resources and economics. ... If farmers are to be expected to provide quality and consistent commodities, they must have an adequate and stable water supply for their crops, especially during severe weather conditions." 2019 Update, at 204.

B. Food Security and Self-Sufficiency

DOA recognizes that the concept of "import replacement" has long been discussed in Hawai'i. However, progress has been slow. See 2019 Update, at 206-207, 225. Included in the issues that could help to promote "import replacement" were reducing costs by encouraging larger farms with increased functional specialization, and developing low-cost irrigation water. Id., at 206. DOA's recap of a 2008 University of Hawai'i paper on the subject, which advocated a doubling of consumption of Hawai'i- grown food products, concludes with the observation that "this forecast assumed that there were available resources and infrastructure to double production". Id., at 207. Presumably, this largely refers to the availability of adequate irrigation water and the means to deliver that water to the land.

Commenting on the USDA's report of an increase in the number farms in its most-recent 5-year statewide census of agriculture, "Gov. David Ige commented on the snapshot of Hawaii agriculture by promoting the need to grow more food for local consumption. 'These numbers should reinvigorate all efforts to continue to increasing Hawaii's food security and self-sufficiency ". See, "Big Shifts Hit Hawaii Farm Landscape", supra.

Hawai'i has always been largely dependent on imports for the mainland or internationally for its food supply, importing 85-90% of its food. As an isolated outpost in the middle of the Pacific, this dependency is a source of risk for the state's inhabitants, making them "particularly vulnerable to natural disasters and global event[s] that might disrupt shipping and the food supply". See "Increased Food Security and Food Self-Sufficiency Strategy", Office of Planning Department of Business Economic Development & Tourism in Cooperation with the Department of Agriculture, State of Hawaii, October 2012, ("**Office of Planning 2012 Food Strategy**"), available at https://files.hawaii.gov/dbedt/op/spb/INCREASED_FOOD_SECURITY_AND_FOOD_SELF_SUFFICIE NCY_STRATEGY.pdf , at 2.

The Office of Planning 2012 Food Strategy identifies three objectives for food security and self-sufficiency: (1) Increase Demand for Locally Grown Foods, (2) Increase Production of Locally Grown Foods, and (3) Provide Policy and Organizational Support to Meet Food Self-Sufficiency Needs. Id., at 18, 23, and 34. It sets forth a number of policy statements and action items to achieve these goals and identifies numerous government and non-government organizations that are tasked with or participate in their implementation. These objectives are repeated by DOA on page 205 of the 2019 Update. DOA is designated as a lead or assisting organization for many of these action items.

With respect to water, the policy statements in the Office of Planning 2012 Food Strategy, focus on the need to maintain, upgrade and repair state irrigation systems and former plantation agriculture irrigation infrastructure, recognizing that "agricultural lands and irrigation system action recommendations are inter-related and inter-dependent". Among the items that are assigned to DOA (and CWRM), is the completion of the AWUDP, which is the subject of this testimony. Id., at 24-25.

The Maui Island Plan, General Plan 2030 ("**Maui General Plan**"), was adopted in 2012. It can be found at: https://www.mauicounty.gov/DocumentCenter/View/84686/Whole-Maui- Island-Plan-Book?bidId=. Among its "key highlights" is "Protection of Maui's Small Towns and Rural Character. Outside of growth areas development will be limited to preserve our agricultural lands and open space." Maui General Plan, at ES-2. While, due to lower than expected population growth since 2012 and economic disruptions caused by the COVID- 19 pandemic, the Maui General Plan is likely already out of date, it does recognize that "[I]ncreasing local consumption of Maui agricultural goods is a long-term opportunity for stabilizing and expanding agriculture. Besides economic benefits to farmers, substituting locally-produced food for imports could allow Maui to become more self-sufficient." Maui General Plan, at 4-16.

C. Diversification of the Economy

The Office of Planning 2012 Food Strategy also recognized that "[I] ncreasing food self-sufficiency will keep money circulating in Hawaii's economy rather than supporting agribusiness in other states or countries. It will help to diversify Hawaii's economy." Office of Planning 2012 Food Strategy, at 2. Even before the invasion of COVID-19, each of the State of Hawai'i and MauiCounty recognized the need to reduce their dependence on tourism and diversify the economy into other areas.

For example, in 2016, the County of Maui Mayor's Office of Economic Development, in partnership with Maui Economic Development Board, released its Comprehensive Economic Development Strategy ("**CEDS**"), which can be found at https://www.mauicounty.gov/DocumentCenter/View/106485/OED-CEDS-Report?bidId=. "Among the major challenges Maui County faces in economic development are diversification of the economy; increasing the number and proportion

of living wage jobs; …". CEDS, at 5.
Agriculture is identified as one of eight industries for which priority goals for diversification were set by the CEDS, including the need to "assure reliable, adequate and affordable water sources for all Ag ventures". CEDS, at 50.

Two objectives of the Maui General Plan are to "[m]aintain or increase agriculture's share of the total island economy" and "[e]xpand diversified agriculture production at an average annual rate of 4 percent". Maui General Plan, at 4-19, 4-20.

The Draft West Maui Community Plan ("**DWMCP**"), which was updated June 2020 but does not appear to have taken into account the impact of COVID-19, can be found at https://wearemaui.konveio.com/draft-west-maui-community-plan. It identifies at least two policies that recognize the importance of agriculture in fostering the goal of economic opportunity: (1) "[s]upport agriculture that provides jobs, improves soil health, is less water intensive, and provides food and products for local markets", and (2) "[s]upport agriculture that is small-scale or self-subsistence farming". DWMCP, at 56. Agriculture is one of 14 land use designations specified in the DWMCP and covers by far the largest area shown on the included community plan map. DWMCP, at 70, 86-87.

If West Maui truly plans to maintain a significant agricultural component for its future economy, water resources need to be allocated to farming areas for them to be successful. While small-scale farms comprise a portion of the KLMC Farming Operations and contribute to food security, they (and subsistence farms) generally are not money-making enterprises and contribute little to the local economy, because they do not provide jobs or spend significant money at other local businesses. The promotion of commercial-scale farming, on the other hand, such as KLMC's coffee and Diversified Agriculture ventures, have the capacity to help grow and diversify the local economy in a positive way.

D. Job Growth

According to an October 2019, Kiplinger article Hawaii was projected to be one of the 10 worst states for job growth for 2019 and 2020. D. Payne, "10 States with the Slowest Rates of Job Growth, 2020", Kiplinger, October 17, 2019. Then the pandemic hit, turning job growth significantly negative. Maui County's unemployment rate rose from 2.2% in March, 2020, to 34.6% in April 2020 and has since eased downward to 23.6% in September 2020. U.S. Bureau of Labor Statistics, "Kahilui-Wailuku-Lahaina Area", October 2020, at: https://www.bls.gov/regions/west/hi_kahului_msa.htm. It will take many years for the rate to revert to anything close to the rate seen before the COVID-19 pandemic decimated Maui's economy.

As stated above, KLMC's Farming Operations provide employment for 20 full-time employees and a number of part-time employees on a seasonal basis. These jobs are in peril if KLMC cannot obtain sufficient water to continue operations. Conversely, to the extent that agriculture can be expanded in West Maui in a manner that is commercially viable, more job opportunities will be created as well. Avoiding the loss of jobs is just as important as growing the number of job opportunities. Providing farmers on West Maui with reliable, adequate, and affordable water sources will help preserve and create local jobs that are especially needed over the next few years.

E. Wildfire Suppression

Wildfires have become common place in Hawaii. Most fires start in "unmanaged nonnative grasslands and shrublands, which have dramatically expanded with declines in Hawaii's agricultural "footprint" by more than 60% since the 1960s." C. Trauemicht, "Recent Maui Fires Require Proactive Statewide Response", Honolulu Civil Beat, October 28, 2019, which can be found at: https://www.civilbeat.org/2019/10/recent-maui-fires- require-proactive-statewide-response/. In 2018, there were 627 wildland fires statewide, including one that impacted lands owned by KLMC. Since the beginning of 2019 in WestMaui, fires in January 2019 in Olowalu, April 2019 near the Kapalua Airport, October 2019 above Kahana Ridge (which burned about 1000 acres), September 2020 between the Kapalua Airport and KLMC's lands (blackening approximately 550 acres), and October, 2020 in Kahoma Valley.

Fires such as these could be minimized through the greening of fallow agricultural lands or the grazing of Livestock, which would reduce the amount of dry vegetation on former plantation acreage. The expansion of the agricultural footprint on West Maui would assist in this effort. Moreover, due to the abandonment or closure of reservoirs in West Maui, there is not a sufficient source of fresh water available to firefighters to battle these blazes and they typically use helicopter drops of ocean water to bring fires under control. The use of ocean water is harmful to the soil and due to its salt content and can make future agriculture in those areas problematic.

While a bill has been introduced that would support reutilizing these reservoirs for fire suppression, it is not clear that this can be done without management of the reservoirs by landowners who have no financial attachment to them. Rehabilitating reservoirs in the context of supporting and expanding commercial agriculture, and providing a ready source of irrigation water for such purpose would also serve the twin goals of reducing the fallow dry acreage and providing a source of fresh water near these lands for fire suppression. See, generally, Staff, "Three bills would impact life in West Maui", LahainaNews, February 13, 2020, which can be found at: https://www.lahainanews.com/news/local- news/2020/02/13/three-bills-would-impact-life-in-west-maui/.

F. Aesthetic Enhancement

While the foregoing benefits of supporting existing and future agriculture on Maui are directly related to the business, another benefit of replanting fallow lands is the enhanced aesthetic value of the greening of the hillsides above the settled areas of the state. In fact, the DOA website, at https://hdoa.hawaii.gov/chair/boa/, states that the "Department is dedicated to the preservation and productive use of agricultural resources so as to assure a healthy and adequate food supply for Hawaii's people, providing employment, maintaining a favorable balance of trade, and *preserving the aesthetic quality of the Islands* [emphasis added]".

With tourism being a major factor in the economy of West Maui, the beautification of the hillsides by providing managed crop and grazing lands versus fallow scrublands enhances the appeal of this area and thus enhances the visitor experience. With respect to the Honokohau Ditch system, the 2004 Update, stated that "the State's interest is based on the agricultural water needs of surrounding State lands and the need to continue scenic greenery on West Maui's western slopes for the tourism industry".
2004 Update, at 66. Of course, since the 2004 Update did not acknowledge any remaining private agriculture on West Maui, it confined its comments to State lands, but the comment applies equally to private agricultural lands.

Response: *Thank you for your comments. These comments are included in an Appendix to the Revision.*

V. IMPORTANCE OF WATER/WATER NEEDS

A. Importance of Water for Agriculture

"If agriculture on Maui is to be economically viable, the State and County will need to ensure that farmers have access to sufficient supplies of affordable water." Maui General Plan, at 4-17. Without water, crops don't grow. Without crops, there is no food.In Hawai'i, agriculture exists in a variety of locations and environments. But, the lion's share of plantation farming was conducted in regions on the leeward side of islands, where the rainfall was less and sunshine was maximized. This provided for healthier yields and more crop cycles. In order to provide needed water for crops in these advantaged locations, extensive irrigation systems were developed to transport water from rainier areas to sunnier ones.

In West Maui, substantially all agriculture was, and continues to be, conducted in these sunny regions, including the KLMC Farming Operations. The 2019 Update "reaffirms that agricultural water systems (irrigation systems) are the most important infrastructural requirement to expand Hawai'i's diversified agriculture industry; and that irrigation water supply should be reliable and adequate to meet the current and future water requirements of Hawai'i's diversified agricultural industry ... achieving the state's goals of agricultural growth, economic diversity, and sustainability." 2019 Update, at 4. KLMC agrees with this assessment and also with the stated goals of the 2019 Update: "to 1) provide a comprehensive plan to protect and increase the agricultural water resources available to the diversified agriculture industry; and 2) maintain and improve the agricultural water systems in the State of Hawaii to support an economically viable diversified agricultural industry". Id.

B. Consequences of Drought

Rainfall is seasonal in Hawaii, particularly on the leeward side of each island. During the "dry season" between April and October, most areas not at significant elevations experience abnormally dry conditions. In addition, some areas may experience prolonged drought periods even during "rainy seasons". According to the

National Integrated Drought Information System, the portion of West Maui that includes the Honokohau Ditch and the Honokowai Water systems is currently in the D2-Severe Drought classification. This data can be found at: https://www.drought.gov/drought/states/hawaii.Among the consequences of severe drought is that "crop or pasture loss likely". Id.

As an arid area on the leeward side of Maui, West Maui has experienced at least moderate drought conditions at times during most of the last 20 years. Drought has become an important enough issue in Hawaii that CWRM adopted a Hawaii Drought Plan in 2000, the most-recent update of which was prepared in 2017 and can be found at: https://files.hawaii.gov/dlnr/cwrm/planning/HDP2017.pdf.

While irrigation water is important at various times during the growing cycle for any crop, loss of water during drought periods can result in significant economic loss. While crop loss insurance can cover some of this for a given year, this will not typically suffice where there is permanent damage to the farms, such as loss of grazing lands or fruit or nut bearing trees. Most small farmers growing Diversified Agriculture products will not be able to afford crop insurance.

C. Cost Considerations

No matter what crop is being produced, or at what scale, the cost of irrigation water can make the difference between a farmer's success or failure. Farms in Hawaii generally have three options (other than hoping for rain) for sourcing irrigation water (1) county potable water systems, (2) private wells, and (3) diversions from stream beds. The first option infringes on the domestic water supplies and is poor use of water that has been treated for human consumption. Private wells are expensive to drill and operate.

That is why, dating back over 100 years, agriculture in Hawaii has largely depended on gravity feed systems that transport stream water or high level ground water from the source to the point of need. While gravity feed systems are not without cost, once the infrastructure is in place the variable cost of maintenance is relatively minor. The Honokohau Ditch and Honokowai Water systems each divert primarily high level ground water from development tunnels and represent the lowest cost option for farmers on West Maui. In keeping with the goals of the 2019 Update stated above, the use of these systems should be maximized to ensure a viable diversified agricultural industry can be maintained and grow in West Maui.

D. Components of 2019 Update

The main components of the 2019 Update include (1) an inventory of water systems not inventoried by the 2004 Update (which earlier inventories are relied upon inthe 2019 Update), (2) development of capital improvement programs for these water systems, (3) updated water demand forecasts, and (4) a proposal for a development plan to meet existing and future water needs. 2019 Update, at 4-5. So, in essence, the purposeof the 2019 Update is to assess the potential supply of irrigation water and ensure that it is sufficient to meet the expected demand for irrigation water.

The water system of interest to KLMC and West Maui generally is the system identified in the 2019 Update as the "Maui Land and Pineapple Co./Pioneer Mill Irrigation System" ("**MLP/PMIS**"), and the infrastructure providing Honokowai Water.The MLP/PMIS originally consisted of three ditch systems that are all included in the definition of Honokohau Ditch used in this testimony.

Response: Thank you for your comments. These comments are included in an Appendix to the Revision.

VI. IMPORTANCE OF THE HONOKOHAU DITCH

A. Historical Use/Capacity; Description in AWUDP

Historically, the central stem of the Honokohau Ditch transported water drawn from many of the valleys in West Maui, including delivering water to the Wahikuli and Crater Hill reservoirs above Lahaina Town where it could be stored and redirected northward at lower elevations or directed further to the south to Launiupoko. The Wahikuli and Crater Hill reservoirs have since been decommissioned. DOA Baseline 2015, at 62. Unless this portion of the system is rehabilitated, the functional southern limit of the Honokohau Ditch is the Kahoma Valley.

The 2004 Update adequately describes the construction, scope and early history ofthe Honokohau Ditch, but makes a number of assertions concerning the use and condition of that system and the so-called "western slopes" sources, meaning the Honokowai Watersystem, that were incorrect then and are incorrect now.

- The 2019 Update categorizes the Honokohau Ditch as managed by the Agricultural Development Corporation ("ADC"), when it should be classified as a private system. 2019 Update, at 3. "The ADC oversees and assists in the management of water systems which are transitioning from the plantation era to diversified agriculture." 2019 Update, at 245. The agricultural lands in West Maui are certainly transitioning to Diversified Agriculture, and the ADC may manage the relatively minor portion of the system that exists on State lands, but this portion has no associated agriculture today. The system is primarily managed by MLP and KLMC.

  Response: The AWUDP does recognize that it is a private system.

- By 2004, when the 2004 Update was released, KLMC and Pioneer Mill (and their parent entities) had emerged from bankruptcy as reorganized entities and continued to engage in Diversified Agriculture on some of their land in West Maui. See 2004 Update, at 66, 75.

  Response: This comment has been incorporated into the document.

- The "sources of water on the western slopes", essentially referring to the Honokowai Water system, was never at any time abandoned by KLMC or PioneerMill and continued to serve as the primary source of irrigation water for KLMC's Farming Operations. See 2004 Update, at 63, 66. Thus the MLP/PMIS should have continued to include the Honokowai Water system in its assessment.

- KLMC, not Amfac/JMB Hawaii, which was a parent entity, is the successor to Pioneer Mill with respect to the lands at Kaanapali, and it never stopped maintaining the Honokowai Water system. See 2004 Update at 64.

- In addition, the uses of irrigation water from MLP/PMIS in the 1980s was not confined to the uses described in the 2004 Update, but was also used by Pioneer Mill (and later KLMC) to irrigate crops, including its remaining sugar fields and its newly-established coffee farm, which is still in business. See 2004 Update, at 64. Later, KLMC continued to use the Honokohau Ditch as a secondary source of irrigation water for its makai fields until reliable water stopped flowing to it during the past few years. (According to Table 113 of the 2019 Update, significant water flowed to KLMC through the Honokohau Ditch during the years 2012-2014. 2019 Update, at 154. Even so, KLMC continues to use the Honokohau Ditch as a mechanism for transporting water to certain portions of its land, and it has never abandoned or stopped using the Honokohau Ditch on the portions it owns.)

Water flowing into the Honokohau Ditch does not comprise only surface water, as suggested by the DOA Baseline 2015, but also ground water that is produced by development tunnels and that utilize stream beds for transmission between the mouth of the development tunnels and the diversions/intakes that deposit water directly or indirectly into the Honokohau Ditch for distribution to users to the south. See, generally, KLMC Honokowai IFSAR Testimony.

The 2019 Update relies upon the 2004 Update for its description and assessment of the Honokohau Ditch and Honokowai Water systems, augmenting it only to recognizethat a portion of the system at Wahikuli is now owned by West Maui Land Company ("**WMLC**"), and the potential to reconnect the system to the south to provide a water source for lands owned (or previously developed) by WMLC and Kamehameha Schools Bishop Estate ("**KSBE**"). This portion of the 2019 Update references Map 125, which is supposed to show the West Maui/Pioneer Mill Irrigation system alignment of the Honokohau Ditch system through these lands, but shows a different ditch system instead.2019 Update, at 152 and Map 125. In addition, Table 113 shows no flow data for Honokowai, but that is not because there was no water being used from the Honokowai Water system during those years, but only because no readings were taken.

Response: *The flow data in Table 113 reflect the flow data reported by the system owner/operator to CWRM.*

B. Rehabilitation and Maintenance of Honokohau Ditch

According to the DOA Baseline 2015, "MLP continues to manage several stream intakes in Honolua and Honokohau Valleys and the Honokohau Ditch, which were once the backbone of the region's water delivery system." DOA Baseline 2015, at 60.

However, this is only partially true, since KLMC maintains those portions of the Honokohau Ditch that exist on KLMC lands and also on such portions that exist on stateland that has been leased by KLMC. MLP never managed portions of the ditch to the south of Mahinahina. The Honokohau today delivers water to support the Kapalua resortand also transmits water to the County Water Department at Mahinahina. Id. While the KLMC portion of the Honokohau Ditch system is operable, KLMC has received no meaningful water from MLP though the ditch for the past few years.

While the geographic scope of the Honokohau Ditch system is smaller than during the plantation days, since it currently is in disrepair from the former Wahikuli Reservoir and southward, the system can still deliver water to a large portion of West Maui and should still be considered an important regional water system.

"As with most infrastructure issues, agricultural water systems require ongoing investment and maintenance to insure their viability… The legacy of plantation era surface water collection and delivery systems is a valuable part of today's agricultural heritage. Many of these systems could never be rebuilt, regardless of price" Id. at 84.

The 2004 Update assessed the condition of those portions of the MLP/PMIS system that it chose to include and provided a list of proposed capital improvement projects ("**CIP**") and maintenance projects. It did not revise these for the 2019 Update and they are woefully out-of-date. Nevertheless, it is important for DOA to revisit this and make proposals based on current facts. Otherwise, because Chapters 4 and 5 of the2019 Update do not contain any current proposed projects that impact the MLP/PMIS system (or any other system in the area), KLMC does not comment on those chapters. Last winter, MLP commenced a series of major repairs to the Honokohau Ditch,to restore damage caused by hurricanes Lane and Olivia in late 2018. Mostly, these repairs were to the intake area in the Honokohau Valley, but also to some of the siphonsand access roads. See, L. Imada, "ML&P begins repairs to Honokohau Stream ditch system", Maui News, December 5, 2019, which can be found at: https://www.mauinews.com/news/local-news/2019/12/mlp-begins-repairs-to-honokohau-stream-ditch- system/ . Apart from these repairs, we recommend that DOA and CWRM consider the following:

- Reconstruction of the Wahikuli Reservoir and provide for the reuse of the Crater and/or "New" reservoirs
- Replacement of the Wahikuli Ditch with pipelines, laterals and control valves
- Repair or replace the Mahinahina Weir
- Repair of Honokowai and Wahikuli Stream siphons and associated siphonboxes
- Rehabilitation of the Honolua intake
- Line the 140 Reservoir

- Repair open ditch sections as needed

Responsibility for maintenance of these systems will depend on the facts. For example, KLMC continues to maintain the Honokowai Water system because it exists almost entirely on land that it owns or manages. The Honokohau Ditch system could be maintained in a number of ways. Landowners could maintain those portions that exist on their land. The incentive for doing so, however, would depend on whether the landowners are receiving adequate irrigation water from the system. Landowners could enter into a contract for the delivery of water, which would include an allocation of maintenance costs. This might raise technical issues concerning priorities, metering or failure to deliver water. Finally, as suggested in the 2004 Update, the State could create an entity to manage and maintain the Honokohau Ditch, such as an irrigation cooperative, which would raise the same issues as a contract and also other issues concerning ownership, easements and resolution of disputes. See 2004 Update, at 67.

Response: *HDOA's consultant contacted the various owners and operators of the irrigation systems that are inventoried in both the 2004 AWUDP and 2019 AWUDP Update. Some private system owners chose not to participate in the study, including private entities associated with the West Maui system. As such, the information in the 2019 AWUDP Update is limited to information obtained for the Pioneer Mill Irrigation System (Honokahau) – West Maui Land Co.*

These comments are included as an Appendix to AWUDP.

Chapter 9 of the 2019 Update includes a general discussion of the development plan presented (consisting of the CIPs and other projects listed in the discussions of theindividual systems in Chapters 4 and 5). While no projects are included for the Honokohau Ditch, we nevertheless have comments on this discussion. KLMC is generally in agreement with some of the statements in support of agriculture that DOA makes:

- KLMC agrees that current rules and regulations for reservoirs, dams and instream flow affect the amount of water supplied to farms and may impede the rehabilitation or growth of affected systems – and, by extension, Diversified Agriculture. See 2019 Update, at 242.

- KLMC acknowledges, as does DOA, that "the State of Hawaii's goals, which require an increase in agricultural production, crop diversity, and economics, include:

  - Diversifying the economy;

  - Sustainability and self-sufficiency; and

  - Support of diversified agriculture"

  2019 Update, at 246.

- While KLMC agrees that the installation of automated irrigation systems may bring the benefits described (See 2019 Update, at 248, 251), the disadvantages should also be considered, such as (1) cost, especially for smaller farms, (2) potential job losses, and (3) reduction of aquifer recharge.

- KLMC agrees that distribution loss studies should be undertaken to ensure that sufficient water is allocated to agricultural lands. See 2019 Update, at 248. However, for reasons stated earlier in this testimony, there are benefits to aquifer recharge caused by these losses that may, on balance, make them less problematic, other than to the extent the farmer is paying for water that is not being applied to the crops or receives insufficient irrigation water because of such losses. Generally, it should be up to the landowner to manage system losses on its own land. Providing other infrastructure for aquifer recharge should also be considered if there is sufficient excess water and funding available. See 2019 Update at 249-250.

- KLMC agrees with the concepts suggested by DOA to "meet the state's goals and provide economic stability to the agriculture industry". See 2019 Update at 251.

Response: *Thank you for your comments. These comments are included in an Appendix to the Revision.*

C. System Capacity/Current and Future Needs

In 2002, MLP estimated the capacity of the Honokohau Stream intake to divert water into the Honokohau Ditch at 60-65 MGD. See R. Fontaine, "Availability and Distribution of Base Flow in Lower Honokohau Stream, Island of Maui", USGS Water-Resources Investigations Report 03-4060, 2003 ("**USGS 03-4060**"), at 21. Historically, the average flow in the Honokohau Ditch was closer to 20MGD, according to the 2019 Update. 2019 Update, Table 113, at 153. This is somewhat lower than the time-series data for the period 193-2000 computed by USGS, which arrived at an average discharge of 24.7 MGD but a median of 19 MGD. USGS 03-4060, at 25. About 1 MGD of this amount was historically redirected into Honokohau Stream through the "taro gate" that was used to water the taro crops in the valley. USGS 03-4060, at 27. The development tunnels in the Honokohau Valley account for about 4MGD of flow. USGS 03-4060, at 24. The average stream flow above the development tunnels is about 25.3 MGD and the median is about 15.5 MGD. USGS 03-4060, Table 11, at 26.

If 13 MGD could be permitted to be diverted into the intake on a consistent basis, with 1MGD diverted through the taro gate, additional water would flow downstream from the diversion about 80% of the time. USGS 03-4060, Table 10, at 26, (utilizing a conversion rate of 1MGD to 1.547 cu.ft./sec). This does not take into account additional ground water inflow or runoff into the stream below the development tunnels. This flow amount would serve to maximize the utility of the Honokohau Stream as a water source while at the same time providing water for the kalo farmers in the Honokohau Valley as well as sufficient excess for the maintenance of biota and the aesthetics of natural stream flow. If Honolua Intake and/or Kaluanaue Intake were reopened to contribute water to theHonokohau Ditch, additional waters could become available for agricultural use. **We strongly recommend that DOA and CWRM include such an analysis in the AWUDP.**

Current nonstream uses of water flowing into the Honokohau Ditch total approximately 4.6 MGD, as noted below. See, Imada, supra. Other agricultural users could utilize an increased volume of water to expand Diversified Agriculture in West Maui.

1. MLP

MLP currently only diverts irrigation water into the Honokoahu Ditch for use in its Kapalua Development, other than the amount that is redirected into the valley through the taro gate. This amounts to 0.9 MGD for the golf courses and 1.0 MGD for the remainder of the resort.

MLP owns significant agricultural lands that are currently fallow and could be used for agriculture, by the company itself, by leasing the land to third parties for agriculture or hiring contract farmers. The amount of additional water needed would depend on the scope of any agriculture that is initiated.

2. Maui County Department of Water Supply ("DWS")

DWS currently uses about 2.5 MGD for its Mahinahina water treatment plant, filtering the water to include in the County's domestic water system. The County plans to complete two ground water wells to augment the Honokohau Ditch water and provide for future growth. The first well will be in Kahana and is expected to draw 0.96 MGD from the Honolua Aquifer; the second well will come later and be drilled mauka of the Mahinahina plant, drawing about 0.672 MGD from the Honokowai Aquifer. See, K. Cerizo, "County moves to take wells from exploratory to full production", The Maui News, July 24, 2019, which can be found at https://www.mauinews.com/news/local-news/2019/07/county-moves-to-take-wells-from-exploratory-to-full-production/. The construction of these wells makes it unlikely that the County would require additional water from the Honokohau Ditch in the foreseeable future. This is especially true since the COVID-19 pandemic has resulted in the delay or cancellation of planned projects, such as the project that the Employee Retirement System of the State of Hawaii ("**ERS**") had planned for the redevelopment of a portion of the current Kaanapali Resort golf courses. See,
A. Gomes, "State retirement fund abandons plan for Maui golf course redevelopment", Honolulu Star Advertiser, November 1, 2020, found at: https://www.staradvertiser.com/2020/11/01/hawaii-news/retirement-fund-abandons-plan-for-maui- golf-course-redevelopment/. This development would have included a hotel and 150 to 250 condominiums, which would have added to potable water demands in West Maui. Id.

3. The Department of Hawaiian Homelands ("DHHL")

DHHL recently abandoned its planned Honokowai community and has restarted the planning effort. See, Staff, "DHHL withdraws plans for massive Honokowai Master Plan development", Lahaina News, December 12, 2019, which can be found at https://www.lahainanews.com/news/local-news/2019/12/12/dhhl- withdraws-plans-for-massive-honokowai-master-plan-development/. DHHL has reserved approximately 2.1 MGD of water from the Honokowai Aquifer to irrigate the agricultural component of these lands. While it could develop wells for this purpose, because of the location of this development it makes far more sense for DHHL to obtain this water from the Honokohau Ditch system. The Honokohau Ditch runs adjacent to portions of the DHHL lands both to the north and south ofthe Honokowai Valley.

4. KLMC

As noted above and in more detail in the KLMC Honokowai IFSAR Testimony, KLMC uses the Honokowai Water system as its main source of irrigation water. Historically, until recently, KLMC also obtained water from the Honokohau Ditch sourced from the intakes on that system. This water had been used as a secondary source when Honokowai Water was inadequate. Because the KLMC Farming Operations are currently water constrained, and because KLMC would work to increase the agricultural footprint on its lands, it could use a significant additional allocation of Honokohau Ditch water. This would help accomplish all of the goals of Diversified Agriculture noted elsewhere in this testimony.

5. Other State Lands

While the DHHL Honokowai Project is in the planning stages, other lands owned by State agencies in the vicinity of the Honokohau Ditch that are now fallow could be replanted in crops. Some of this land lies between KLMC's land an Wahikuli. Historically, Pioneer Mill leased much of this land for sugar cultivation. Most of it is not in the path of development in any reasonable timeline and thus will remain unused unless repurposed. As with MLP, the State could lease the land or hire contract farmers. DHHL also intends to have a small agriculture component in its Leiali'i development, near Lahaina. This area could receive Honokohau Ditch water if the Wahikuli Ditch is rehabilitated or reconstructed. Again, the amount of water required for these lands would depend on the facts.

6. Others

Other users currently account for 0.2 MGD of Honokohau Ditch water, primarily for small parcels adjacent to MLP lands. If there remains sufficient Honokohau Ditch water after accommodating the upstream users mentioned above, so that the Wahikuli Reservoir and other associated improvements could be profitably rebuilt, then there is the potential for downstream agricultural users such as WMLC and KSBE to be able to increase their agricultural footprints. It would make sense in this case to revisit the ability to divert additional Kahoma and/or Kanaha Stream water to augment this supply.

Response: *These comments are included in an Appendix to the Revision, and will also be shared with the Commission on Water Resource Management, County of Maui, Department of Water Supply, and Department of Hawaiian Home Lands.*

D. Aquifer Recharge

"The amount of recharge available to enter the aquifers is the volume of rainfall, fog drip, and irrigation water that is not lost to runoff or evapotranspiration or stored in the soil." USGS Report FS 126-00, "Ground Water in Hawaii", 2000. "Overall irrigation rates have been steadily decreasing since the 1970s, when large-scale sugarcane plantations began a conversion from furrow to more efficient drip irrigation methods and a reduction in the amount of acreage dedicated to sugarcane production." P. Young, Images of Old Hawai'i, "Irrigation-enhanced Recharge", June 7, 2016. Nevertheless, even drip irrigation contributes to ground water recharge and an increase in the agricultural footprint of West Maui would help increase recharge rates. To the extent that water is moved from aquifers with larger excess capacity to aquifers with less excess capacity, such as occurs with the Honokohau Ditch, there is an opportunity to benefit the overall water management of the region. The 2019 Update should consider this opportunity.

E. DHHL Aquifer Allocation

As stated above, DHHL has reserved approximately 2.1 MGD of water from the Honokowai aquifer. Some of this allocation may be attributed to the Mahinahina Well to be drilled by DWS, but the remainder would likely be for irrigation water for the agricultural component of DHHL's Honokowai planned development. Virtually none of this development could be irrigated from surface or high-level ground water within the Honokowai aquifer because (1) there is no existing irrigation system that could transport this water to the development, (2) the Honokowai stream and other streams within the Honokowai aquifer are not perennial streams at lower elevations, and (3) substantially all of the water developed by the Honokowai Water system is used by KLMC for its farming operations and the entire irrigation system is on private land owned by KLMC.

According to DWS, the Honokowai Aquifer has an estimated sustainable yield of 6.0 MGD. While this number may be understated in part due to the recent research that suggests that Hawaiian aquifers may extend beneath the ocean floor, under current estimates this aquifer may become fully committed in the future due to the aquifer's proximity to more concentrated development. Conversely, the Honolua and Honokohau Aquifers, which can each be serviced by the Honokohau Ditch, have estimated sustainable yields of 8 MGD and 9 MGD, respectively. While there is some significant pumpage from the Honolua Aquifer (though less on a percentage basis relative to sustainable yield than Honokowai) there is currently none from the Honokohau Aquifer. See, County of Maui, Department of Planning, "West Maui Community Plan – Water

Technical Resources Paper", October 15, 2018, at 6, found at: https://westmaui.wearemaui.org/technical-resource-papers-water. Given the excess capacity of these aquifers and the ability of the Honokohau Ditch system to deliver irrigation water directlyto DHHL's Honokowai lands, it would be to the benefit of DHHL and all other users of water in West Maui to move DHHL's water allocation to either the Honolua or Honokowai Aquifer. The 2019 Update should suggest this reallocation.

Response: *Stormwater recharge is discussed in Section 9.2.2. Additional discussion on aquifer recharge and DHHL aquifer reallocation evaluations are beyond the scope of this AWUDP Update and associated Revision. These comments are included in an Appendix to the Revision.*

VII. MODELING WATER DEMAND

A. Water Demand for Diversified Agriculture Generally

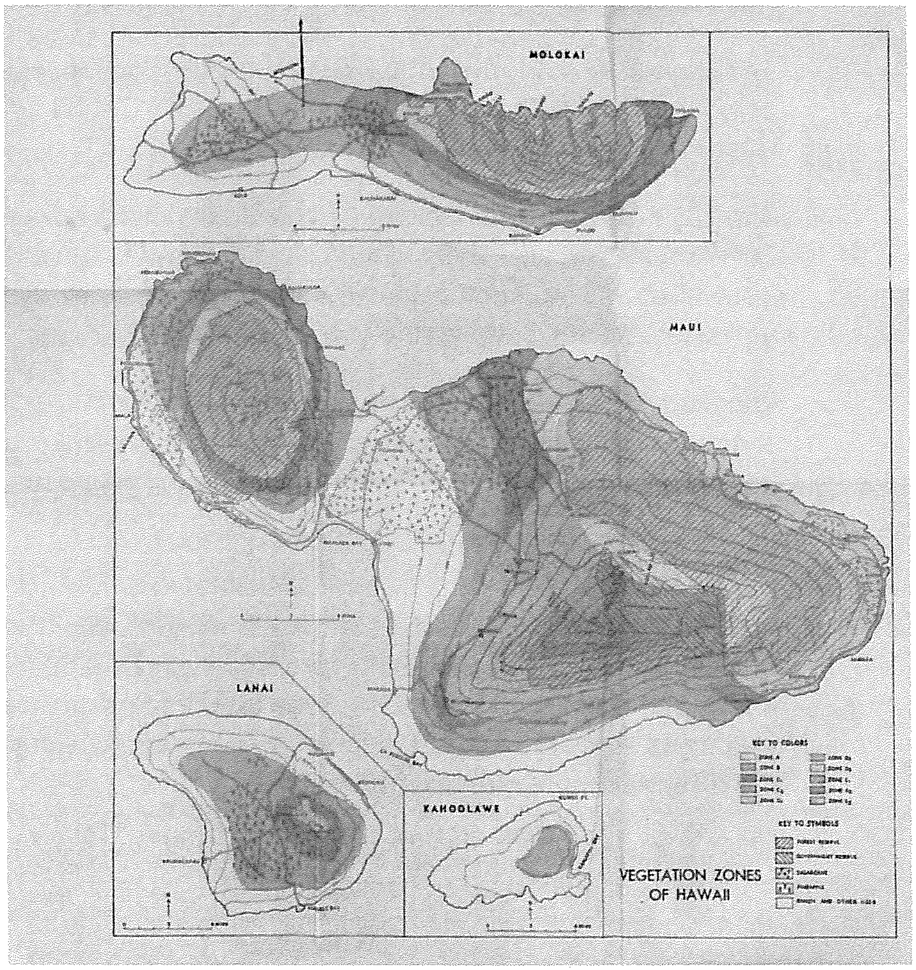
The 2019 Update refers to "water demand" as "water use as measured at the farm's boundary or water meter", before subtracting system losses and non-irrigation uses. 2019 Update at 168. It does so because this is the amount of water that needs to be allocated to the user. KLMC agrees with this definition.

DOA reviewed 8 different studies of water use for various dates between 1953 and 2011 (the "**Historical Studies**") in an attempt to get a handle on average and maximum water requirements (on a monthly or daily basis). In addition, in 2014, it conducted research on 113 farms and engaged informal discussions with other farmers, ranchers, system managers and other stakeholders (the "**Farmer Survey**"). See 2019 Update, at 170-190. DOA also acknowledged (by conducting its analysis differently) that the average recommended water demand determined by the 2004 Update, was flawed. 2019 Update at 2019. Nevertheless, DOA included this study among those that it examined to determine an agricultural water demand planning rate ("**AWDPR**") for diversified agriculture (for acreage that is 50% or 100% planted) and irrigated pastures(assuming acreage that is 100% planted), as shown in its Table 130. Id., at 194.

While the main takeaway from this is that the results of these studies provide data with extremely wide variations, KLMC makes the following specific comments:

1. Ripperton and Hosaka Vegetation Zones ("R&H Zones")

The R&H Zones for each island are based on elevation, climate, soil and vegetation and are separated into 5 categories. The map for Maui is reproduced below:



2019 Update, at 176. The agricultural lands of West Maui that would likely be serviced by the Honokohau Ditch are included in either Zone A or Zone B, which are the two most arid zones. The DOA and CWRM (and the 2019 Update) should take this fact into account in determining site specific water allocations for farms in this area. The KLMC Farming Operations are primarily conducted in Zone A.

Each of the Historical Studies are problematic when applied more broadly to farms in arid regions that require water, particularly those in Zone A.

- The 1956 and 1959 Historical Studies examined by DOA relate to the Waimānalo Irrigation System, which is on the windward side of Oahu and includes lands primarily in Zones C and D. Because these areas can expect much more natural rainfall than occurs in Zones A and B, the lower reported water demands of these studies should be irrelevant when examining water demand rates for West Maui.

- While the reported water demand for the Kailau and Kāne`ohe farms in 1953 is higher than Waimānalo, those farms are likewise in Zones C and D.

- Kahuku Farms, at the northernmost point of Oahu, is primarily in Zone B.
- The sugarcane study from 1995 examined the irrigation requirements for acrop that is no longer grown anywhere in Hawai'i, and thus shouldn't be relevant (despite the higher water demand rates).
- The 1999 study of water demand in the vicinity of the Lower Hāmākua Ditch, on the windward side of the Island of Hawai'i, deals with lands that are entirely within Zone D. How this study can have any relevance to agriculture on the leeward side of Maui is unknown.
- The study of average water demand undertaken for the 2004 Update examined farms in the Lālamilo area, served by the Waimea IrrigationSystem near the town of Waimea on the Island of Hawai'i. This area appears to be in Zone C. Again, higher elevations and more rainfall.
- The 2011 study relative to Upper Kula Farms and Lower Kula Farms, relates to lands in Zone C (with possibly some in Zone B) for Lower Kula, and Zones C or E for Upper Kula. Even with drought, the higher elevations suggest that water demands will not be as high because of significantly lower average temperatures.

While it is possible for drought conditions to exist even at higher elevations during unusual weather, based on the foregoing, it appears that DOA'sreliance on past studies, at least as they pertain to water demand in drier parts of the islands, is misplaced.

Response: *The water demand rate included farm responses throughout the state. An acknowledgment of drier areas is made through the inclusion of planning rate for drought and dry areas. The 2019 Update improves on the demand rate provided in the 2004 AWUDP. It is anticipated that future versions of the AWUDP will provide additional refinement of the water demand at the farm meter.*

IWREDSS Model

DOA also has taken into account the Irrigation Water Requirement Estimation Decision Support System ("**IWREDSS**"), which is "an Arc-GIS-based numerical simulation model", developed for CWRM by Ali Fares, Ph.D. ("**Dr. Fares**"), who is a Professor of Water Security at Prairie View A&M University,in Prairie View, TX. See 2019 Update, at 184. CWRM has been relying on the IWREDSS model to estimate irrigation requirements for individual farmers seeking allocated water. These requirements are determined based on an 80 percent rainfall frequency (drought rate of one in five years). Id., at 185.

No data is provided in the 2019 Update relative to the IWREDSS model, so it is not possible to ascertain whether any data from the model was used to arrive at DOA's AWDPRs, though it does not appear from the narrative that the

IWREDSS model was incorporated into the numbers. However, it appears that CWRM's water allocation method in effect assumes crop failure every fifth year, at least with respect to a portion of the farmer's crop. For certain types of crops, such as coffee, macadamia nuts or bananas, that rely on planted trees that take years to reach maturity, the prospect of having insufficient water and losing mature, fruit-bearing trees would have a profound impact on the profitability of the farm. No mention is made in the 2019 Update about this consideration and KLMC is concerned that over reliance on the IWREDSS model would result in under-allocation of irrigation water to farms that are particularly at economic risk for drought.

Response: *IWREDSS modeling is a tool provided by CWRM, and was not included in the calculation of rates in the 2019 Update. Instead, the water demand rates in the AWUDP Update are based on past studies and farm survey data. The water demand rates are intended as a planning tool for farmers to consider in conjunction with their own farm-specific knowledge.*

2. 2014 Farmer Survey

The final information that DOA considered in its determination of AWDPR is the data it collected from its Farmer Survey. KLMC believes that this information may be more relevant to agriculture in West Maui because it at least included some feedback relative to farms in R&H Zones A and B. However, as stated above, most Kula farms are in Zone C or above, which would account for the lower average water usage there (far outside the water demand ranges of the Keāhole, Moloka'i and Mililani areas also reported for R&H Zones A or B, but some farms surveyed could be in Zone C or higher in Moloka'i and Mililani depending on the farms selected). See, 2019 Update, Table 129, at 189.

Regardless of foregoing and the reliability of the numbers presented, the data presented does show that the average water needs of farmers is significantly higher in the dry season that the wet season. 2019 Update, Table 127, at 188. One would expect farms in dry areas such as R&H Zones A or B to require the dry season amounts for most of the year, since those areas are not augmented with much rainfall even during the wet season. For Maui, however, since only farms in Kula were considered for the formal portion of the Farmer Survey, the numbers presented in Table 127 are significantly understated relative to what the actual experience would be in West Maui where the KLMC Farming Operations are located.

Response: *Comment noted. Table 127 reflects the water demand on the farms surveyed and assisted in the development of the water demand rates. It should be noted farms in the Keahole area of Hawaii Island were included in the survey and in an area designated as Zone A.*

3. Recommended AWDPRs

All in all, KLMC does not find the methodology used to develop the AWDPRs to be persuasive and believes that the actual planning rates should be significantly higher, particularly relative to farms in R&H Zones A or B, such as those in West Maui.

- The numbers used to compute averages is highly dependent on the location of the farms selected. Thus, it cannot be said (2019 Update, at 188) that "[t]he dry season monthly averages range from 161,500 to 442,800 gallons per acre for most of the state, excluding Kaua'i". The Kaua'i farms chosen were in R&H Zone C, which would naturally translate to lower water demand. If farms had been chosen in different zones, water demand would likely have approximated needs for farms elsewhere in the state for those same zones. It would have made more sense for DOA to collect data by zone and compute averages for each zone rather than lumping them all together.

- The data presented does not discriminate by type of crop. It is also suspected that many of the farms surveyed are small, without extensive irrigation systems, although this is unknown. This could skew the results when compared with larger commercial operations.

- While rainfall numbers are presented, it would make sense to adjust those numbers for the average temperature at the chosen locations, since obviously hotter areas need more irrigation waterthan cooler ones.

- The DOA appears to have simply averaged the results from the Farmer Survey, the Historical Studies and metered results from farms in the Kunia O'ahu area, which are in R&H Zones B or C. Based on this, DOA arrives at an average of 3,946 gpd/acre, based on 50% planted area, and rounded this down to 3,900 gpd/acre to establish its AWDPR, and did the same for dry season usage rates to establish an AWDPR for drought conditions of 8,100 gpd/acre. These amounts are doubled for farm acreage that is 100% planted. 2019 Update, at 190-194. Because of the problems outlined above with respect to the numbers input, KLMC believes that theAWDPR amount is unreliable.

- The DOA does acknowledge that "it should be noted that for dry periods throughout the year or during drought conditions, water demand is higher to account for the lack of rainfall". 2019 Update, at 182. This is clearly the case for agricultural land in Zone A. Also, the DOA concedes that "water use varies by many factors, and a one-size-fits-all approach should not be applied in every agricultural endeavor". Id., at 193. With that in mind, we think it is error to take an "average" and use it as a starting point, where the average includes many dissimilar farms and climates.

- This discussion says that it does not apply to "gentleman farms". It is unclear what DOA means by this term or what would be included or not included when specific farms are examined, but it clearly cannot apply to the KLMC Farming Operations, which are among the largest on Maui, notwithstanding that some of the farms exists on Ag Lots owned by third parties.

Response: The water demand planning rates are a tool for planning purposes and do not replace an individual farmer's knowledge of their water needs. The 2019 Update improves on the demand rate provided in the 2004 AWUDP. It is anticipated that future versions of the AWUDP will provide additional refinement of the water demand at the farm meter.

B. Water Demand for Specific Crops

The DOA in Chapter 7 of the 2019 Update attempts to establish water demand rates for specific crops by relying on the 2004 Update's water use guidelines (which asstated above) were based on data taken from a single area on the Island of Hawaii (see 2004 Update, at 159-162). While this data may have relevance to farms with similar topography, soil, rainfall and average temperature, it has little relevance to Diversified Agriculture in dry areas such as West Maui. Moreover, as respects the KLMC Farming Operations, which emphasize coffee production, no data is presented for coffee at all. 2019 Update, at 196.

Likewise, when comparing the 2004 Update's numbers to the Farmer Survey amounts, on a per crop basis, no indication is made as to the location of each farm whose numbers are incorporated into the data for any particular crop. This makes the use of thisdata for a real assessment of irrigation needs for individual crops highly suspect. Id.

Conversely, KLMC acknowledges and does not disagree with DOA's general analysis of environmental factors, although we find the comments concerning what may occur with the availability of food supplies from other parts of the world to be quite speculative. See 2019 Update, at 197-203. In particular, the DOA points out that during "zero (0) rainfall events, irrigation water must supply the total water need for the crop". 2019 Update, at 198. While this may seem obvious, it is a normal condition in the arid but fertile leeward areas of the islands, such as West Maui, which can go for months without rain at lower elevations. In addition, we agree with DOA's statement that "for all crops, evenly distributed water supply (rainfall or irrigation) is conducive to optimal growth". Id. This supports, among other things, the notion that backup irrigation sources are important to agricultural success. So, DOA concludes that "[i]f agriculture is to survive, the availability of agricultural commodities in the market needs to be dependable. In addition, if the State's policies continue to trend toward sustainability and food security, the importance of available water during drought conditions is even more critical." Id., at 200.

C. Support for Agriculture in the Law

KLMC has no specific comments at this time on the general discussion of the current legal framework provided by DOA. See 2019 Update at 207-219. With respect to the status of agriculture, and water for agriculture, under the laws of Hawai'i, however, KLMC cites the following relevant laws and decisions:

- The state water resources trust as articulated by the Hawai'i Supreme Court "embodies a dual mandate of 1) protection and 2) maximum reasonable and beneficial use." *In re Water Use Permit Applications*, 94Hawai'i 97, 139, 9 P.3d 409, 451 (2000) (hereinafter "***Waiahole I***").

- Per Haw. Rev. Stat. § 174C-2:

  "The state water code shall be liberally interpreted to obtain **maximum beneficial use** of the waters of the State for purposes such as domestic uses, aquaculture uses, **irrigation and other agricultural uses**, power development, and commercial and industrial uses." (Emphasis added).

- Article XI, § 3 of the Hawai'i State Constitution provides:

  "**The State shall conserve and protect agricultural lands, promote diversified agriculture, increase agricultural self-sufficiency and assure the availability of agriculturally suitable lands.** The legislature shall provide standards and criteria to accomplish the foregoing." (Emphasis added).

- "The people of Hawaii have a substantial interest in the health and sustainability of agriculture as an industry in the State." HRS § 205-41.

- "[T]he state water resources trust acknowledges that private use for 'economic development' may produce important public benefits and that such benefits must figure into any balancing of competing interests in water[.]" Waiahole I, 94 Hawai'i at 138, 9 P.3d at 450.

- In Waiahole I, the Hawai'i Supreme Court agreed with CWRM that, "as a general matter, water use for diversified agriculture on land zoned for agriculture is consistent with the public interest." Waiahole I, 94 Hawai'i at 162, 9 P.3d at 474. "**Such use fulfills state policies in favor of**

reasonable and beneficial water use, diversified agriculture, conservation of agricultural lands, and increased self-sufficiency of this state." Id. (citing Haw. Const. art. XI, §§ 1 & 3; HRS § 174C-2(c)) (emphasis added). "The public has a definite interest in the development and use of water resources for various reasonable and beneficial public and private off stream purposes, including agriculture[.] Id.at 141, 9 P.3d at453.

Given the foregoing policy pronouncements in the State Constitution, its statutes and the seminal Supreme Court case on the subject, it is clear that there is recognition of the importance of agriculture and irrigation water to the state and that such uses are in the public interest. While the Supreme Court declined to include agriculture among the uses protected by it in articulating the "public trustdoctrine" for water, it is clear that it nevertheless recognized agriculture as an important use for water and that it recognized many of the same benefits of Diversified Agriculture that we identify in this testimony.

It is incumbent on DOA and CWRM to recognize and promote agricultural irrigation water consistent with these constitutional, statutory and judicial pronouncements and to recognize the allocation of water for this purpose is in the public interest and serves compelling policy goals that have been articulated by state, county and local governments. Nowhere are these interests better served than to utilize these goals to support the expansion of Diversified Agriculture in West Maui and to provide the irrigation water necessary to do so.

Response: These comments are included in an Appendix to the Revision.

D. Characteristics of West Maui and Factors Affecting Demand

As stated above, almost all of the agricultural land in West Maui that can be served by the Honokohau Ditch system lies within R&H Zones A or B, meaning that it is drier and hotter than average and needs a reliable supply of irrigation water. (The KLMC Farming Operations lie primarily in Zone A.) It has a materially different climate than the Kula farms surveyed by DOA to model water needs on Maui. The lion's share of such West Maui land is Prime under the ALISH grading system and rests in LCC soil capability classes I, II or III. While that area has not been classified as IAL, it is clearly important agricultural land and could deserve such a classification. It is an area where, with proper policies and government support, the state could help realize its goals for diversified agriculture.

Response: These comments are included in an Appendix to the Revision.

E. Recommended Agricultural Forecast

Chapter 8 of the 2019 Update attempts to forecast agricultural water demand going forward 5 and 20 years from the 2015 baseline date. While KLMC does not have data on how the 2020 results have come out, it is possible that they are materially lower than the forecast. In any event, the 2019 Update's forecast should not be relied upon because:

- the determination of the average water demand rate of 3,400 gpd/acre was flawed (this same number was used by DOA in its land-based model and thus it is also wrong),
- forecasts of population growth made as a basis for planning have proved to be overstated, and;
- changed circumstances during the past year due to the economic devastation caused by the COVID-19 pandemic will likely push the timeline for most investments forward by many years.

DOA admits that "the correlation of land area to water demand is also complicated by the assumption that all crops have the same water demand". 2019 Update,at 227. It also states that "[e]ach agricultural water system will have a water demand rate based on the climate, soil, crop diversity and farming techniques used by the individual farmer". Id., at 229. So, relying on any state or even island-wise average, when so many variables play into actual water demand, is speculative, and won't be useful for farm areas that are not "average".

The citation to a Mink and Yuen study of farmers in Kula is instructive in that the study confirmed the obvious, that farmers would grow more crops and expect better yields if they had more water. 2019 Update, at 233. KLMC argues above that it would also do the same.

The linear regression analysis presented also raises a few questions that should be reexamined by DOA in order to ensure that the output can be relied upon for planning purposes:

- It is not clear that the value data provided in Table 137 is in real dollars and if not, then the values in the later years will be overstated compared to the earlier ones and the assumed growth rate in terms of water demand would thus also be overstated.
- Also the high trend line for the 1997-2012 dataset does not seem from our perspective to have enough data points to suggest that the trend line should continue at the same growth rate going forward. There are many reasons that the growth rate between 2007 and 2012, for example, showed a rapid increase, since the amount of Diversified Agriculture started at a very low number in 1997. This could be due to a number of one-time or short-term events, such as the rapid rise and then moderation of the seed corn industry. In fact, we already know that this trend line is wrong because the value of farm industry output fell 15% to $564 million in 2017 from the 2012 amount. Gomes, "Big Shifts Hit Hawaii Farm

Landscape", supra. All of this leads to DOA assuming an average growth rate going forward (from 2015) of 0.6% per year. While KLMC thinks that such a growth ratemay be achievable if adequate water is made available, it does not fall naturally from the numbers presented.

The agricultural land use tables presented on pages 234-236 of the 2019 Update suffer from the fact that the year that these numbers represent is not stated. For West Maui, it unknown how DOA obtained a cultivated acreage amount of 6,320 acres, since KLMC believes that it has been over 20 years since that much acreage was cultivated inWest Maui. If that is true for the other areas as well, the number of cultivated acres is overstated and the number of available acres is understated. Regardless, using numbers that old for the purpose of making a forecast projecting trends from the present is problematic.

Finally, the 2019 Update arrives at a recommended forecast of water demand based on three different scenarios for capital investment and maintenance of water systems: "1) no action, 2) maintained water systems, and 3) large capital investment." Id.,at 236. While DOA used an assumed demand rate of 3,400 gpd/acre for the land-based model, it used the numbers derived from its recommended AWDPRs derived earlier in the report (7,800 gpd/acre for field crops and 3,900 gpd/acre for diversified crops, assuming crop rotation and a 50% system loss) for this forecast. It uses its assumed 0.6% annual agricultural growth rate. Id.

We have discussed above why these amounts cannot be used for crops that, because of climate, husbandry or other factors, do not fit neatly within these averages. Infact, the DOA acknowledges that the "forecasts provide a guide to water demand, as the actual demand varies based on farmer practices, soil type, crop type, intensification, diversity, climate, politics, transportation costs, fuel and energy costs, market variability, consumer demand, etc." – a lot of variables. Id., at 241. Also, "[u]nfortunately, a lack of agricultural statistics hampers the development of an accurate baseline for agricultural water demand in 2015". Id., at 236.

So, while the three scenarios show a difference in the forecast trends that might be recognized by common sense, the actual numbers are so speculative that they should not be used for planning purposes. Also, while some areas may need substantial new investment to grow, other areas have significant available land to grow Diversified Agriculture with existing systems, ongoing maintenance and possibly some incremental investment to improve storage and distribution infrastructure. The Honokohau Ditch would fall into this latter category. The 2019 Update should include a reassessment of systems like Honokohau Ditch consistent with their value for serving the state's goals for Diversified Agriculture.

Response: These comments are included in an Appendix to the Revision. The forecast supports the development of more water infrastructure to increase agricultural production. It is based on enabling the individual system owners/operators to determine their role and funding in the development of agriculture (including water) in the state and to determine how best they will meet the states goals of food security and sustainability.

2020 DEVELOPMENTS

The 2019 Update was released in December of 2019. Two significant developments have occurred since the release of the report that could have a meaningful impact on the report's conclusions. Given the importance of these developments, the 2019 Update should be revised with them in mind before being incorporated into the Hawai'i Water Plan.

A. COVID-19

The most obvious development is the emergence and continuation of the COVID-19 pandemic. COVID-19 has caused untold health crises, economic devastation and personal suffering to people all over the United States and across the world. Hawai'i, given its dependence on the tourism industry, has been among the hardest hit states. In October, 2020, Hawai'i had the nation's highest unemployment rate, at 14.3%. See U.S. Bureau of Labor Statistics Economic News Release, USDL-20-2132, November 20, 2020, available at: https://www.bls.gov/news.release/laus.nr0.htm. See also, HNN Staff, "Hawaii's unemployment rate highest in the nation for second month", HawaiiNewsNow,November 20, 2020, which can be found at: https://www.hawaiinewsnow.com/2020/11/20/hawaiis-unemployment-rate-highest-nation-second- consecutive-month/. On Maui, the news is even worse, with a rate of 22.5% in October. Id.

While the state has recently relaxed its travel restrictions in order to attempt to revive the dormant hospitality sector, it will still take many years for Hawaii's economy to return to the level enjoyed in 2019. This is even more true for Maui, which is more dependent on tourism than the other islands. Based on 3rd quarter 2020 numbers, civilian unemployment for the State was 13.9%, but this number is overly optimistic, because thelabor force also contracted by 5.1% from the year-ago quarter. See, Hawaii Department of Business, Economic Development and Tourism ("**DBEDT**"), Quarterly Statistical & Economic Report, Executive Summary, 4th Quarter 2020 ("**DBEDT 4Q Summary**"), at
3-5, 12, available at https://files.hawaii.gov/dbedt/economic/data_reports/qser/qser-2020q4-es.pdf. If it is assumed that the civilian labor force had stayed constant, adjusted only for the percentage change in the population for 2020 (-0.1%), the actual unemployment rate would be approximately 18.2%. On Maui, the civilian labor force contracted by 7.0% over the same period, so if it is assumed that the civilian labor force only changed by the estimated change in the population (0.48%), then the actual unemployment rate of Maui would be approximately 27.1%.

State and County tax receipts overall were down dramatically in 2020, although income tax receipts were up mostly because of payment of 2019 taxes and 2020 estimated taxes based on prior years' income. See DBEDT 4Q Summary, at 3. Given the severe reduction in business activity, it should be expected that income taxes collected in2021 will be significantly below the 2020 amounts, while other types of taxes will experience a modest rebound in line with slowly improving economic conditions. While the GDP for the entire country is projected to decrease by 3.7% for 2020, and increase by4.0% in 2021, in Hawaii the 2020 GDP decrease is expected to be 11.2%

and only increase by 2.1% in 2021. Id., at 5. It will take until 2025, at least, for the economy to recover to 2019 levels in terms of employment and GDP. As a consequence, with tax revenues down and the government needing to redeploy assets to COVID relief, the governor is looking to make substantial budget cuts, of $600 million in 2021, asking state departments to trim budget between 10-20%. See HNN Staff, "Gov. Ige looks to trim
$600 million from state's budget", HawaiiNewsNow, November 30, 2020, available at https://www.hawaiinewsnow.com/2020/11/30/gov-ige-seeking-trim-million-fro-states-budget/.

Therefore, the State should look to spend dollars on agricultural water projects that provide the best cost/benefit profile. This would suggest that major new projects be deferred and emphasis be placed on rehabilitating existing systems, particularly those, like the Honokohau Ditch system where (1) there is the prospect of significant additional acreage, (2) the system is largely functional, (3) the system includes significant portions on private lands, and (4) water diversions through the system can be increased consistent with state priorities. The 2019 Update does not do this and any reexamination of projects with a view toward prioritizing should favor Diversified Agriculture and provide the most water for irrigation of agricultural lands possible.

B. Possible Extension of Aquifers Below the Ocean Floor

In November 2020, scientists associated with the University of Hawaii at Manoa, Frontier Geosciences, Universiti Malaysia Terengganu, and the Scripps Institution of Oceanography, University of California at San Diego, published a research paper that suggests that conventional hydrogeologic model for onshore aquifers may be missing significant pools of fresh water in nearshore and offshore formations. See, Attias, Thomas, Sherman, Ismail and Constable, "Marine electrical imaging reveals novel freshwater transport mechanism in Hawai'i", Science Advances, November 25, 2020, which can be found at https://advances.sciencemag.org/content/6/48/eabd4866. While research was done on the nearshore and offshore formations in the vicinity of Hualalai on the Island of Hawai'i, the authors identified five other volcanic islands, including the Island of Maui, that "present hydrogeological layered formations analogous to the submarine multilayer formation" that the authors revealed in the vicinity of Hualalai. Id., at 6. The authors believe that their findings support global-scale applicability to volcanic islands generally.

While this study "reveals a novel mechanism that transports substantial volumes of freshwater from onshore aquifer to deep submarine aquifer offshore", it is new and was confined to one volcanic island. Id. If it is true that substantial amounts of freshwater do exist in nearshore and offshore formations surrounding any of the islands of Hawaii, but particularly in regions where the onshore aquifers have relatively low sustainable yields, this could be a game changer for the future of water in Hawaii, and would support additional transport of surface water for agricultural uses.

Response: The effects of COVID-19 and the evaluation of offshore aquifers are beyond the scope of this 2019 AWUDP Update and its associated Revision.

VIII. CONCLUSION

In its conclusion to the 2019 Update, DOA states that "[a]griculture is an essential component for the state to achieve its goal of sustainability and a diversified economy. The agricultural industry relies on these water systems to deliver inexpensive water to meet and expand agricultural production. ... As the saying goes, ... without water there is no agriculture ... which is the reason these agricultural water systems were originally constructed – and why they need to be maintained for another 100 years." 2019 Update, at 253. KLMC agrees with these statements.

The "public trust doctrine" as articulated by the courts, does not include agriculture as a public trust use, but it should, and the DOA should advocate for this position. At a minimum, there is ample support in the State's Constitution, statutes and policy pronouncements, that support of agriculture is in the public interest and that water resources should be managed for maximum benefit. As stated in the State Water Code:

Per Haw. Rev. Stat. § 174C-2:

> The state water code shall be liberally interpreted to obtain ***maximum beneficial use*** of the waters of the State for purposes such as domestic uses, aquaculture uses, irrigation and other ***agricultural uses***, power development, and commercialand industrial uses. (Emphasis added).

In order to best support the State's stated policy goals of supporting and promoting Diversified Agriculture, DOA and CWRM need to make sure that sufficient water is provided to farmers who need it and that secondary sources are taken into consideration.

The 2019 Update fails to properly assess the Honokohau Ditch system in its current state and has made a number of assertions concerning the ownership, use and condition of the system that are not accurate. The Honokohau Ditch system is the most important source of irrigation water in West Maui. While it isn't the primary system used by KLMC Farming Operations, it constitutes and important secondary source for existing crops and a necessary source to expand operations on additional land. Other landowners in West Maui that own significant agricultural lands, including DHHL, would require irrigation water from the Honokohau Ditch system to grow their footprint of Diversified Agriculture. The 2019 Update needs to be revised to considerthis system and the benefits that can flow from it.

The 2019 Update fails to properly assess the water demands tied to agriculture because the methodology does not use enough data points or take into account the varied factors that would be considered in arriving at reliable water demand numbers at a specific location. Some of the data used is too old to be of use. In particular, use of 80% numbers for drought demand may work in some locations at cooler locations, but would mean significant crop losses at warmer locations. The DOA admits that the numbers don't take much of this into account, but it uses them anyway. The DOA should withdraw the 2019 Update, reexamine the methodology used to determine water demand and adjust it accordingly.

The DOA and CWRM have an opportunity to help revitalize an industry that is important to the State and to local citizens on each island. The Hawaii Water Plan, including the AWUDP component, need to provide for the opportunity to get this done. The benefits of Diversified Agriculture are many, and include:

1. Sustainability
2. Food Security and Self Sufficiency
3. Economic Diversification
4. Job Growth
5. Wildfire Suppression
6. Aesthetic Enhancement

Finally, the 2019 Update should be revised to take into account the profound impact that COVID-19 has imposed on the state and local planning processes. Projects will be deferred or eliminated, and those that are chosen to go forward will inevitably be based on an assessment ofcost versus benefit. The State has already recognized that the promotion and development of Diversified Agriculture, can help solve some of the problems that were exposed as the pandemichas evolved. Moreover, if it is true that the islands of Hawaii have more fresh water aquifer capacity than previously thought, the pressure to divert irrigation water for other purposes couldbe greatly ameliorated. The DOA and CWRM should examine the recent research concerning nearshore and offshore fresh water reservoirs and determine whether to modify their planning criteria based on their conclusions.

Response: Thank you for your review and comments.

Fujimoto, Janice

Subject: FW: [EXTERNAL] Comment for the State Agricultural Water Use and Development Plan

From: Tim Little <tim.e.little@gmail.com>
Sent: Friday, December 4, 2020 6:23 AM
To: DLNR.CW.DLNRCWRM <dlnr.cwrm@hawaii.gov>
Subject: [EXTERNAL] Comment for the State Agricultural Water Use and Development Plan

Regarding: State Agricultural Water Use and Development Plan

Dear Commissioners:

I am writing to request enclosure of the waters of the Lower Hamakua Ditch.

Our family farm is in the Kalopa makai area 3 miles east of Honoka'a town. We rely heavily on the Lower Hamakua Ditch (LHD) for irrigation especially in periods of drought and for water demanding crops. We pay for access to the ditch water but that access has been unreliable. We lost access to water for many months after the heavy flooding in March of 2004 damaged and obstructed the LHD with silt. We lost access again for many months after the October 2006 Kiholo Bay earthquake that damaged intake in the Waipio Valley headwaters.

Almost all the LHD dependent farmers were relieved when FEMA agreed to grant $3.9 million to enclose the LHD water in HDPE piping only to have the grant scuttled through the efforts of a small group of politically connected residential property owners. Fearing for their property values they complained loudly that the fully funded enclosure process would defile the "historic" nature of the ditch. Small farmers were given little or no voice as the project was terminated at the behest of the privileged.

We continue to struggle with heavy silting and failure of our irrigation systems due to contamination of the ditch waters by silt intrusion from its open banks. We have struggled with repeated acts of vandalism which damage our water intake and pump at the open LHD itself which is not within the boundary of our property and causes us to have to haul priming pumps and equipment to the site to prime the lines whenever the area is disturbed.

We worry about crops being contaminated and farmers being exposed to leptospirosis from animal waste and carcasses that fall into the open ditch waters. We are aware that two farmers almost lost their lives to contaminated water exposure on Ohau in 2014.

The silting, the vandalism, the water born disease risk, and the State's heavy maintenance costs of the open ditch could all be mitigated by enclosing as much of the ditch as politically possible in cost effective polyethylene pipe.

We feel like we are at the mercy of a handful of powerful gentry who propagandize the Lower Hamakua Ditch as a residential property enhancement when its primary purpose has been for many generations to support agriculture.

We are asking that the DNLR include the enclosure of the Lower Hamakua Ditch in its development plan through as much of its course as can be reasonably negotiated with all stakeholders. We further point out that federal funds were historically set aside for this purpose and the project derailed by a few local politicians not acting in the best interest of the majority of the public who depend on the existence of this vital resource. This project could almost certainly be successfully funded and completed with a negotiated agreement before hand.

Respectfully,

Tim Little
PO Box 1955
Honoka'a, HI 96727
tim.e.little@gmail.com

JOSH GREEN, M.D.
Governor

SYLVIA LUKE
Lt. Governor

PHYLLIS SHIMABUKURO-GEISER
Chairperson, Board of Agriculture

MORRIS M. ATTA
Deputy to the Chairperson

State of Hawaiʻi
DEPARTMENT OF AGRICULTURE
KA ʻOIHANA MAHIʻAI
1428 South King Street
Honolulu, Hawaii 96814-2512
Phone: (808) 973-9600 FAX: (808) 973-9613

December 6, 2022

Mr. Tim Little
PO Box 1955
Honokaa, Hawaii 96727

Dear Mr. Little:

SUBJECT: Response to Comments Regarding December 2019 Agricultural Water Use and Development Plan Update

The Department of Agriculture (HDOA) appreciates your review and comments to the December 2019 Agricultural Water Use and Development Plan Update (AWUDP). We appreciate your comments and commitment to agriculture.

As you noted in your comments, improvements were planned to enclose a portion of the Lower Hamakua Ditch (LHD) system with pipelines. Unfortunately, the Federal Emergency Management Agency (FEMA) elected to allow the funds to lapse and the project was not completed. HDOA irrigation staff provide ongoing maintenance of the ditch in an effort to keep irrigation water flowing in these areas. The AWUDP Update does identify pipeline retrofit as a proposed Capital Improvement Project for the system.

Thank you again for your comments to the AWUDP Update. Please contact Ms. Janice Fujimoto, Agricultural Resource Management Division, at 808-973-9473 with any questions.

Sincerely,

Phyllis Shimabukuro-Geiser

Phyllis Shimabukuro-Geiser
Chairperson, Board of Agriculture

cc: DLNR, Commission on Water Resource Management