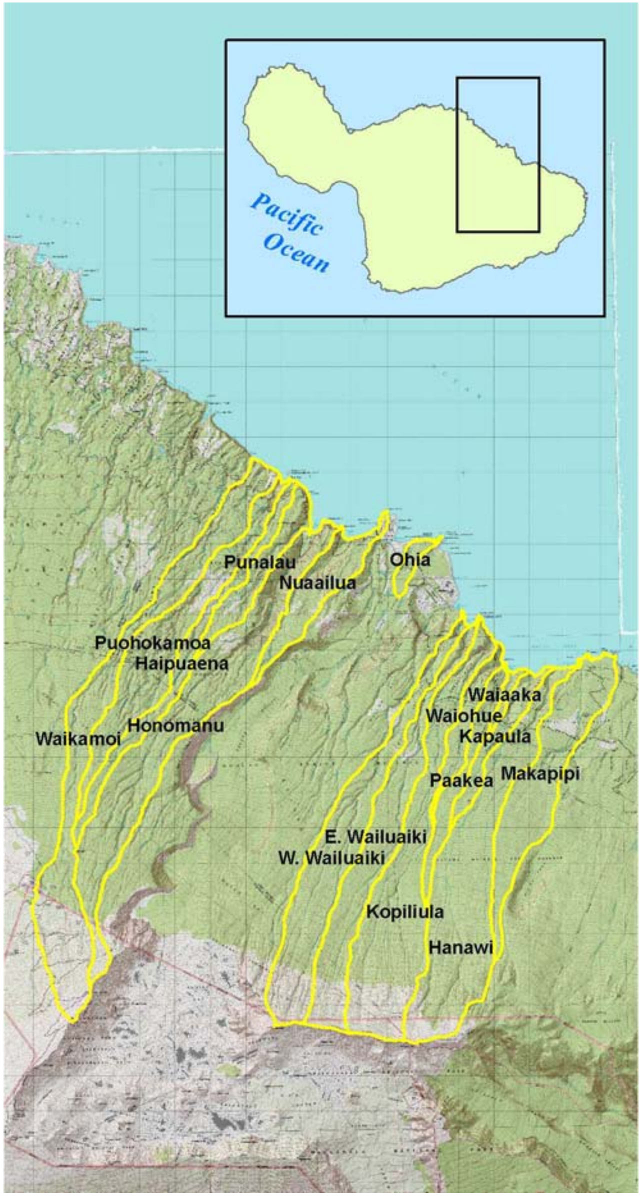
Compilation of Data Submissions

Hydrologic Units:

Waikamoi (6047)
Puohokamoa (6048)
Haipuaena (6049)
Punalau (6050)
Honomanu (6051)
Nuaailua (6052)
Ohia (6054)
West Wailuaiki (6057)
East Wailuaiki (6058)
Kopiliula (6059)
Waiohue (6060)
Paakea (6061)
Waiaaka (6062)
Kapaula (6063)
Hanawi (6064)
Makapipi (6065)



Island of Maui

November 2009
PR-2009-17

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

INTRODUCTION

On January 20, 2009, at the request of the State Department of Agriculture, the staff of the Commission on Water Resource Management (Commission) met with representatives of the Department of Agriculture, Maui Mayor's Office, Maui County Council, Maui Office of Economic Development, Maui Department of Water Supply, Hawaii Farm Bureau Federation, and the Maui County Farm Bureau.

The Commission staff prepared a list of data needs which would aid in assessing noninstream uses related to the surface water hydrologic units of Waikamoi (6047), Puohokamoa (6048), Haipuaena (6049), Punalau (6050), Honomanu (6051), Nuaailua (6052), Ohia (6054), West Wailuaiki (6057), East Wailuaiki (6058), Kopiliula (6059), Waiohue (6060), Paakea (6061), Waiaaka (6062), Kapaula (6063), Hanawi (6064), and Makapipi (6065), Island of Maui.

Additionally, the Department of Agriculture issued a press release on May 22, 2009, urging farmers and ranchers in East Maui to complete and submit an agricultural water information survey being conducted by the Maui County Farm Bureau.

This Compilation of Data Submissions (PR-2009-01) presents all of the information that was submitted and assessed as part of the Commission's Instream Flow Standard Assessment Report preparation for these 16 surface water hydrologic units.

All submissions have been separated into individual sections according to the submitting organization or individual, and the date of submission. Page numbers have also been applied to each original page. Comments were subsequently reduced to 2-per-page to save space and paper. Please contact the Commission to request full-size copies of any documents. Copying charges may apply.

Starting from Section 3.0, comments are listed in the order they were received by the Commission.

TABLE OF CONTENTS

1.0 Commission on Water Resource Management, Data Needs Sheet

Data Needs

Water Use

- Historical trends – may indicate seasonal changes; staff may correlate with annual rainfall trends
- Current use
- Future demands

Water Use Purpose

- Who is using the water? What is water used for?
- If applicable, provide the following:
  - Domestic – geographic area, number of end users
  - Agriculture – number of acres, type of crop, farming practices
  - Livestock – type of animal, number of pastures, farming practices
  - Traditional – number of acres, type of crop, farming practices
  - Hydroelectric – energy capacity, average amount of power generated (per day, month, and/or year), any surplus power sales, revenue generated, users of this power
  - Recreation / ornamental - type of recreation (golf course, landscape, water features), number of acres

Water Requirement

- Minimum water requirement
- Prioritize water use purposes (i.e. if water is used for agriculture, which fields are watered first or any crop changes)

Water Supply

- Sources of water
- Contractual obligations
- Minimum amount of water supplied (i.e. via system) during drought conditions
- Alternate water sources (e.g. recycled water, why/why not?)

Economic Impact

- When water supply drops 25%, 50%, 75%
- Restricting offstream uses

Water Use Efficiency

- Irrigation efficiency
- Ways to decrease water use and water needs
- Past experiences:
  - What has been done to cope with decreasing water supply?
  - During drought conditions, what has been done to decrease water use or needs?
- Future demands:
  - Are there any future plans that would change water use or needs, i.e. changes in farm acreage, capacity of system, urban development, etc…

For more information contact:

Commission on Water Resource Management
Stream Protection and Management Branch
1151 Punchbowl St., Room 227
Honolulu, HI 96813

Phone: (808) 587-0214
Fax: (808) 587-0219
E-mail: dlnr.cwrm@hawaii.gov
Website: http://hawaii.gov/dlnr/cwrm/

Toll free from neighboring islands: (ext is 70214)

Kauai	274-3141 ext.	Hawaii	974-4000 ext.
Maui	984-2100 ext.	Molokai/Lanai	1-800-468-4644 ext.

2.0 Department of Agriculture, May 22, 2009 Press Release

HAWAII DEPARTMENT OF AGRICULTURE

News Release

LINDA LINGLE
GOVERNOR

SANDRA LEE KUNIMOTO, CHAIRPERSON
Phone: (808) 973-9550
Fax: (808) 973-9613

For Immediate Release: May 22, 2009
NR09-06

MAUI FARMERS URGED TO RESPOND TO SURVEY ON WATER USE

HONOLULU — Farmers and ranchers in East Maui County are strongly urged to complete and submit an important survey being conducted by the Maui County Farm Bureau (MCFB) on agricultural water usage and needs in the area. Completion of this survey will provide data which will help to determine water designations that will have a profound affect on agriculture now and for the future.

For several months, the MCFB has been requesting that farmers and ranchers submit agricultural water information to them. MCFB e-mailed a survey to agricultural associations, farmers and ranchers in East Maui County. The information from the survey will help provide information to the Commission on Water Resource Management as it develops policies for instream flow standards as mandated by the State Water Code. These policies will have a direct impact on the amount of water that will be available for agriculture.

All farms and ranches on East Maui receive their water from streams in East Maui. Pertinent information that MCFB is asking for includes:

1) How water is used on your farm
2) If changes have occurred on your farm because of water availability - do you avoid planting during certain periods due to uncertainty of water availability?
3) What practices are done to make best use of water
4) The agricultural value and other values that result from the use of the water
5) If you are planning investments and what your assumptions are on the availability of water
6) What will happen if your access to water was reduced
7) If you have greater assurance of water, will you expand?

"Farming and ranching operations cannot survive without water," said Sandra Lee Kunimoto, Chair-person of the Hawaii Board of Agriculture. "So it is imperative that East Maui farmers and ranchers participate in this survey as the future of agriculture depends on the availability of irrigation water."

The deadline to submit the surveys is May 28. Farmers and ranchers who have not yet submitted their information yet or have questions about the survey, may contact MCFB Executive Director Warren Watanabe at 281-9718.

# # #

3.0 Maui Department of Water Supply, Upcountry Maui Surface Water Requirements

CHARMAINE TAVARES
Mayor

JEFFREY K. ENG
Director
ERIC H. YAMASHIGE, P.E., L.S.
Deputy Director

DEPARTMENT OF WATER SUPPLY
COUNTY OF MAUI
200 SOUTH HIGH STREET
WAILUKU, MAUI, HAWAII 96793-2155
www.mauiwater.org

RECEIVED
09 JAN 2 A9:19
COMMISSION ON WATER RESOURCE MANAGEMENT

December 30, 2008

Ms. Laura H. Thielen, Chairperson
Department of Land and Natural Resources
State of Hawaii
Commission on Water Resource Management
P.O. Box 621
Honolulu, HI 96809

Dear Ms. Thielen:

SUBJECT: UPCOUNTRY MAUI SURFACE WATER REQUIREMENTS

The Department of Water Supply's (DWS) water systems that serve upcountry Maui may be the most unique in the entire state of Hawaii because of their reliance on surface water. In fact, over 90% of upcountry Maui's water source is surface water, and most of the water originates from the East Maui watershed. The pending decisions by the Commission on Water Resource Management (Commission) on interim instream flow standards for the streams of the East Maui watershed give the DWS concern that its surface water needs of upcountry Maui could be severely impacted.

I would like to give you a brief overview of the DWS' three distinct surface water systems in upcountry Maui:

- Upper Kula water system

  The primary water sources for this system are three stream intakes at Haipuaena, Puohokamoa and Waikamoi streams at about the 4200 and 4400 ft. elevations. The water is treated at the DWS Olinda Water Treatment Facility (WTF).

"By Water All Things Find Life"

- Lower Kula water system

  The water sources are seven stream intakes in the Koolau Forest Reserve: West and East Waikamoi streams; West, Middle and East Puohokamoa streams; Haipuaena stream and Honomanu stream at about the 2900 and 3000 ft. elevations. The water is treated at the DWS Piiholo WTF.

- Makawao water system

  The water source is East Maui Irrigation Company's Wailoa Ditch, which originates near Nahiku. The water is treated at the DWS Kamole WTF. Raw water is further transported beyond the Kamole WTF by the Hamakua Ditch to serve the Kula Agricultural Park.

Attached please find data showing average daily surface water requirements going back to year 2000. As you can see, the average day surface water requirement is over 7.5 mgd.

As the Commission continues to consider interim instream flow standards for the East Maui streams, the DWS asks that its municipal and domestic water requirements for upcountry Maui be given appropriate consideration.

Sincerely,

JEFFREY K. ENG
Director

Attachment

xc: Jane Lovell, Deputy Corporation Counsel
Edward S. Kushi, Jr., Deputy Corporation Counsel

Upcountry Water System Surface Water Requirements

	Ave. Day, MGD Calendar Year Olinda WTF	Ave. Day, MGD Calendar Year Piiholo WTF	Ave. Day, MGD Calendar Year Kamole WTF	Ave. Day, MGD Fiscal Year Kula Ag Park Pumps	Ave. Day, MGD Total
2000	1.403	2.653	3.429	0.554	8.039
2001	1.301	2.863	3.024	0.595	7.783
2002	1.371	2.665	2.091	0.602	6.729
2003	1.177	2.967	3.132	0.532	7.808
2004	0.962	2.958	2.947	0.545	7.412
2005	1.268	3.269	2.022	0.681	7.240
2006	1.084	2.998	2.752	0.656	7.490
2007	0.939	2.587	3.741	0.620	7.887
Average	1.188	2.870	2.892	0.598	7.549

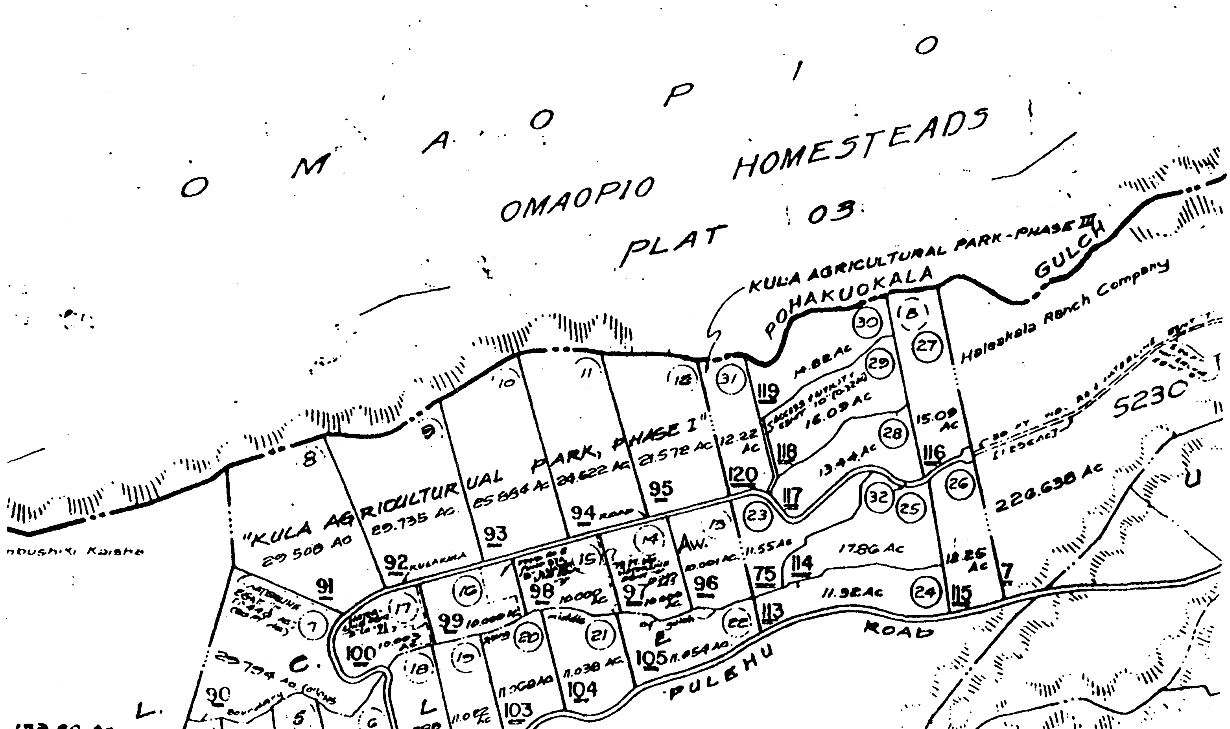
4.0 Maui Office of Economic Development, Kula Agricultural Park

The Kula Agricultural Park

The concept of the Kula Agricultural Park was conceived by the then Mayor Elmer Cravalho. In 1979, Mayor Cravalho proposed to Maui Land and Pineapple Company to acquire by way of land exchange, fee simple title to vacant unimproved land in Kula, containing approximately 326 acres , for the purpose of developing said land as a County agricultural park. The Kula Agricultural Park started construction by the County of Maui in 1982. In 1985, the first lots were leased to farmers. Today, there are 445 acres on 31 lots, farmed by 26 farmers. The lots range from 8 to 29 acres in size. The Office of Economic Development serves as the County's land management entity for the Kula Agricultural Park

The purpose of the Kula Agricultural Park is to promote the development of diversified agriculture by providing appropriately-sized agricultural lots at a reasonable rent and a long-term tenure. The rates are $100 per acre per year with the tenure of the lease being 50 years. All 31 lots are currently leased out to farmers. Crops grown include vegetables (lettuce, tomato, Kula onions , zucchini, cucumbers, bush beans, sweet corn, eggplant, head cabbage, Chinese cabbage, peppers, ginger root) taro, bananas, mango, turf grass, nursery plants, tuberose, plumeria, and landscape plants.

The County of Maui currently has an agreement with Alexander & Baldwin (A&B), through its division of Hawaiian and Commercial & Sugar Company (HC&S) and East Maui Irrigation (EMI) to withdraw up to 1.5 million gallons of water per day from the Hamakua Ditch to provide irrigation water to the Park. The Department of Water Supply withdraws water from the Hamakua Ditch and conveys non-potable water to the Kula Agricultural Park for irrigation of the 445 acres of land.


O M A O P I O
OMAOPIO HOMESTEADS
PLAT 03
KULA AGRICULTURAL PARK-PHASE II
POHAKUOKALA GULCH
Haleakala Ranch Company
523C
"KULA AGRICULTURAL PARK, PHASE I"
29.508 Ac
25.735 Ac
25.884 Ac
24.622 Ac
21.572 Ac
12.22 Ac
14.88 Ac
16.09 Ac
13.44 Ac
15.09 Ac
220.638 Ac
17.86 Ac
12.26 Ac
11.55 Ac
11.32 Ac
10.001 Ac
10.002 Ac
10.000 Ac
11.054 Ac
11.038 Ac
11.060 Ac
11.012 Ac
10.398 Ac
29.734 Ac
153.80 Ac.
PULEHU ROAD
L. C. A W.
Maui Pineapple Co. Ltd.

5.0 Maui Department of Water Supply, Instream Flow Standard Assessment Report Data Needs, Department of Water Supply, County of Maui Perspective

CHARMAINE TAVARES
Mayor

JEFFREY K. ENG
Director

ERIC H. [illegible]E, P.E., L.S.
Deputy Director

DEPARTMENT OF WATER SUPPLY
COUNTY OF MAUI
200 SOUTH HIGH STREET
WAILUKU, MAUI, HAWAII 96793-2155
www.mauiwater.org

RECEIVED
COMMISSION ON WATER
RESOURCE MANAGEMENT
2009 JUN -1 AM 9: 10

May 28, 2009

Mr. Ken Kawahara, Deputy Director
Department Land and Natural Resources, State of Hawaii
Commission on Water Resource Management
P.O. Box 621
Honolulu, Hawaii 96809

Dear Mr. Kawahara:

RE: Instream Flow Standard Assessment Report Data Needs, Department of Water Supply, County of Maui Perspective

Thank you for the opportunity to provide the data needs from the Department of Water Supply, County of Maui perspective regarding the East Maui streams.

You will find enclosed the INSTREAM FLOW STANDARD ASSESSMENT REPORT DATA NEEDS for the Commission on Water Resource Management, Stream Protection and Management Branch provided by the Department of Water Supply, County of Maui, the WATER CREDITS AGREEMENT and the KULA AGRICULTURAL PARK WATER RESERVOIR AGREEMENT.

Should you have any questions, please contact our Water Resources & Planning Division at 244-8550.

Sincerely,

for Jeffrey K. Eng, Director
ayi

Enclosures: INSTREAM FLOW STANDARD ASSESSMENT REPORT DATA NEEDS
WATER CREDITS AGREEMENT
KULA AGRICULTURAL PARK WATER RESERVOIR AGREEMENT

c: Office of Economic Development, Agriculture section, County of Maui
Department of Agriculture, State of Hawaii
Maui County Farm Bureau

"By Water All Things Find Life"

INSTREAM FLOW STANDARD ASSESSMENT REPORT

DATA NEEDS

Prepared for

Commission on Water Resource Management
Stream Protection and Management Division

Department of Water Supply
County of Maui

May 27, 2009

Table of Contents

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List of Tables

INTRODUCTION

This document is prepared in response to a request by the State Commission on Water Resource Management for "Instream Flow Standard Assessment Report Data Needs". Information is provided in the order requested. Therefore, a general system description appears later in this document, in the section responding to questions on water supply and sources of water. The three figures that follow are intended to help orient the reader at the outset:

- Figure 1 Community Plan Districts on the island of Maui.
- Figure 2 The County of Maui Department of Water Supply's "Upcountry System" or "Upcountry Water District", showing five distinct sub-district areas, each served by a slightly different set of sources and waterlines during normal operating conditions.
- Figure 3 The Upcountry Water District overlaid on the Makawao-Pukalani-Kula and Paia-Haiku Community Plan boundaries.

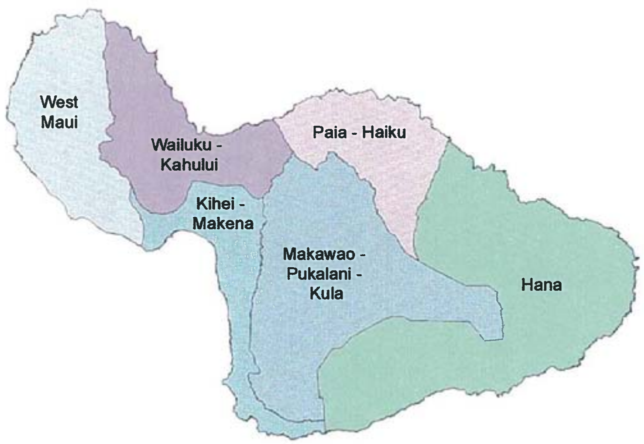


Figure 1 Community Plan Boundaries - Maui Island

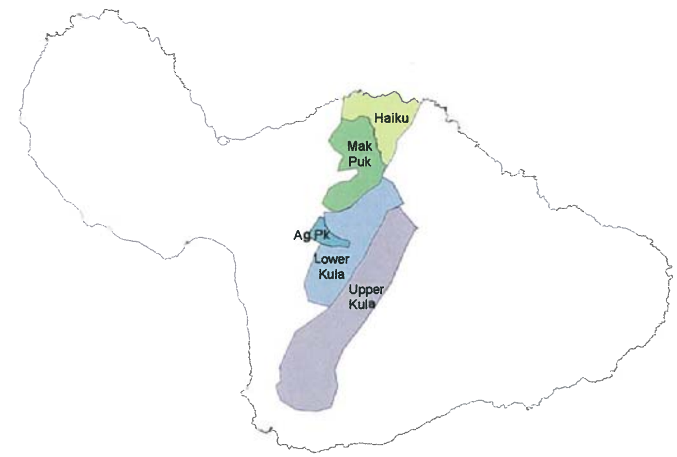


Figure 2 County of Maui Department of Water Supply - Upcountry Water District - Normal Operating Conditions

The "Upcountry Water District" may be operationally divided into five, or technically six sub-systems:

- Upper Kula (including Ulupalakua-Kanaio) - (shown in purple)
- Lower Kula (shown in blue)
- Makawao-Pukalani - (shown in green)
- Haiku-Kokomo - (shown in lime)
- Kula Ag Park - (shown in teal)
  (non-potable system, not connected to the other sub-systems)
- Opana/Awalau - (not shown - too small to show separately)
  (non-potable, not connected to other systems, serves only 4 meters)

These are described further in the section of this document pertaining to water supply and sources. The potable Upcountry systems are interconnected and rely on each other for backup. During dry seasons or droughts, water is frequently pumped from the lower systems to the upper. Similarly, during wet times, water may flow from higher service areas to lower. This is cost-effective, and also necessary. Lower pumping expense during wet seasons enables the Department to have the funds for uphill pumping during dry months, which would otherwise be cost-prohibitive. Surface water sources can also provide backup to areas normally served by groundwater during repairs or maintenance.

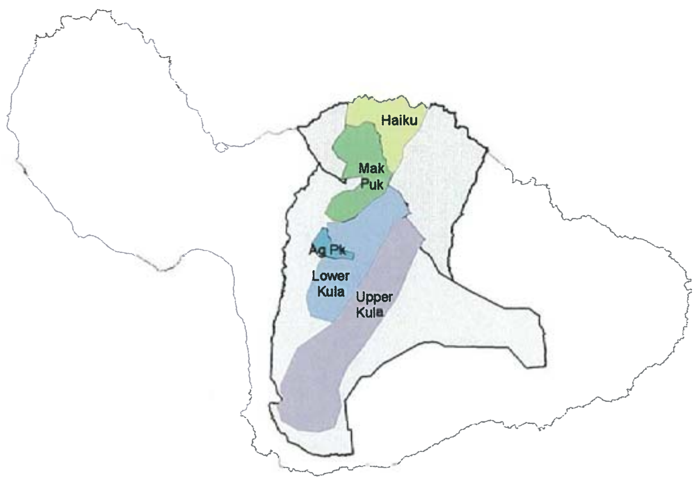


Figure 3 Upcountry Water District overlaid on Makawao-Pukalani-Kula and Paia-Haiku Community Plan District Boundaries

As shown in Figure 3 above, there is not a perfect one-to-one match between the Upcountry Water District or subdistricts and the Makawao-Pukalani-Kula or Paia-Haiku Community Plan District boundaries. Community Plan boundaries are political divisions used for land use planning. They do not shift with new source development or seasonal needs. Water Districts are areas which typically share a set of sources and transmission facilities. Their boundaries are determined by water sources and operational parameters. So it is not surprising that these would not match perfectly.

WATER USE

Historical trends

DWS historical water use is documented and characterized in various tables below:

- Figure 4 shows the historical metered consumption by the DWS Upcountry District (Makawao, Hali'imaile, Pukalani, Kula and Haiku).
- Figure 5 shows the historical metered consumption for the Makawao-Pukalani-Kula Community Plan District (Makawao, Hali'imaile, Pukalani and Kula).
- Figure 6 shows the historical metered consumption for the Haiku portion of the Paia-Haiku Community Plan District
- Figure 7 shows seasonal variation in consumption in the Makawao-Pukalani-Kula Community Plan District
- Figure 8 shows seasonal variation in consumption in the Paia-Haiku Community Plan District
- Figure 9 shows the historical water use by user class codes for the Makawao-Pukalani-Kula Community Plan District
- Figure 10 shows the historical water use by user class codes for the Haiku portion of the Paia-Haiku Community Plan District
- Figure 11 shows historical annual rainfalls for specified locations.

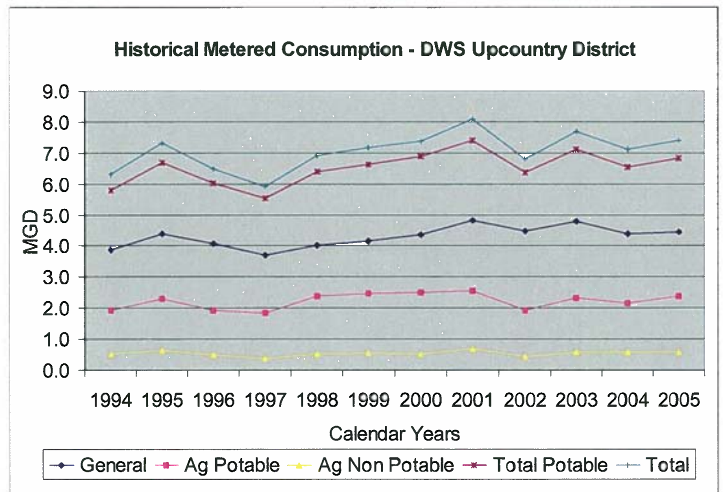


Figure 4 Historical Metered Consumption - Upcountry District

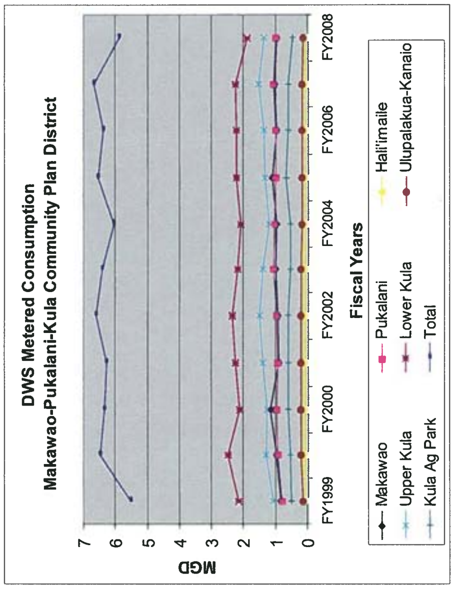


Figure 5 DWS Metered Consumption - Makawao-Pukalani-Kula

Historical metered consumption for the Makawao-Pukalani-Kula Community Plan District averaged about 6.286 MGD for the period shown. For FY 2008, average daily consumption was 5.89 MGD. Lower Kula dominates water consumption in this community plan district. Historical metered consumption for Haiku averages about 0.952 MGD for the period shown. For FY 2008, average daily consumption in the Haiku portion of the Paia-Haiku Community Plan was 1.075.

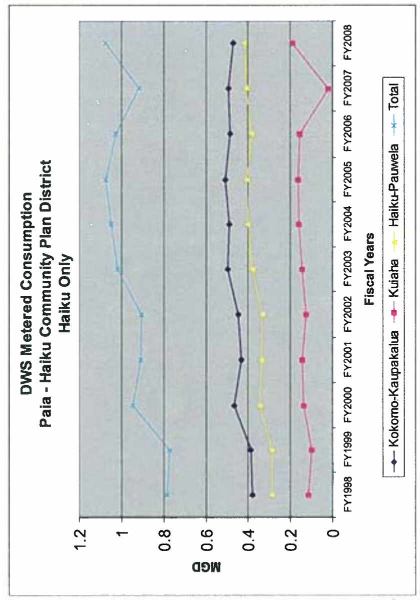


Figure 6 DWS Metered Consumption - Haiku

Table 1 **Historical Metered Consumption for DWS Upcountry District (Makawao-Hali'imaile-Pukalani-Kula-Haiku)**

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
General	3.871	4.382	4.083	3.693	4.003	4.146	4.370	4.823	4.461	4.778	4.387	4.441
Ag Potable	1.931	2.300	1.923	1.829	2.382	2.474	2.504	2.563	1.908	2.320	2.138	2.378
Ag Non Potable	0.504	0.634	0.481	0.374	0.512	0.555	0.505	0.690	0.433	0.582	0.575	0.571
Total Potable	5.802	6.682	6.007	5.521	6.381	6.620	6.873	7.387	6.368	7.098	6.525	6.820
Total	6.306	7.317	6.487	5.895	6.897	7.175	7.379	8.077	6.801	7.680	7.100	7.391

Table 2 DWS Upcountry - Metered Consumption by Community Plan

DWS Metered Consumption by Makawao-Pukalani-Kula Community Plan District											
	FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	FY2006	FY2007	FY2008
Makawao	0.831	0.951	1.152	0.880	0.920	0.979	0.955	1.090	0.953	1.013	0.957
Pukalani	0.784	0.940	0.961	0.913	0.957	1.051	1.015	0.994	0.998	1.070	1.006
Hali'imaile	0.087	0.100	0.102	0.096	0.091	0.098	0.105	0.108	0.106	0.087	0.094
Upper Kula	1.050	1.289	1.256	1.380	1.497	1.383	1.205	1.337	1.344	1.515	1.348
Lower Kula	2.136	2.487	2.110	2.255	2.353	2.181	2.078	2.208	2.217	2.230	1.868
Ulupalakua-Kanaio	0.148	0.184	0.188	0.188	0.198	0.190	0.151	0.157	0.166	0.157	0.144
Kula Ag Park	0.479	0.516	0.580	0.578	0.585	0.529	0.527	0.647	0.605	0.585	0.473
Total	5.515	6.467	6.349	6.290	6.601	6.411	6.036	6.541	6.389	6.657	5.890

DWS Metered Consumption for Haiku											
	FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	FY2006	FY2007	FY2008
Kokomo-Kaupakalua	0.380	0.385	0.465	0.431	0.446	0.496	0.488	0.507	0.483	0.491	0.470
Kuiaha	0.115	0.099	0.137	0.142	0.125	0.145	0.159	0.163	0.157	0.017	0.189
Haiku-Pauwela	0.287	0.289	0.345	0.337	0.334	0.378	0.402	0.404	0.384	0.409	0.416
Total	0.782	0.773	0.947	0.910	0.905	1.019	1.049	1.074	1.024	0.917	1.075
Total (including Haiku)	6.297	7.240	7.296	7.200	7.506	7.430	7.085	7.615	7.413	7.574	6.965

Figures 7 and 8 and Table 3 show water use from 2002 to 2006 by user class. Single Family and Agricultural uses account for the lion's share of consumption in these areas. Both areas demonstrate a strong seasonal variation in consumption, particularly in these two classes.

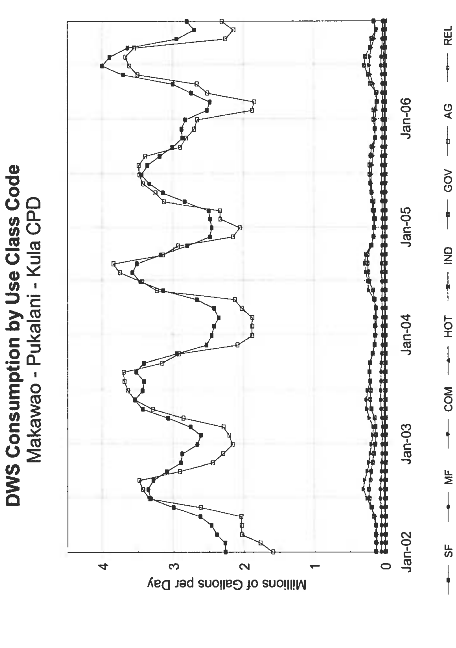


Figure 7 Makawao-Pukalani-Kula Consumption by User Class

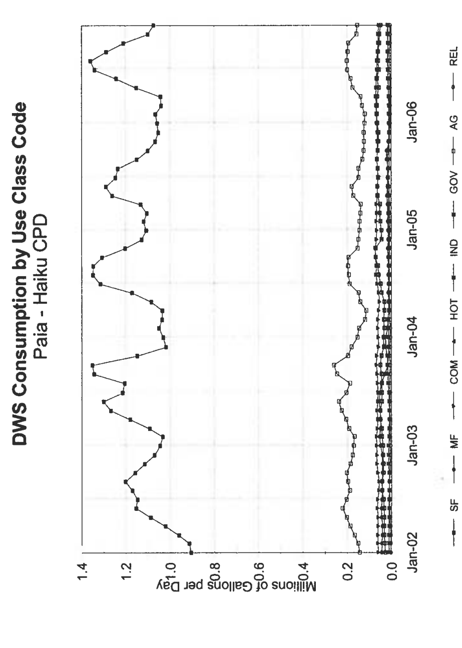


Figure 8 Haiku Consumption by User Class

Table 3 DWS Consumption by User Class

DWS Historical Metered Consumption by User Class for the Makawao-Pukalani-Kula Community Plan District

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Single Family	2.446	2.756	2.496	2.221	2.443	2.526	2.716	3.066	2.828	3.122	2.89	2.97	3.118
Multi-Family	0.041	0.051	0.045	0.041	0.036	0.06	0.065	0.07	0.065	0.059	0.05	0.049	0.048
Commercial	0.183	0.19	0.207	0.136	0.185	0.208	0.16	0.187	0.208	0.219	0.205	0.177	0.171
Hotel	0.006	0.007	0.006	0.006	0.007	0.008	0.011	0.011	0.009	0.007	0.006	0.01	0.006
Industrial	0	0	0	0	0	0	0	0	0	0	0	0	0
Government	0.168	0.166	0.172	0.175	0.219	0.198	0.215	0.237	0.182	0.188	0.191	0.186	0.199
Agriculture	2.781	3.357	2.719	2.53	3.241	3.327	3.26	3.513	2.51	2.973	2.708	2.952	2.732
Religious Inst.	0.016	0.02	0.016	0.015	0.017	0.018	0.018	0.021	0.015	0.019	0.017	0.016	0.017
Total	5.642	6.546	5.662	5.123	6.149	6.345	6.445	7.106	5.817	6.588	6.066	6.361	6.291

DWS Historical Metered Consumption by User Class for the Paia-Haiku Community Plan District

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Single-Family	0.790	0.864	0.914	0.857	0.868	0.950	1.019	1.070	1.077	1.185	1.176	1.157	1.166
Multi-Family	0.016	0.044	0.047	0.043	0.037	0.040	0.041	0.047	0.043	0.040	0.014	0.016	0.014
Commercial	0.051	0.065	0.076	0.079	0.060	0.066	0.070	0.064	0.062	0.065	0.064	0.065	0.065
Industrial	0.012	0.013	0.018	0.016	0.021	0.019	0.018	0.016	0.012	0.015	0.014	0.012	0.014
Government	0.026	0.026	0.031	0.028	0.034	0.026	0.025	0.039	0.036	0.045	0.048	0.058	0.059
Agricultural	0.095	0.130	0.129	0.121	0.120	0.143	0.178	0.178	0.186	0.207	0.159	0.144	0.165
Religious Inst.	0.007	0.008	0.007	0.006	0.006	0.007	0.005	0.005	0.007	0.007	0.009	0.012	0.006
Total	0.998	1.149	1.223	1.150	1.145	1.251	1.356	1.420	1.425	1.565	1.485	1.464	1.490
Total (including Haiku)	6.640	7.695	6.885	6.273	7.294	7.596	7.801	8.526	7.242	8.153	7.551	7.825	7.781

Figures 9 and 10 show the breakdown by use classes on an annual basis from 1994 through 2006. As shown in Figure 9, Single Family use has been growing faster than other uses in both Makawao-Pukalani-Kula and Paia-Haiku.

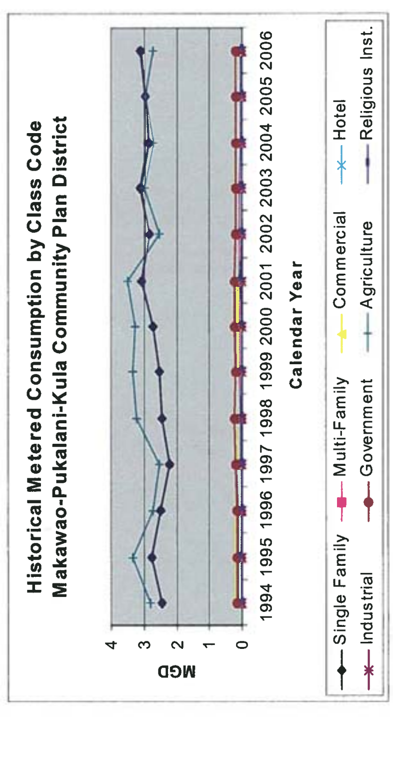


Figure 9 Historical Annual Consumption by User Class - Makawao-Pukalani-Kula Community Plan District (Makawao, Hali'imaile, Pukalani & Kula)

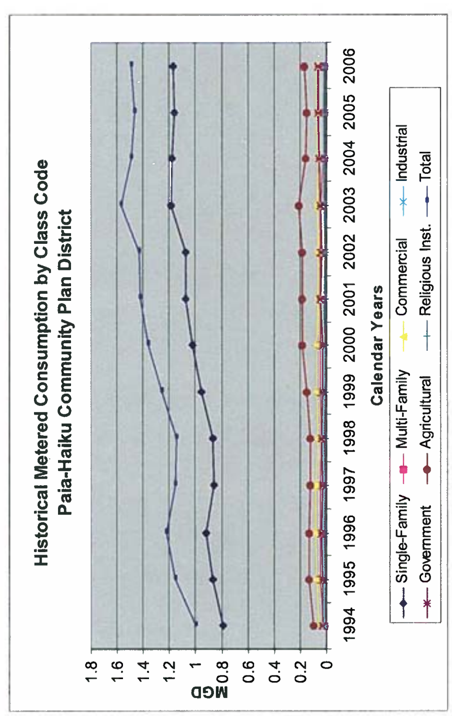


Figure 10 Historical Annual Consumption by User Class - Paia-Haiku Community Plan District - Haiku Only

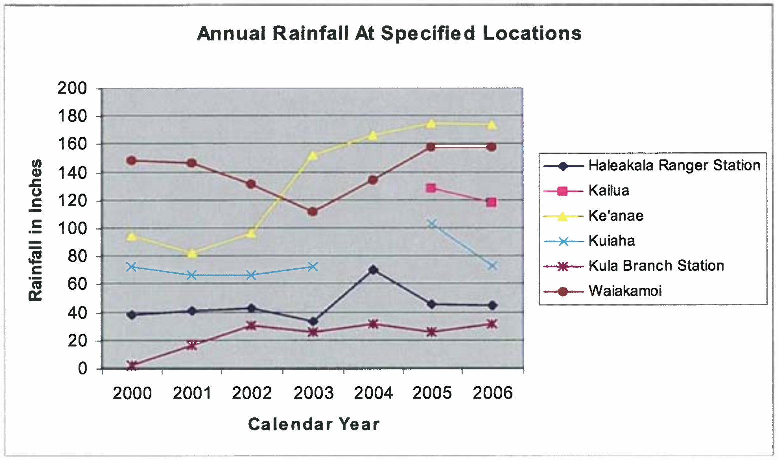


Figure 11 Annual Rainfall Source: U.S. Department of Commerce, National Oceanographic and Atmospheric Administration, National Weather Forecast Office, Honolulu

In general, mild temperatures, cool and northeasterly winds, and a rainy season characterize the months of October through April. A dry and warmer season characterize the months of May through September.

Data from the U.S. Geological Survey National Hydrography Dataset indicate certain trends during the following water years:

- During 1913 to 2002, there is an indication of generally decreasing rainfall.
- During 1933 to 2002, base flows increased from1933 to about 1940, and decreased after about 1960 to 2002.
- During 1953 to 2002, there is an indication of downward trends in rainfall.
- During 1973 to 2002, there was below average rainfall during the 1970s.
- During 2002 to 2005, rainfall increased annually in East Maui.

However, further study is needed to determine whether the downward rainfall trends will continue or whether the observed patterns are part of a long-term cycle in which rainfall may increase to previous levels during 1913 to the early 1940s.

(Source: *Trends in Streamflow Characteristics at Long-Term Gaging Stations; Scientific Investigations Report 2004-5080*)

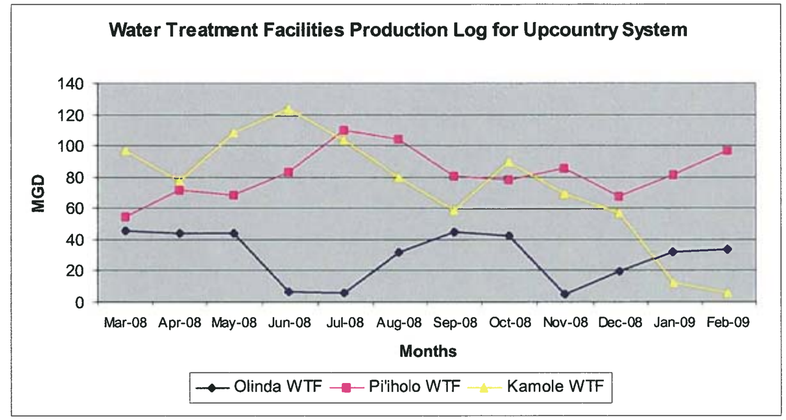


Figure 12 DWS Upcountry System - Monthly Production

The DWS Monthly Water Treatment Facilities Production Logs for the past twelve months ending February 2009 reflect the fact that lower elevation sources are pumped to higher elevation reservoirs during the early dry months.

Table 4 **DWS Monthly Water Treatment Facilities Production Logs for Upcountry Water System**

(MGD)

	Mar-08	Apr-08	May-08	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08	Jan-09	Feb-09
Olinda WTF	45.450	44.250	43.940	6.170	5.430	31.900	44.530	42.510	4.590	19.380	32.720	34.000
Pi'iholo WTF	54.588	71.224	68.274	82.697	110.276	104.550	80.330	77.778	85.443	67.360	81.347	96.578
Kamole WTF	97.034	77.265	108.330	124.053	103.608	80.018	58.232	89.929	69.196	56.574	12.028	5.323

Current Use

The total consumption for the Department of Water Supply's Upcountry Water District in 2008 was 6.966 MGD. This is further broken down into general and agricultural rate classes.

- General consumption by Makawao-Pukalani-Kula Community Plan District for fiscal year 2008 was 4.352 MGD.
- Agricultural consumption by Makawao-Pukalani-Kula Community Plan District was 2.614 MGD.

Future Demands

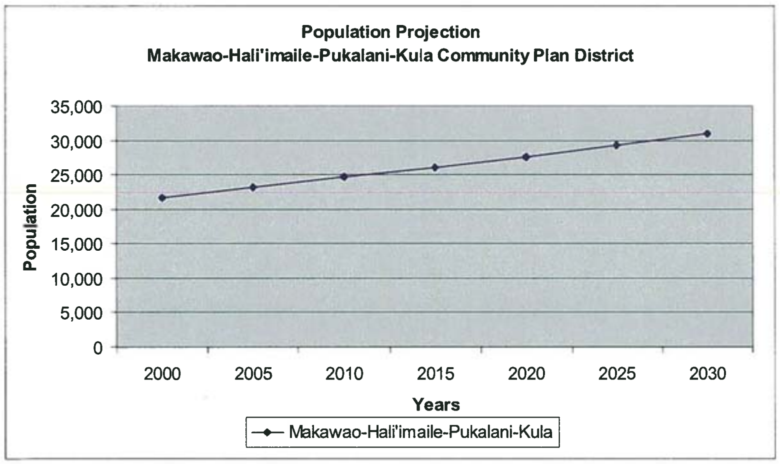


Figure 13 Population Projection - Makawao-Pukalani-Kula Community Plan (does not include Haiku)

Table 5 Community Plan Upcountry District (Makawao-Pukalani-Kula) Population Projection

2000	2005	2010	2015	2020	2025	2030
21,571	23,176	24,644	26,098	27,640	29,243	30,880

Baseline population projections for the Makawao-Pukalani-Kula Community Plan District show an increase of 9,309 or a 45.3% increase from 2000 to 2030.

Table 6 Demand for Resident and Non-Resident Housing Units - Makawao-Pukalani-Kula Community Plan District

Existing 2004 Land Use Database	2015 Housing Demand	2015 Need for Additional Units	2030 Housing Demand	2030 Need for Additional Units	Sum of Additional Units Needed to 2030
8,747	10,563	1,816	13,121	2,558	4,374

Upcountry Water District - Upcountry Water Service Request List (waiting list)
As of May 15, 2008, there were 1,312 applicants on the list for building permit applications, subdivisions and water service requests.

Urban development (planned/committed and planned designated) for Community Plan Upcountry District (Makawao-Pukalani-Kula) from Long Range Planning, Department of Planning, County of Maui:

- Hali'imaile Residential (A&B, Inc.) - 148 single family (SF) units
- Grove Ranch Lots - 9 SF units
- Kualono - 49 SF units
- Kulamalu Town Center - 14 SF units
- Cottages at Kulamalu - 12 SF units and 28 multi-family (MF) units
- Mauna Lani - 6 SF units
- Kauhale Lani Residential Subdivision - 156 SF units
- Barto Project Crook Estate Project District 3 - 54 SF units
- Department of Hawaiian Home Lands (DHHL) Waiohuli-Keokea subdivisions - per WATER CREDITS AGREEMENT made on December 9, 1997, the Department of Water Supply agreed to commit five hundred thousand gallons of potable water per average day to DHHL for DHHL home sites in the Makawao-Pukalani-Kula Community Plan District.

Urban development (proposed)

- Hali'imaile Expansion A&B, Inc. 400 - 1,200 SF units
- Hali'imaile Expansion (ML&P) - 1,500 units
- Kula Meadowood - 130 SF and 130 MF units
- Makawao Mauka Homes - 95 SF and 100 MF units
- Pukalani Uplands - 98 SF units
- DHHL Waiohuli-Keokea subdivisions - 1,100 SF units

Forecasted Demand

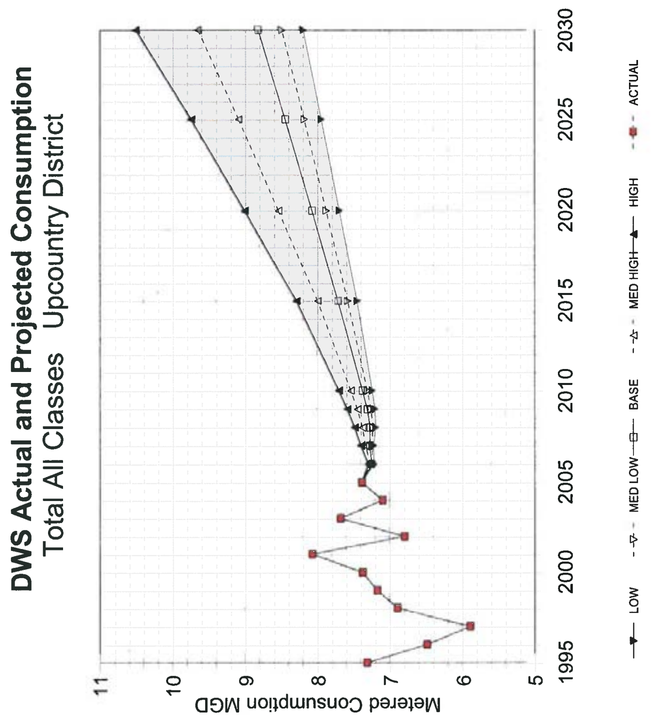


Figure 14 Community Plan District Unit Forecast 2006 Update for the Makawao-Pukalani-Kula District Water Use and Demand Draft, Econometric Model by Haiku Design & Analysis.

The guidelines for updating the Hawaii Water Plan indicate that a range of forecasts should be evaluated in planning for water supply. These are graphed in Figure 14 above, and shown in Table 7 below. Forecasts for the Upcountry Water District in general range from about 8.5 to 11 MGD by the year 2030, with the base case prediction at about 9.75.

Table 7 Upcountry Metered and Forecasted Demand

Historical Metered Consumption and Projected Consumption
Demographic Forecast (Base Case) (Millions of Gallons per Day)

		2005	2010	2015	2020	2025	2030
Upcountry							
	Low Case	4.441	4.483	4.754	5.041	5.313	5.577
	Medium Low Case	4.441	4.571	4.945	5.313	5.664	6.010
General	Base Case	4.441	4.659	5.137	5.577	6.010	6.444
	Medium High Case	4.441	4.754	5.313	5.837	6.379	6.921
	High Case	4.441	4.848	5.485	6.092	6.715	7.339
	Low Case	2.378	2.258	2.258	2.258	2.258	2.258
	Medium Low Case	2.378	2.292	2.326	2.361	2.397	2.434
Ag Potable	Base Case	2.378	2.326	2.397	2.472	2.551	2.634
	Medium High Case	2.378	2.343	2.433	2.530	2.633	2.744
	High Case	2.378	2.361	2.471	2.591	2.721	2.862
	Low Case	6.820	6.742	7.013	7.299	7.571	7.835
	Medium Low Case	6.820	6.863	7.271	7.674	8.061	8.444
Total Potable	Base Case	6.820	6.984	7.534	8.049	8.561	9.078
	Medium High Case	6.820	7.097	7.746	8.367	9.012	9.665
	High Case	6.820	7.208	7.956	8.683	9.436	10.201
	Low Case	0.571	0.573	0.573	0.573	0.573	0.573
	Medium Low Case	0.571	0.583	0.592	0.602	0.612	0.622
Ag Non Potable	Base Case	0.571	0.592	0.612	0.633	0.654	0.676
	Medium High Case	0.571	0.597	0.622	0.649	0.676	0.704
	High Case	0.571	0.602	0.633	0.665	0.699	0.734
	Low Case	7.391	7.315	7.586	7.872	8.144	8.408
	Medium Low Case	7.391	7.445	7.864	8.276	8.673	9.067
Total	Base Case	7.391	7.577	8.146	8.681	9.215	9.754
	Medium High Case	7.391	7.695	8.369	9.015	9.688	10.370
	High Case	7.391	7.810	8.589	9.347	10.134	10.935

WATER USE PURPOSE

Who is using the water and what is the water used for

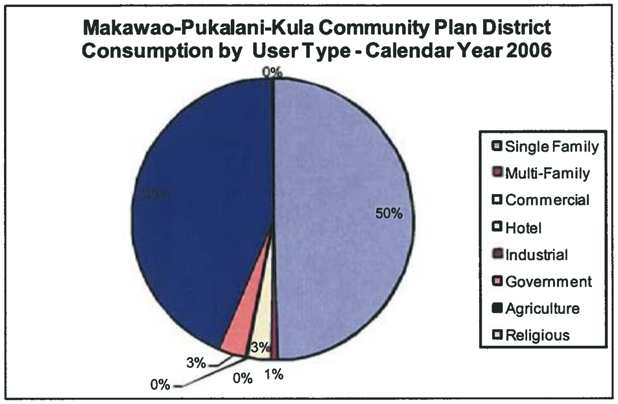


Figure 15 Makawao-Pukalani-Kula Community Plan District Consumption By User Type

Consumption by User Type - Calendar Year 2006
Makawao-Pukalani-Kula Community Plan District

- Single Family - 3.118 MGD
- Multi-Family - 0.048 MGD
- Commercial - 0.171 MGD
- Hotel - 0.006 MGD
- Industrial - 0.0 MGD
- Government - 0.199 MGD
- Agricultural - 2.732 MGD
- Religious - 0.017 MGD

General and Agricultural Water Meters Issued in DWS Upcountry District - FY 2008
Makawao-Hali'imaile-Pukalani-Kula-Haiku

- Regular (General) - 9,136 or 92.7%
- Agricultural - 717 or 7.3%

Agricultural Water Use

Table 8 Agricultural Water Use in Community Plan Upcountry District*

	Acres	Number of Farms
Pineapple	1,200	2
Vegetables and Melons	800	100
Onions, Green Onion, Head Cabbage, Chinese Cabbage, Tomato, Beans, Lettuce, Taro, Cucumber, Zucchini, Herbs, Sweet Corn, Celery, Daikon, Egg Plant, Ginger Root, Parsley, Romaine Lettuce, Peas, Watercress, Radish, Dasheen and Sweet Potato		
Fruits	600	150
Bananas, Oranges, Persimmons, Avocado, grapes, Limes, Lemons, Cherimoya, Mango, Plums, Peaches, Loquat		
Coffee	200	12
Protea, Nursery & Tropicals	150	12
Protea, Nursery, Ginger, Heliconia, Nursery Operations and Turf		
Livestock		
Cattle	93,000	120
Hogs		50
Other - Sheep, Deer, Goats		20

* Data from the Office of Economic Development, County of Maui and the Maui County Farm Bureau (includes some East Maui farms)

Hydroelectric Use
Although DWS does not utilize hydroelectric sources, this and other energy alternatives are being considered as an independent component of the Upcountry District Water Use and Development Plan.

Recreational and Ornamental Use
The Community Plan Upcountry District has one golf course, the Pukalani Country Club. It has a priva private well are used for golf course and landscape irrigation.

WATER REQUIREMENT

Minimum water requirement for current use

Table 9 Surface Water Purchases from East Maui Irrigation Company, Ltd. (Millions of Gallons per Day)

FY2005	FY2006	FY2007	FY2008	FY2009 *
7.169	7.126	7.622	6.607	5.227

* (FY 09 number reflects only 8 months - year to date July, 2008 through February 2009)

Decreased surface water purchases in FY2008 and FY 2009 may be attributed to several factors:

- Higher rainfall months from February 2009 to April 2009
- DWS price structure and price increases
- Lower defacto population
- Decreased economic activity associated with the current recession
- Appeals for conservation by DWS
- DWS conservation program implementation
- Adoption of newer and more efficient appliances

DWS Monthly Source Report
Pookela Well is used as a back up well in the Makawao-Pukalani-Kula Community Plan District. During fiscal year 2008, the DWS Monthly Source Reports showed an average of 0.188 MGD. For the one year period ending in February 2009, the report showed an average of 0.328 MGD.

Prioritize Water Use Purposes

In determining whether drought conditions are warranted, DWS monitors five components of the Upcountry water system:

- Wailoa Ditch flows
- Pi'iholo Water Treatment Plant and reservoir levels and flows
- Kamole Water Treatment Plant flows
- Waikamoi reservoir and Kahakapao reservoir levels and flows
- Olinda Water Treatment Plant flows

For the DWS Upcountry District (Makawao-Hali'imaile-Pukalani-Kula-Haiku), the Board of Water Supply Resolution No. 98-18 outlines actions for DWS to implement varying stages of a declaration of drought. Response actions are based on ditch flows, and water treatment plant and reservoir capacities. Actions may include voluntary and mandatory water use restrictions, operational controls, and public education and outreach activities.

During declaration of droughts and the drier months, DHHL makes requests to its lessees for water conservation.

In recent decades, agricultural consumers and farmers have been exempt from water restrictions during declarations of drought.

Currently, there are about 27,000 head of cattle in Upcountry Maui and Hana. Cattle require a minimum of 20 GPD or a total of 540,000 GPD. There are also about 6,000 head of deer being farmed. Deer require a minimum of 10 GPD or a total of 60,000 GPD. Although there are no current figures available, other livestock include pigs, sheep, goats, elk and horses. Without water livestock such as cattle die within a couple of days or less.

The U.S. Department of Agriculture offers post disaster programs that share with agricultural producers the cost of rehabilitating eligible farmlands damaged from natural disasters and provide emergency water conservation assistance. The funds are used for conservation practices and compensation for livestock and agricultural losses. Since 1999, more than $1,000,000.00 has been dispersed on Maui for drought related compensation.

Typically, during a drought, monitoring and enforcement are more lenient for homes using less than three or four hundred gallons per day. Drought enforcement has not had to reach the point where a more stringent life-line amount has had to be set.

No prioritization of uses has been set in Maui as of this draft. However, both Hawaiian Home Lands and preservation of Agriculture are typically deemed high-priority uses within the county. There is some concern as to whether potential future conflicts for drought supply will result from continued growth upcountry, combined with build-out of the Hawaiian Homes project and intended agricultural park.

Policies regarding allocation, distribution and reliability are under discussion, both as part of the Water Use and Development Plan (WUDP) Process and in other venues. However, it is doubtful that all such potential issues can be fully resolved in the upcoming iteration of the WUDP.

WATER SUPPLY

Sources of water

Surface water

- Wailoa Ditch - The Wailoa Ditch runs at approximately 1,100 feet and draws water from approximately 200 East Maui streams as far east as Makapipi. Water from this collection system is used in two areas of the system. The Kamole Weir Water Treatment Plant withdraws water from the Wailoa Collection System and is the primary source of water for Makawao, Pukalani and Hali'imaile. During drought conditions, this plant can also serve water to Lower Kula, and ultimately even Upper Kula. This was also once the main source for the system to Haiku and eastward, and still backs up this region for pump failures or repairs and maintenance. Water for the Kula Agricultural Park is also drawn from a ditch downstream of the Kamole Weir Water Treatment Plant in the Omaopio region.

- Upper Kula Collection System - The collection system that serves the primary source for the Upper Kula system runs at about 4,200 feet and draws water from the Waikamoi, Haipuaena, Middle Branch Puohokamoa, West Branch Puohokamoa and Kailua Streams. Water from the collection system is treated at the Olinda Water Treatment Plant and serves the Upper Kula and Ulupalakua-Kanaio regions. When water is plentiful, it can also serve Lower Kula and even below. During a drought, this source is backed up by the Lower Kula and ultimately Wailoa sources, with Pookela as the supplemental source.
- Lower Kula Collection System - The Lower Kula collection system runs at about 2,900 feet and draws water primarily from the East and West Waikamoi, Honomanu, Haipuaena, West Branch Puohokamoa, Middle Branch Puohokamoa and East Branch Puohokamoa Streams. Water is treated at the Pi'iholo Water Treatment Plant and serves the Lower Kula area. During wet times, this water can serve the lower elevation areas of Makawao-Pukalani. During drought, this water can be used to supplement the Upper Kula system.
- Opana Stream at Awalau - This is a small source shared by Maui Land and Pineapple Company, Haleakala Ranch, Kaonuolu Ranch and DWS. DWS takes only a small portion of the water and it currently serves only four non-potable meters, with a total water use between 2,000 and 2,500 GPD.

Surface water purchases from the East Maui Irrigation Company, Ltd. have averaged 7,131,353 GPD during the four fiscal years, peaking in fiscal year 2007 with 7,622,079 GPD.

Ground water
Three wells currently serve the Upcountry system. The Pookela well serves as backup source for the surface water systems. While the Kaupakalua well could serve as additional backup with some capital expenditure, its main function is as the major source for Haiku. The Haiku well serves the lower elevations of the Haiku service area.

Table 10 Ground Water Capacity in the DWS Upcountry System

Well	Pump Capacity GPM	Well Capacity GPD	Function
Pookela	900	1,296,000	Backup well; can serve several system areas
Kaupakalua	1,020	1,468,800	Major source for Haiku sub-district
Haiku	320	460,000	Source for small portion of Haiku sub-district

Contractual Obligations and Agreements

- **MASTER WATER AGREEMENT** - The East Maui Irrigation Company, Ltd. and Hawaiian Commercial & Sugar Company, Ltd. and the Board of Water Supply of the County of Maui signed a master agreement on December 22, 1961. The agreement was extended for another 25 years.

- **WATER CREDITS AGREEMENT**
The AGREEMENT between the STATE OF HAWAII, DEPARTMENT OF HAWAIIAN HOME LANDS, an agency of the Hawaiian Homes Commission, and the COUNTY OF MAUI DEPARTMENT OF WATER SUPPLY made an agreement on December 9, 1997.

  Highlights of the AGREEMENT:
  - DWS shall commit five hundred thousand gallons (500,000) gallons of potable water per average day to DHHL for the DHHL Homesites except during any drought affecting the Lower Kula area.
  - In consideration of its contribution for construction including (1) off-site Booster Pumping Station at Kula Kai Reservoir, and construction of transmission water main from Naalae Road to DHHL subdivision, and (2) construction of on-site reservoirs, booster pumps, and transmission lines, which shall be licensed to the DWS in perpetuity, DHHL shall receive from the DWS water credits as follows:
    a. Source Credits - No credits for source.
    b. Transmission and Storage Credits - No payments for transmission and storage components of the fees shall be required of DHHL by DWS
    c. Additional Credits - DHHL shall receive from the DWS an additional $1,561,600 credit for increasing the transmission and storage capacity of the DWS water system beyond current and planned DWS and future DWS and DHHL needs.

- **KULA AGRICULTURAL PARK WATER RESERVOIR AGREEMENT**
The AGREEMENT between the County of Maui, East Maui Irrigation Company, Limited (EMI) and Alexander & Baldwin, Inc., through its division Hawaiian Commercial & Sugar Company was made on December 30, 2002.

  Highlights of the Agreement:
  - The County, among other things, has the right to withdraw up to1.5 million gallons of water per twenty four hour period to serve the needs of the Kula Agricultural Park.
  - The County to complete upgrades of the Park pumps and relocate them to A&B's Reservoir 40.
  - The County wishes to have the right to use such water to serve, in addition to the needs of the Park, agricultural needs of that certain Haleakala Ranch Company property located at TMK No. 2-3-02:7, to be used as an agricultural park.

- The County shall require users of withdrawn water to use their best efforts to limit their use of such water during times of water shortage.

Minimum amount of water supplied by the Upcountry water system during drought conditions

The following are estimated drought capacities for the Upcountry water treatment plants:
- Kamole Weir Water Treatment Plant - 4.5 MGD
- Olinda Water Treatment Plant - 1.2 MGD
- Pi'iholo Water Treatment Plant - 2.11 MGD

With an additional 100 million gallon raw water storage, there would be an additional 1.19 MGD or 3.3 MGD.

With an additional 300 million gallon raw water storage, there would be an additional 2.73 MGD or 4.84 MGD.

Po'okela Well is only used for drought and emergency backup.

The Upcountry water system is an interconnected system that uses about 90% surface water and 10% ground water. The use of surface water has been very cost efficient. During periods of low rainfall and surface flows, DWS uses a declaration of drought, operational controls, and public education and appeals of conservation. Typically, treated surface water from the Kamole Weir Water Treatment Plant is pumped to higher elevation reservoirs with its high lift pumps prior to the drier months.

Alternate water sources
- Hamakuapoko Wells - There are two wells each with a capacity of 720,000 GPD. During periods of low flow in the Wailoa Ditch, these wells can be pumped to the ditch downstream of the plant but upstream of the Kula Agricultural Park. At this point the ditch is called the Hamakua Ditch, but it is essentially a downstream portion of the same system. In exchange for pumping these wells to provide additional irrigation water in the ditch, an equivalent amount of water may be removed from the upstream, Wailoa Ditch portion for treatment at the Kamole Weir Water Treatment Plant.
- Recycled water from wastewater treatment plants are not currently available for the Upcountry water system. However, treated wastewater from Pukalani is mixed with wellwater and used to irrigate the Pukalani Golf Course.
- The USDA-Central Maui Soil and Water Conservation District is conducting a Stormwater Reclamation Planning and Engineering Study to examine possible design and siting for storage of surface water in the Lower Kula system area in support of the Hawaii Hazard Mitigation Plan and the County of Maui Drought Mitigation Strategy. The strategy program is administered by the State Commission on Water Resource Management. Funding is provided by a state appropriation. Technical assistance will be provided by the USDA Natural Resources Conservation Service. They will conduct data collection and technical analyses and prepare the study report. The study report should be completed by

September 2009.
- In addition, the Draft Final Candidate Strategies Chapter for the Upcountry District for the Water Use and Development Plan evaluates the following major options:
  - Incremental basal well development
  - Expansion fo raw water capacity
  - "Drought proof" full basal backup
  - Extensive conservation measures, with or without redirecting or restricting growth

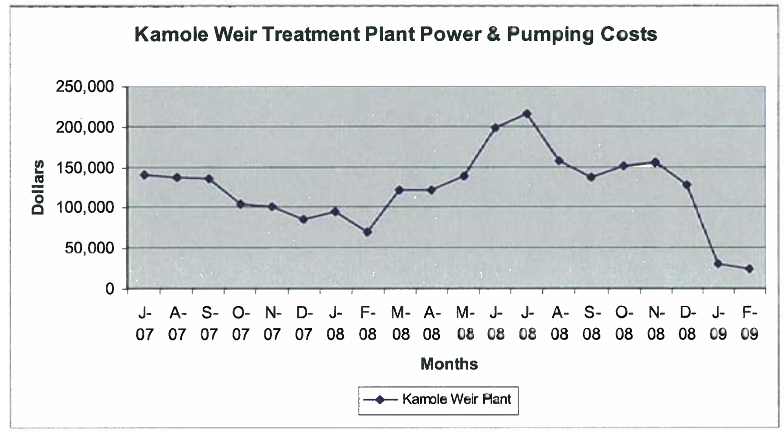


Figure 16 DWS Kamole Weir Treatment Plant Power & Pumping Costs (includes highlift pumps)

ECONOMIC IMPACT

When water drops 25%, 50%, 75% or more

Power and Pumping Costs
Over 26% of DWS operating costs during 2007 were for power and pumping (more than 10.5 million dollars). With strong seasonal variation demands, power and pumping costs peak in summer months. Drought operations can run up hundreds of thousands in extra expenses. Power and pumping costs for the Kamole Weir Water Treatment Plant are higher than any others in the Upcountry system.

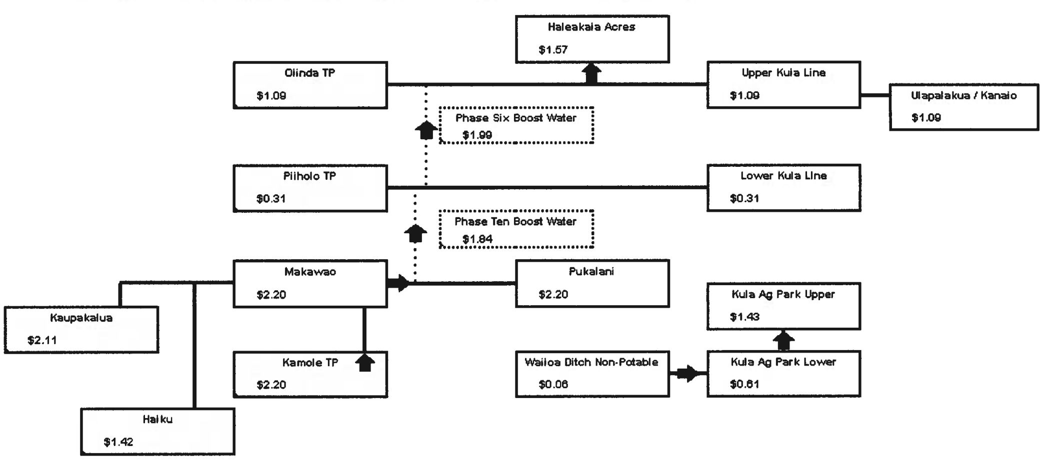
Figure 17 on the following page provides short-run marginal costs to serve 1,000 gallons of water at various elevations. These differences are almost entirely due to power and pumping.

Table 11 DWS Power and Pumping Costs for Upcountry Water System Facilities

	N-07	D-07	J-08	F-08	M-08	A-08	M-08	J-08	J-08	A-08	S-08	O-08	N-08	D-08	J-09	F-09
Haleakala Acres Tank #36	782	795	1,004	1,448	1,467	1,066	1,029	1,372	1,328	1,202	1,589	1,334	997	754	867	608
Omaopio Steel Tank	83	84	89	147	93	93	149	98	164	172	103	105	162	149	86	120
Harry Field Tank #371	2,404	2,479	2,451	2,779	2,668	2,674	2,500	13,927	29,252	28,921	9,038	2,596	13,826	20,141	4,324	1,704
Mauka Estates Pump #1	43	44	46	47	47	46	49	48	48	49	50	49	49	47	47	45
Kealahou Tank 30K #401	43	42	47	47	47	47	46	50	49	48	49	49	48	47	47	44
Kula Kai Tank #358	3,199	2,746	3,483	3,350	3,578	3,628	3,654	17,063	29,959	29,525	5,802	3,796	15,675	19,388	3,637	2,038
Kula Ag Park A	9,718	6,054	7,854	7,898	10,174	10,622	10,812	14,021	12,640	12,795	15,732	14,789	11,640	7,857	5,008	3,251
Kula Ag Park B	12,024	7,326	10,339	10,085	12,946	12,137	12,570	15,294	15,114	15,588	17,416	17,975	13,291	8,609	6,106	4,877
Kula Ag Park Pump #3	26	26	28	28	28	28	28	28	28	28	28	28	28	28	28	28
Kamole Weir Plant	100,749	84,166	95,028	69,245	120,581	120,740	138,763	198,199	214,998	157,749	136,898	151,157	155,280	128,067	29,180	23,861
Maluhia Tank #255	3,224	6,468	3,108	3,147	17,733	17,228	22,989	69,263	78,763	22,121	3,102	9,071	50,175	30,629	3,102	3,102
Pookela Tank #256	3,083	4,968	2,395	3,661	19,247	12,985	15,947	43,489	48,327	15,308	9,677	11,835	31,607	18,999	2,311	2,327
1285 Makawao Ave.	0	0	0	0	0	133	106	116	116	127	120	120	106	101	96	80
Olinda Tank 50K #254	2,944	6,235	3,120	3,159	14,852	14,848	21,523	63,563	70,575	21,011	3,134	7,990	42,114		3,134	3,134
Piiholo Main Line	26	26	27	28	28	28	28	28	28	28	28	28	28	28	28	28
A/C Kamole Storage Tank	26	27	28	28	28	28	28	28	28	28	28	28	28	28	28	28
Kahakapao Reservoir	26	26	28	28	28	28	35	32	28	31	28	28	28	35	32	32
Lower Kula WTP	5,417	3,715	5,970	4,600	6,109	6,251	6,924	6,747	7,979	8,974	8,409	8,159	7,449	5,946	5,178	4,660
Haiku Well Pump Station	11,355	12,064	13,439	12,803	15,609	15,329	16,848	18,749	19,186	18,993	19,141	18,836	17,410	13,439	11,869	9,605
Olinda Road Pole #E69	46	46	50	50	50	50	50	52	52	52	54	52	51	50	49	46
Olinda WTP	13,323	9,743	13,771	11,324	15,305	16,142	17,035	14,598	2,611	4,434	24,662	22,199	11,466	5,801	12,111	10,128
Upper Kimo Tank	1,142	1,142	1,198	293	292	242	245	13,609	29,768	28,346	7,603	1,214	12,660	20,508	3,423	1,223
Lower Kula Booster	1,593	1,009	1,069	1,082	1,082	11,856	15,210	23,927	29,551	30,496	23,530	19,228	22,923	17,154	7,867	6,281
Kula Hwy. #3000	26	26	27	28	28	28	28	28	28	28	28	28	28	28	28	28
Kula Hwy. #2355	30	26	28	28	28	28	28	28	28	28	28	28	28	28	28	28
Kula Res. Lots Bstr. Pumps	498	531	666	790	678	710	700	591	674	635	721	654	708	636	552	414
Kaupakalua Road Well	972	30,226	48,724	48,120	52,745	54,685	64,631	71,466	76,650	75,101	78,311	77,435	61,414	51,744	45,672	35,206
Holomua Rd., H'Poko	211	170	232	191	191	241	248	262	277	289	228	162	325	1,559	126	152
Olinda Rd. #E12 Pookela	3,211	5,774	3,457	3,900	4,487	3,093	4,409	44,024	77,381	7,403	28,735	3,066	59,122	17,501	4,806	3,875
Hamakuapoko Well #2	343	259	329	292	292	292	248	318	337	351	355	408	553	3,029	256	227

5.0-31

Upcountry System Variable Operating Costs by Geographic Area (Short Run Marginal Costs)



The variable operating costs of producing and delivering water to each water tank on the DWS system was calculated. These costs are presented for several geographic areas in the chart below. Variable operating costs include the cost of electrical energy for water pumping and any other costs that vary directly with the amount of water produced.
The cost shown for each area is the calculated variable water production cost per thousand gallons for the year 2008.
Shaded boxes show water source production costs. Arrows show booster pumps. Dotted boxes show the additional costs of water boosted to higher elevations under some summer months and drought conditions.

Figure 17 Upcountry System Variable Operating Costs (Short Run Marginal Costs)

5.0-30

Agricultural Costs
Whenever there is low rainfall and surface water flows, agricultural production and income decrease. Planting and irrigation schedules are altered producing lower crop yields. More agricultural produce must be imported. Imported produce lose freshness and have added packaging and transportation costs. Local restaurants also depend heavily on local produce which include vegetables, fruits and livestock.

Recent agricultural losses:
- During the 1996 drought that affected Hawaii, Maui and Molokai, there were heavy damages to agriculture and especially to cattle. State-wide cattle losses totaled at least $9.4 million.
- During the 1998-1999 drought, state-wide cattle losses were estimated at $6.5 million.
- During the 2000-2002 drought, state-wide cattle losses were projected at $9 million.
- A&B, Inc., mostly through HC&S, lost nearly $13 million in 2008 as a result of lower yields due to prior droughts.
- A&B, Inc. anticipates even greater losses in 2009 due to prior droughts.

Development and Construction Costs
Maui County Administrative, Title 16, Chapter 106, Water Meter Issuance Rule for the Upcountry system states that there is a finding of insufficient water supply developed for fire protection, domestic and irrigation purposes to take on new or additional services without detriment to those already served in the regulated area.

Until additional water sources are added to the Upcountry system, future development will be limited in the both the Community Plan Upcountry District (Makawao-Pukalani-Kula) and the DWS Upcountry District for water service (Makawao-Hali'imaile-Pukalani-Kula-Haiku).

All of the capital plans currently under analysis for the Water Use and Development Plan represent an expenditure beyond the Department's current rates and fees. To meet anticipated demands while accounting for drought and/or the need to pump, DWS will have to invest on the order of $9,000 per service for the source portion of the Water System Development Fee alone. The current fee of $6,030 covers source, storage and transmission. So even in the absence of drought, planning for drought-prone conditions is expensive.

<u>Restricting offstream uses</u>
Offstream users include domestic and municipal, irrigation, industrial and hydroelectric. The County of Maui and DWS currently use surface water for domestic, municipal and irrigation purposes.

- **Domestic and municipal uses**
  - Under existing conditions, the Upcountry system is already prone to seasonal restrictions, which are exacerbated during drought conditions. Further restrictions on such use could create negative impacts to the community.
  - Among the municipal uses served by the DWS system are hospitals, schools,

and other important community facilities. Increasing the severity of restrictions on the Upcountry system could ultimately reach the point of affecting these crucial services.
  - In fiscal year 2008, the Upcountry system served 9,853 meters in the "Upcountry" communities, including Makawao, Hali'imaile, Pukalani, Kula, Ulupalakua-Kanaio and Haiku.
  - The DWS Upcountry system also serves the Department of Hawaiian Home Lands, which would be adversely affected by further domestic and municipal restrictions.
  - Continued use of surface water from East Maui streams is consistent with state land use designations.
  - Continued use of surface water from East Maui streams is consistent with the Maui County General Plan. The General Plan objectives are "to provide an adequate supply of potable and irrigation water to meet the needs of Maui County's residents" and "to make more efficient use of the our ground, surface and recycled sources".
  - Continued use of surface water from East Maui streams does not interfere with the right of DHHL. DHHL does not have its own potable water source. The WATER CREDITS AGREEMENT between DHHL and DWS on December 9, 1997 supports DHHL's Waiohuli-Keokea subdivisions by agreeing to provide 500,000 GPD of potable water.
  - Despite considerable effort to improve operating efficiency, limit additional commitments, and encourage conservation, DWS has been unable to supply sufficient and reliable potable water to meet seasonal demands for its Makawao-Pukalani-Kula District customers.

- **Irrigation use**
  - Article XI, Section 3, of the State Constitution, states that "The state shall conserve and protect agricultural lands, promote diversified agriculture, increase agricultural self-sufficiency and assure the availability of agriculturally suitable lands".
  - The preservation of agricultural lands has been a key objective of the last several community plans for the Upcountry region. However, drought-prone conditions have already created problems for many farmers. Further restrictions to agricultural irrigation could have detrimental impacts to an already-staggering sector.
  - As noted earlier, the KULA AGRICULTURAL PARK WATER RESERVOIR AGGREEMENT gives the County of Maui the right to withdraw up to 1.5 million gallons per day from EMI's Hamakua Ditch. Non-potable water use for irrigation of agricultural farms requires that the water be pumped up to the park at varying points. The park has a total of 445 acres and supports 26 farms.
  - The majority of the farms on the Upcountry system utilize water that is treated at three water treatment plants. Most of these farms produce diversified agriculture or livestock.

Until more cost effective water sources are available for general and agricultural services served by the Upcountry system, the County of Maui and DWS continue to rely on surface water from East Maui streams.

WATER USE EFFICIENCY

DWS has existing and pending programs to improve efficiency. Between fiscal years 2007 and 2008, the number of meters in the Upcountry system increased, while consumption dropped. In fairness, efficiency is only one of the factors that have contributed to this downward trend in consumption. The current downward trend in both general and agricultural consumption may be attributed to:

- Increase in rainfall during the months of February 2009 through April 2009
- DWS price structure and price increases
- Lower defacto population
- Decreased economic activity associated with the current recession
- Appeals for conservation by DWS
- DWS conservation program implementation
- Wet weather in recent months

<u>Irrigation efficiency</u>

- **Farm irrigation**

For most of the agricultural operations, including DHHL, on the Upcountry system, water use is potable. The exception would be the Kula Agricultural Park which uses non-potable water. Agricultural water rates are available for qualified operations. Most agricultural users utilize the most efficient irrigation techniques available.

The Natural Resources Conservation District has cooperative agreements with most of the Upcountry farmers for conservation and water as well as prevention of soil erosion. Although these agreements are voluntary, the NRCS provides expertise and assistance with improving efficiency.

- **Landscaping**

DWS co-funds operations of the Maui Nui Botanical Garden, and funded construction of its nursery and portions of other facilities and displays. They are a resource that provides expertise in the propagation and maintenance of native plants, promotes water conservation, irrigation and maintenance techniques, and serves as a major demonstration and educational facility.

DWS promotes conservation in its staff comment letters for discretionary projects by promoting:

- The use of climate-adapted native plants to conserve water and protect the watershed from degradation due to invasive alien species.
- The maintenance of fixtures to prevent leaks and the loss of water.
- The use of low-flow fixtures and devices in faucets, showerheads, urinals, water

closets and hose bibs.

- The prevention of over-watering by automated irrigation systems by providing rain-sensors on all automated controllers. Check and reset controllers at least once a month to reflect the monthly changes in evaporation rates at the site. As an alternative, provide more automated, soil-moisture sensors on controllers.
- Limiting irrigated turf by using low-water use plants and ground cover.
- The use of brackish water or reclaimed water for dust control and for non-potable uses during construction.
- Looking for opportunities to conserve water. For example, use a broom instead of a hose to clear debris.

<u>Ways to decrease water use and water needs</u>

The Maui County Department of Water Supply is developing and expanding its conservation program, which includes both supply-side and demand-side measures.

<u>Past experiences</u>

Supply-side measures to date include leak detection, preventive and predictive maintenance, use of reclaimed water and alternate system backups and resource protective measures.

Leak Detection: Though the County has long practiced leak detection, due to staffing it has historically been primarily reactive. Leak detection staff were sent out when a leak was suspected, either based on system performance, or flow and pressure monitoring undertaken as part of hydraulic model development or other efforts. The Department now has a proactive program. A preliminary water audit by district has been completed and eighteen miles of distribution line has been surveyed in the first quarter of this year (versus ten in the same quarter last year). We are in the process of hiring additional leak detection staff and expect the pace to increase. Leak detection equipment includes digital correlating loggers, a digital correlator, a leak detector and a line tracer. More detection equipment is also in the FY2010 budget. Systematic survey and detection of leaks may be supplemented by flow and pressure monitoring as needed. Several major leaks have been identified and repaired.

Preventive & Predictive Maintenance: This is two pronged. Facilities are regularly maintained and pumps are periodically calibrated. In the course of such maintenance, facilities are regularly checked for signs of wear. DWS also has a system inventory with age, diameter and material of lines and other facilities. Based upon the status and performance of system facilities, upon known inventory status and demand trends, DWS maintains a 30-year project list. This can help to reduce unaccounted-for water in the system by targeting old and substandard lines for replacement.

Reclaimed Water Use: About 3.905 MGD is in use county-wide with 1.8 MGD utilized in South Maui. As part of its Water Use and Development Plan process, DWS is currently investigating the costs and benefits of large scale capital investment to further expand this use to offset potable use.

Back-up Sources: In the event of a major leak, most areas of the sysytem can be served by other sources so that any key portion of the system could be valved off as needed.

Watershed and Resource Protection: The Department spent $1,223,500 in FY2008. It has budgeted $1,252,500 for FY2009 and $1,256,000 for FY2010 to protect and monitor water resources, including more than $600,000 on watershed protection. DWS also has co-funded studies to monitor stream flow, duration, temperatures, aquatic and ecologic features of East Maui streams in the recent past. Department staff give talks and run ads on the importance of watershed protection as well as co-sponsoring events at the Maui Nui Botanical Garden facility.

Demand-side measures to date include fixture distribution, a tiered rate structure, educational programs, and regulations as well as resource protection. Ongoing planning efforts are evaluating the benefits and costs of increased aggressiveness in these efforts.

Fixture Distribution: To date DWS has given out 36,713 low-flow showerheads, 33,596 bathroom aerators, 21,567 kitchen aerators, 19,763 self-closing hose nozzles, and many more leak detection dye tablets, versus a customer base of about 35,000 meters. Despite what would seem like high market penetration, estimated savings based on these giveaways is only about half a million gallons per day. More aggressive fixture distribution programs under consideration include audits and direct install programs, as well as rebates and incentives for larger appliances.

Audits/Retrofits: The Department co-funded its first direct install retrofits in the late 1990s with low flow toilets. However, no large scale programs were funded. More recently retrofit trials of high efficiency toilets have been started in the Central District. If these continue to prove successful, retrofits will expand to the Upcountry district. Ongoing retrofit trials include:

- Ka Hale A Ke Ola, a homeless resource center with about 70 units and two dormitories - 74 toilets, two urinals, 76 showers and 76 faucets have been retrofitted, and almost immediately realized substantial water savings.
- Hale Makana O Waiale is a low income housing complex with 200 units. Two hundred showerheads, 200 bathroom and kitchen aerators will be replaced with more water efficient models.
- All DWS properties and the 5th and 9th floors of the county building are being retrofitted with 10 waterless urinals and 22 dual flush toilets.
- DWS staff are working with the Department of Parks and Recreation staff to retrofit aquatic facilities with more efficient fixtures and conserve water in other ways.

The Water Use and Development Plan in progress is evaluating the costs and benefits of high efficiency fixture rebates and direct installation programs. Ongoing trials will help to provide some preliminary data on the effectiveness of some of these options. Longer term options for the future may also include review of various means of sub-metering multi-family units and multi-purpose buildings. Studies indicate that metering un-metered units is among the most effective conservation measures, by billing explicitly for use rather hiding this cost in the rent.

Conservation Pricing: DWS currently has a tiered rate structure to encourage conservation. Data improvements under way could enable the Department to move forward a more

aggressive tier structure.

Regulation: The Maui County has the following existing regulations and rules that support conservation: 1) Prohibition of discharging cooling system water into the public wastewater system; 2) Requirements that low-flow fixtures are required in new development;
3) Requirements that all commercial properties within 100 feet of a reclaimed water line utilize reclaimed water for irrigation and other non-potable uses; 4) A water waste prohibition with provision for discontinuation of service where negligent or wasteful use of water exists; 5) A provision enabling the water director to enact special conservation measures in order to forestall water shortages. In addition, a comprehensive conservation ordinance has been drafted, and may be implemented in stages. Discussions with various consultants about how to phase such implementation is under way. Though the draft is fairly comprehensive, initial provisions enacted may focus on simple measures which have been proven effective - such as limited landscape watering days.

Education and Behavior Modification: Conservation marketing efforts include ads run on all local radio stations and newspapers to encourage water conservation. The permit review process is also utilized as an educational tool, with use-specific conservation tips and location-specific landscape tips included in each review. The Department participates in about 25 public events per year, such as the County Fair, Earth Day and Taro festivals. In order to provide demonstration and an ongoing educational facility with demonstration and learning, the Department funds the operations of the Maui Nui Botanical Garden.

The local paper, the Maui News, publishes a weekly update of water use, including past use, for all districts within the County of Maui. It also has surface water and storage capacities, and water treatment plant production (for Upcountry systems) and rainfall data.

Expanded education and marketing efforts under consideration include targeted marketing survey and campaign development, a hotel awards program, a building manager users group, and an agricultural users group.

In addition to the previously mentioned items, DWS also promotes the utilization of low-flow fixtures and devices, and the maintenance of fixtures to prevent leaks in its comment letters on discretionary projects.

Landscaping: Maui DWS co-funds operations of the Maui Nui Botanical Garden, and funded construction of its nursery and portions of other facilities and displays. This provides a resource for promoting expertise in propagating and maintaining native plant materials, helps to increase the potential marketability of appropriate plants, promotes a conservation ethic, provides training on appropriate propagation, planting, irrigation and maintenance techniques, and generally helps to increase the likelihood of successful appropriate landscapes with a "Hawaiian Sense of Place". It also helps protect watersheds by promoting native and non-invasive plants over potentially invasive species, providing for educational opportunities on the importance of the watershed and how to protect it, and serving as a major demonstration and educational facility. The nursery is also a source of native plants for the Department outreach projects and give-aways. The Department developed (with help from the arborist committee) and prints a brochure entitled "Saving Water in your Yard, What and How to Plant in your

Area", which is distributed by the Maui Nui Botanical Garden as well as by the Department at events and permit reviews. Future plans for landscape conservation include a conservation ordinance, landscape audit and retrofit program, and smaller satellite demonstration projects. DWS is also investigating the costs and benefits of major capital expenditure in reclaimed water transmission to offset use of potable water in South Maui landscapes. The pending conservation ordinance includes mandatory watering schedules and irrigation efficiency measures among other requirements.

Ongoing Planning Efforts: Source options considered as part of the Water Use and Development Plan process will include consideration of extensive conservation measures as a source supply. In order to displace or delay source development, an aggressive program is required. Preliminary design of such a program is ongoing as part of the Water Use and Development Plan process. Anticipated program elements include targeted audit and direct install programs, rebates and incentives, expanded conservation requirements for landscaping and other uses, expanded marketing efforts including user groups, such as a hotel awards program, a building manager information program, agricultural user working groups/services, as well as energy production and efficiency measures, continued watershed protection and restoration, and possible major capital expenditure to support reclaimed water use.

<u>Future</u>

- A second conservation specialist is currently in recruitment.
- A comprehensive water conservation ordinance has been drafted that would require more efficient landscape irrigation practices, as well as retrofit on resale and other measures. This ordinance is in draft form and undergoing review. Based on the advice of conservation professionals, it will be broken out in phases rather than attempt to pass the entire program at once.
- DWS will continue its implementation of a declaration of drought in varying stages as a management measure to control water use.
- The Water Use and Development Plan for the Makawao-Pukalani-Kula District, as well as other county districts, is considering extensive conservation measures as a supply source.
- Work is ongoing to fill data gaps and gather geographic and other information that will enable the Department to design a better-targeted and more steeply tiered water rate structure in the future.
- Expanded education and marketing efforts under consideration include targeted marketing survey and campaign development, a hotel awards program, a building manager users group, and an agricultural users group.

<u>Future Changes</u>

- **Changes in water use or needs**
  - The Maui County Farm Bureau does not envision major changes in farm acreage in the near future. Increase production will be dependent on the availability of water. However, it does anticipate a larger number of farmed deer.
  - As noted earlier, there are thousands of single family and multi-family units either planned/committed, planned/designated or proposed in the Makawao-Pukalani-Kula District. There are also hundreds of applicants on the Upcountry Water

Service list for subdivisions, building permit applications and water service requests. However, the previously mentioned Water Meter Issuance Rule for the Upcountry system prevents future development in the Makawao-Pukalani-Kula District until sufficient and new water sources are developed.

- **Changes in the capacity of the Upcountry water system**
  - The County of Maui SIX YEAR CAPITAL PROGRAM includes the following projects that will increase system capacity.
    - Waikamoi Flume Improvements (FY 2010-2012) will rehabilitate and reconstruct an old and leaking existing structure which may add a considerable amount of surface water for the Olinda Treatment Plant.
    - Upcountry water storage (FY2011-2015) for the Lower Kula system.
  - Other changes that will increase system capacity include:
    - Extensive conservation program to add source, including the retrofit of highly efficient low flow toilets as well as showerheads and kitchen and bathroom faucet aerators.
    - Cooperative ventures with the private sector for new ground water sources.
      1) ML&P's Pi'iholo Well - Although the well is completed, its production is lower than anticipated. Negotiations are ongoing.
      2) A&B, Inc. well for its Hali'imaile subdivision is still in its planning stage. Negotiations are ongoing.
  - Water Use and Development Plan, Upcountry District, Final Candidate Strategies (draft) will offer future alternatives for increasing system capacity. These strategies include:
    - Expansion of raw water storage at Kamole for the Kamole Water Treatment Plant or Lower Kula for the Pi'iholo Water Treatment Plant
    - Full basal groundwater backup well
    - Limited growth with extensive conservation measures and keep demands within surface water system capacity
    - Expanded Kamole Water Treatment Plant capacity and volume
  - Other measures that are considered in the plan include:
    - Watershed protection and restoration measures to help maintain healthy forests that add water to streams and the groundwater aquifers. DWS's current watershed grant funding includes the Tri-Isle RC&D, Maui Invasive Species Committee, The Nature Conservancy, and the East Maui Watershed Partnership. It also includes grant funding of the Leeward Haleakala Watershed Restoration Partnership.
    - Stream restoration measures that create a more balanced use of surface water. The County and DWS supports the establishment of instream flow standards for East Maui streams.

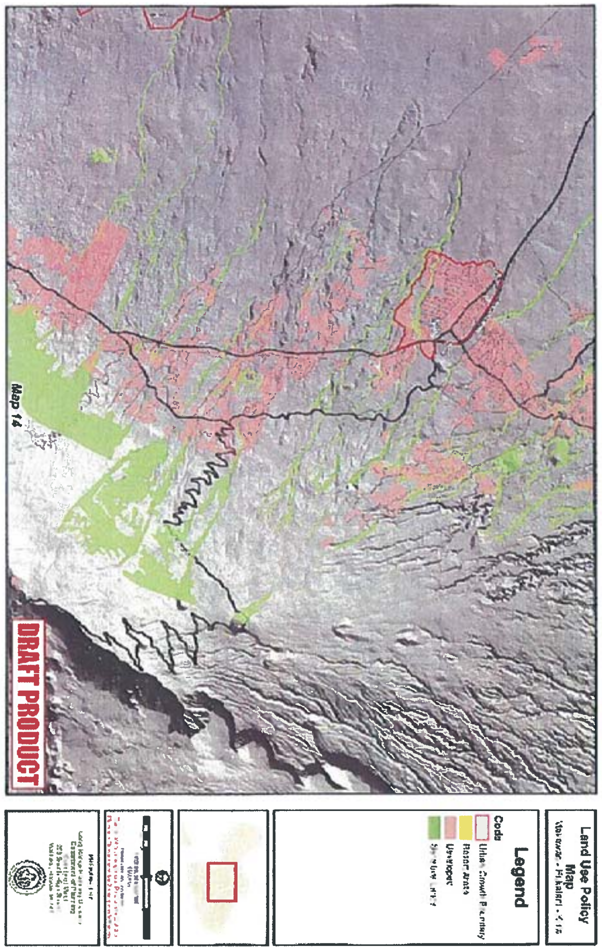


Figure 18 Land Use Policy Map for Makawao-Hali'imaile-Pukalani-Kula Showing Proposed Urban Growth Boundary

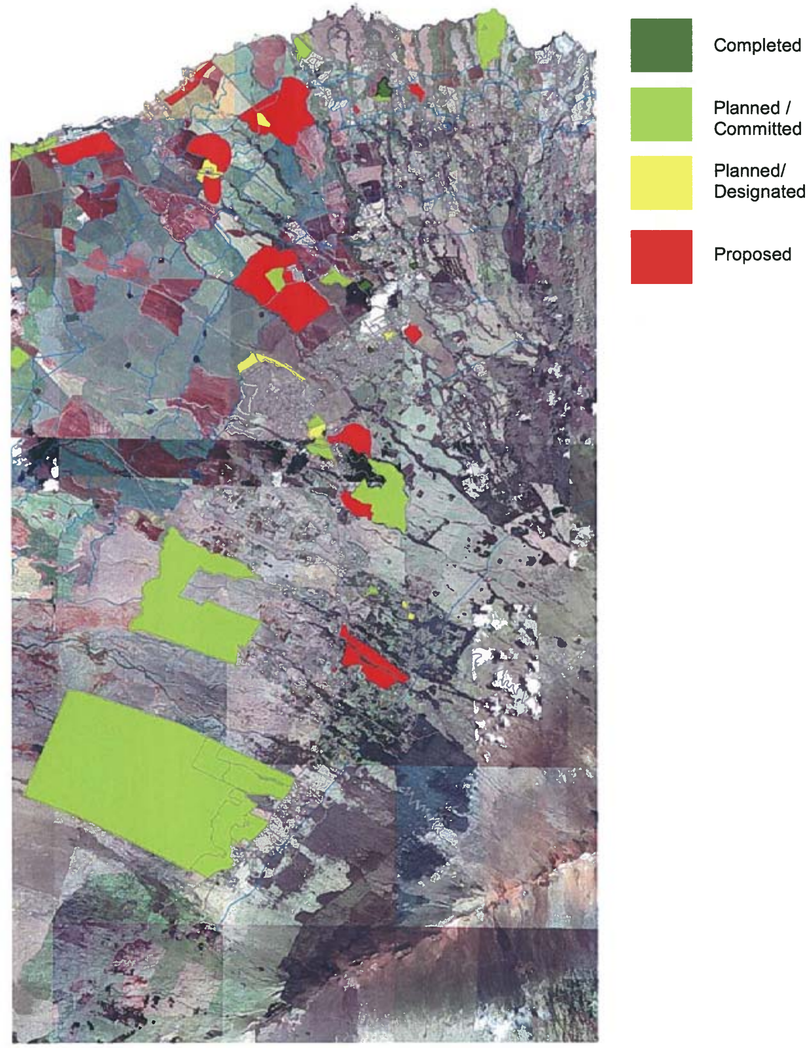


Figure 19 Planned Land Uses In Upcountry Region

WATER CREDITS AGREEMENT

THIS WATER CREDITS AGREEMENT ("AGREEMENT"), made this **9th** day of **DECEMBER**, 1997, by and between the STATE OF HAWAII, DEPARTMENT OF HAWAIIAN HOME LANDS, an agency of the Hawaiian Homes Commission, whose principal place of business is 335 Merchant Street, Honolulu, Hawaii 96813, and whose mailing address is P.O. Box 1879, Honolulu, Hawaii 96805, hereinafter referred to as the "DHHL", and the COUNTY OF MAUI DEPARTMENT OF WATER SUPPLY, a semi-autonomous department of the County of Maui, a political subdivision of the State of Hawaii, whose mailing address is 200 South High Street, Wailuku, Hawaii 96793, hereinafter referred to as the "DWS".

W I T N E S S E T H:

WHEREAS, the DHHL wishes to develop its homesites projects in Kula and Keokea, Maui, Hawaii, shown as (1) the "Kula Residence Lots - Unit 1" on Exhibit "1" attached hereto and made a part hereof, LUCA File No. 2.2305, TMK: (2) 2-2-02-56 (Portion), and (2) Keokea Farm Lots on Exhibit "2" attached hereto and made a part hereof, TMK: 2-2-02-55, both hereinafter called the "DHHL Homesites"; and

WHEREAS, the DHHL estimates that the DHHL Homesites at Kula will be ready to receive water in approximately December of 1999 and the DHHL Homesites at Keokea in 2000; and

WHEREAS, certain water improvements, as hereinafter set forth, are necessary to increase transmission and storage capacity of the DWS's water system in Lower Kula to deliver water to the DHHL Homesites and other potential users in the Lower Kula area; and

WHEREAS, the DHHL and the DWS are willing to cooperate with each other to make the necessary water improvements; and

WHEREAS, Pursuant to the Memorandum of Understanding between County of Maui, DWS and DHHL dated December 8, 1997, a copy of which is attached hereto as Exhibit "3" and incorporated herein by this reference ("MOU"), the DWS committed to make the following improvements: (a) construct a new in-line pump station and, (b) a new two (2) million gallon water storage tank served by the Lower Kula transmission main. In the same MOU, DHHL committed to make the following off-site and on-site improvements: (a) a new off-site transmission main between Naalae Road and DHHL Homesites, (b) two (2) new off-site booster pumps in the vicinity of the existing Kula Kai reservoir, and (c) three (3) new on-site reservoirs and two (2) new on-site pumps, transmission, and distribution lines within the DHHL Homesites ("DHHL Improvements") (the details of these improvements are more fully set forth in the MOU); and

WHEREAS, the MOU contemplated that in consideration of its contribution for construction of the Booster Pump at Kula Kai

Reservoir, construction of transmission water main from Naalae Road to the DHHL subdivision, and construction of on-site reservoirs, pumps, transmission, and distribution lines, DHHL would receive Water System Development Fee ("WSDF") credits from the DWS by separate agreement; and

WHEREAS, the DHHL improvements will be licensed to the DWS in perpetuity (For purposes of this Agreement, and in consideration of Sections 204, 205, and 207 of the Hawaiian Homes Commission Act, DHHL and DWS agree that reference to "dedication" in the WSDF Rules is equivalent to a "license in perpetuity".); and

WHEREAS, no source credits will be granted to DHHL for the DHHL Homesites as DHHL is not developing source as defined in the WSDF Rules; and

WHEREAS, transmission and storage credits will be given to DHHL based on the DHHL improvements; and

WHEREAS, the DWS and DHHL intend this AGREEMENT to set forth the amount of credits DHHL shall receive from the DWS;

NOW, THEREFORE, in consideration of the mutual promises described herein, the undersigned parties hereby agree as follows:

1. WATER FOR DHHL HOMESITES. The DWS shall commit five hundred thousand (500,000) gallons of potable water per average day to DHHL for the DHHL Homesites. Upon completion of the DWS

Improvements and the DHHL Improvements, the DWS shall maintain the improvements and deliver potable water to the DHHL up to an amount of 500,000 gallons per average day, as needed by the DHHL Homesites, except during any drought affecting the Lower Kula area as declared by the DWS in accordance with its rules and regulations. The DWS shall not impose any sort of time limitation on DHHL to draw or use such reservation of potable water from the DWS system.

2. DHHL WATER CREDITS. In consideration of its contribution for construction of (1) the off-site Booster Pumping Station at Kula Kai Reservoir, and construction of transmission water main from Naalae Road to DHHL subdivision, and (2) construction of on-site reservoirs, booster pumps, and transmission lines, which shall be licensed to the DWS in perpetuity, DHHL shall receive from the DWS water credits as follows:

a. Source Credits - No source credit is given. DHHL, or the appropriate applicant, will pay the source component of the Water System Development Fee for the DHHL Homesites in Maui, Hawaii, when DHHL or applicants request the installation of each water meter. No source development payments shall be required by DWS in advance of applying for a water meter.

b. Transmission and Storage Credits - DHHL has satisfied the transmission and storage components of the DWS

Water System Development Fee for any 5/8" meter for the DHHL Homesites in Maui, Hawaii, up to the 500,000 gallons per average day of the water committed. No payment for transmission and storage components of the fees will be required of DHHL by DWS. For any meter over 5/8", the difference between the storage and transmission components for the larger meter and the 5/8" meter shall be deducted from the credits in 2.c below provided the system is adequate.

c. Additional Credits - DHHL shall receive from the DWS an additional $1,561,600 credit as set forth in Exhibit "4" for increasing the transmission and storage capacity of the DWS water system beyond current and planned DWS and future DWS and DHHL needs. The $1,561,600 credit may be used by DHHL to off-set the Water System Development Fee, on a dollar-for-dollar basis, for its other subdivision projects in the County of Maui where the DWS system is adequate and water is available.

3. OTHER DHHL CREDITS. This Agreement shall not affect any of the other DHHL credits the DHHL has with the DWS.

4. GOVERNING LAW. This Agreement shall be construed and enforced in accordance with the laws of the State of Hawaii.

5. ASSIGNABILITY. This Agreement, and the rights and obligations hereunder, shall not be assigned, in whole or in part, by any of the parties hereto to any other persons or entities without the prior written consent of all of the parties

hereto, which consent may be withheld at the sole discretion of any of the parties hereto.

6. NO THIRD PARTY BENEFICIARIES. The execution and delivery of this Agreement shall not be deemed to confer any rights upon, nor obligate any of the parties hereto, to any person or entity not a party to this Agreement.

7. FURTHER ASSURANCES. Each of the parties hereto shall execute and deliver any and all additional papers, documents, and other assurances, and shall do any and all acts and things reasonably necessary in connection with the performance of their obligations hereunder and to carry out the intent of the parties hereto.

8. AMENDMENTS. This Agreement may be amended in whole or in part only by further written agreement executed by all of the parties hereto.

9. INTEGRATION. This Agreement contains all of the agreements of the parties hereto with respect to the matters covered hereby, and no prior agreements, oral or written, or understandings or representations of any nature whatsoever pertaining to any such matters shall be effective for any purpose unless specifically incorporated in the provisions of this Agreement.

IN WITNESS WHEREOF, the parties hereto have executed this Agreement effective on the day and year first above written.

STATE OF HAWAII
DEPARTMENT OF HAWAIIAN HOME LANDS

By ______________________
KALI WATSON
Chairman
Hawaiian Homes Commission

Approved by the Chairman on

DECEMBER 9, 1997

APPROVED AS TO FORM
AND LEGALITY:

____
Deputy Attorney General
State of Hawaii

BOARD OF WATER SUPPLY
OF THE COUNTY OF MAUI

By ______________________
DORVIN D. LEIS
Its Chair

APPROVED AS TO FORM
AND LEGALITY:

____
GARY W. ZAKIAN
Corporation Counsel
County of Maui

STATE OF HAWAII)
) SS.
~~CITY &~~ COUNTY OF ~~HONOLULU~~ Maui)

On this 9th day of December, 1997, before me appeared KALI WATSON, to me personally known, who being by me duly sworn did say that he is the Chairman of the Hawaiian Homes Commission, and that he is authorized to sign the foregoing instrument on behalf of the State of Hawaii, Department of Hawaiian Home Lands, an agency of the Hawaiian Homes Commission, and the said KALI WATSON acknowledged that he executed the said instrument as the free act and deed of said State of Hawaii, Department of Hawaiian Home Lands.

IN WITNESS WHEREOF, I have hereunto set my hand and official seal.

L.S.

____
Notary Public, State of Hawaii

My commission expires: 1-13-99

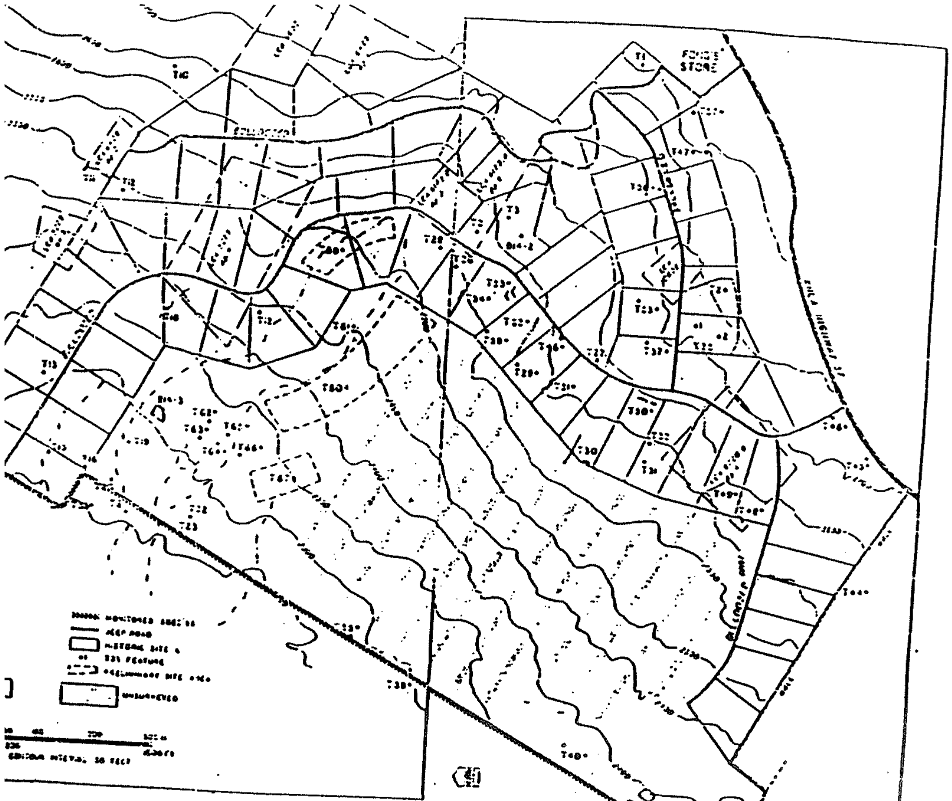
STATE OF HAWAII)
) SS.
COUNTY OF MAUI)

On this 9th day of December, 1997, before me appeared DORVIN D. LEIS, to me personally known, who being by me duly sworn did say that she is the Chairperson of the Board of Water Supply of the County of Maui, a semi-autonomous department of the County of Maui, a political subdivision of the State of Hawaii, and that the seal affixed to the foregoing instrument is the lawful seal of the said Board of Water Supply of the County of Maui, and that the said instrument was signed and sealed on behalf of said Board of Water Supply of the County of Maui, and the said DORVIN D. LEIS acknowledged the said instrument to be the free act and deed of said Board of Water Supply of the County of Maui.

IN WITNESS WHEREOF, I have hereunto set my hand and official seal.

____
Notary Public, State of Hawaii

My commission expires: 4/19/98

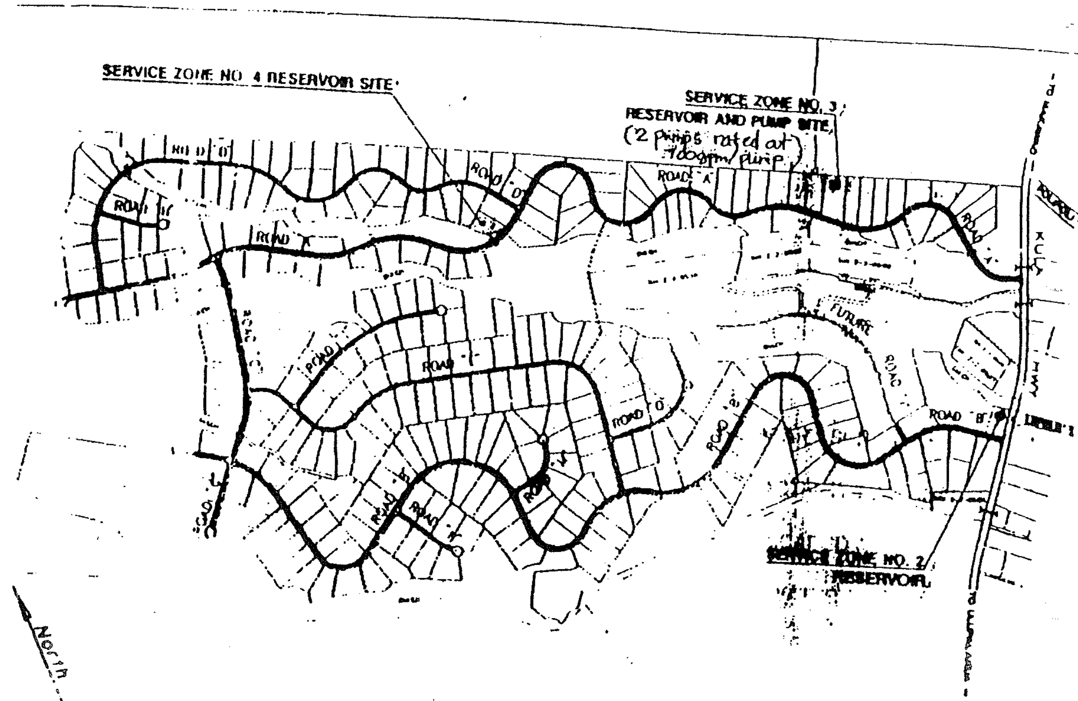


KEOKEA AGRICULTURAL LOTS

EXHIBIT "2"

5.0-51

EXHIBIT "1"



VICINITY MAP

KULA RESIDENCE LOTS - UNIT I

NOT TO SCALE

5.0-50

MEMORANDUM OF UNDERSTANDING

THIS AGREEMENT, made this 8th day of December, 1997, between the STATE OF HAWAII, DEPARTMENT OF HAWAIIAN HOME LANDS, an agency of the Hawaiian Homes Commission, whose mailing address is 335 Merchant Street, Room 307, Honolulu, Hawaii 96813, hereinafter called "DHHL", the DEPARTMENT OF WATER SUPPLY OF THE COUNTY OF MAUI, a semi-autonomous department of the County of Maui, a political subdivision of the State of Hawaii, whose mailing address is 200 South High Street, Wailuku, Hawaii 96793, hereinafter called "DWS", and the COUNTY OF MAUI, a political subdivision of the State of Hawaii, whose mailing address is 200 South High Street, Wailuku, Hawaii 96793, hereinafter called "COUNTY".

W I T N E S S E T H:

WHEREAS, the DHHL wishes to develop its homesites projects in Kula and Keokea, Maui, Hawaii, shown as (1) the "Kula Residence Lots - Unit 1" on Exhibit "1" attached hereto and made a part hereof, LUCA File No. 2.2305, TMK: (2) 2-2-02-56 (Portion), and (2) Keokea Farm Lots on Exhibit "7" attached hereto and made a part hereof, TMK: 2-2-02-55, both hereinafter called the "DHHL Homesites"; and

WHEREAS, the DHHL estimates that the DHHL Homesites at Kula will be ready to receive water in approximately December of 1999 and the DHHL Homesites at Keokea in 2000; and

WHEREAS, certain water improvements, as hereinafter set forth, are necessary to increase transmission and storage capacity

EXHIBIT "3"

of the DWS's water system in Lower Kula to deliver water to the DHHL Homesites and other potential users in the Lower Kula area; and

WHEREAS, the DHHL and the DWS are willing to cooperate with each other to make the necessary water improvements; and

WHEREAS, the COUNTY is willing to financially assist the DHHL and the DWS by appropriating a certain amount of funds, as hereinafter set forth, for the DWS to construct the necessary water improvements, for which contribution the COUNTY shall receive water credits from the DWS as hereinafter set forth; now, therefore,

The undersigned parties agree as follows:

1. **COUNTY APPROPRIATION**. The Maui County Council has adopted those certain ordinances, collectively attached hereto as Exhibit "2", which amend the COUNTY's budget for the 1996-1997 fiscal year to appropriate and authorize the issuance of bonds for ONE MILLION FIVE HUNDRED AND 00/100 DOLLARS ($1,500,000.00) for the DWS to use to construct the "Lower Kula Booster Pump Station and Storage Tank", and enable the Mayor to execute this intergovernmental agreement pursuant to Section 2.20.020, Maui County Code.

2. **DWS IMPROVEMENTS**. Pursuant to an executed contract for construction of the "Lower Kula Booster Pump Station and Storage Tank", the DWS shall construct the following improvements, hereinafter collectively called the "DWS Improvements":

a. **New Pump Station and New Storage Tank**. The DWS intends to construct, at its own expense including the aforesaid appropriation of funds by the COUNTY, a new in-line pumping station and a new two (2) million gallon water storage tank on the Lower Kula transmission main. These DWS Improvements are intended to increase transmission capacity between the Lower Kula Water Treatment Plant and the Kula Kai Tank and increase storage capacity. The location of the proposed booster pump and tank site are shown on Exhibit "3" attached hereto and made a part hereof.

The DWS's contract documents for construction of the proposed booster pump station and tank are attached hereto as Exhibit "4" and made a part hereof. The DWS estimates that its project to construct the DWS Improvements will require approximately fourteen months for completion.

b. **Land Rights**. The proposed pump station and tank site are to be located on Lot 3-B, being a 5.6 acre portion of TMK: (2) 2-4-13-179. Lot 3-B is shown on Exhibit "5" attached hereto and made a part hereof. Lot 3-B is not currently owned by the DWS. The DWS shall secure all temporary and permanent land rights to Lot 3-B before the aforesaid appropriation of funds by the COUNTY is released, in whole or in part, to the DWS.

c. **Construction Standards**. The DWS shall construct the foregoing DWS Improvements in accordance with all laws, ordinances, codes, permits, guidelines, rules and regulations of the County, State and Federal governments.

3. **DHHL IMPROVEMENTS**. The DHHL shall construct, at its own expense, the following improvements, hereinafter collectively called the "DHHL Improvements":

a. **New Transmission Main**. The DHHL intends to construct a new eighteen (18) inch water transmission main, approximately 8,000 to 9,000 feet in length, from approximately Naalae Road to the DHHL Homesites. The location of the proposed transmission main is shown on Exhibit "6" attached hereto and made a part hereof.

b. **New Booster Pumps**. The DHHL intends to construct two (2) new booster pumps (rated at 4,200 gpm each pump) in the vicinity of the existing Kula Kai Tank. The location of the proposed reservoir sites and pump sites are shown on Exhibit "8".

c. **New Reservoirs and Pumps**. The DHHL intends to construct, within the DHHL Homesites, three (3) new reservoirs and two (2) new pumps (rated at 700 gpm each pump). The location of the proposed reservoir sites and pump sites are shown on Exhibit "1".

d. **Subdivision Requirements**. The DHHL intends to construct the drainage, roadway, on-site water, grading and all other subdivision improvements for the DHHL Homesites pursuant to construction plans approved by the Department of Public Works and Waste Management, County of Maui, for LUCA File No. 2.2305. The DHHL shall complete these subdivision improvements prior to final subdivision approval of the DHHL Homesites. Upon final subdivision approval of the DHHL Homesites, the DHHL shall make all of the

"Kula Residence Lots - Unit I", as shown on Exhibit "1", available to lessees of the DHHL to construct residences thereon.

e. **Land Rights**. The DHHL shall secure all necessary land rights for the DHHL Improvements to be constructed.

f. **Construction Standards**. The DHHL shall construct the DHHL Improvements in accordance with all laws, ordinances, codes, permits, guidelines, rules and regulations of the County, State and Federal governments. The DHHL shall also warrant and guarantee by way of assignment of Contractor's bond the improvements set forth in the construction plans and specifications, from any defects in materials and workmanship for a period of one year from the date of final approval of improvements.

4. **WATER FOR DHHL HOMESITES**. Upon completion of the DWS Improvements and the DHHL Improvements, the DWS shall maintain the improvements and deliver water to the DHHL up to an amount of 500,000 gallons per day, as needed by the DHHL Homesites, except during any drought affecting the Lower Kula area as declared by the DWS in accordance with its rules and regulations. The DWS will not impose any sort of time limitation on DHHL to draw or use such reservation of potable water from DWS system.

5. **COUNTY WATER CREDITS**. In consideration of its contribution of ONE MILLION FIVE HUNDRED AND 00/100 DOLLARS ($1,500,000.00) to the DWS for the construction of the DWS

Improvements, the COUNTY shall receive from the DWS dollar-for-dollar credit for every dollar appropriated and disbursed to or for the DWS for the DWS Improvements, if paid for out of COUNTY general funds, or dollar-for-dollar credit on the principal amount for bonds issued by the COUNTY for the DWS Improvements.

The COUNTY may use its water credits, or transfer the same to other persons or entities, hereinafter called "transferee(s)", to obtain water from the DWS. The COUNTY or its transferee(s) may use the water credits to off-set, dollar for dollar, any fees or charges imposed by the DWS for water to be supplied by the DWS to the COUNTY or its transferee(s), including but not limited to using the water credits to off-set any Water System Development Fee. The COUNTY or its transferee(s) may use the water credits to obtain water from the DWS at any time, unless water is not available as mutually determined and agreed in writing by the COUNTY and the DWS. The COUNTY or its transferee(s) may use the water credits without the restriction stated in Section 16-8-11(c) of the Water System Development Fee.

6. **DHHL WATER CREDITS**. In consideration of its contribution for construction of the Booster Pump at Kula Kai Reservoir, construction of transmission water lines from Naalae Road to DHHL subdivision, and construction of on-site reservoirs and pumps, DHHL shall receive Water System Development Fee credits as agreed between DHHL and DWS by separate agreement.

a. Further, DHHL will pay the source portion of the Water System Development Fee when applicants request the installation of each water meter. No advance source development payments shall be required; and

b. This agreement shall not affect any previously accumulated hook-up credits, nor any reimbursements due DHHL by the DWS for past projects such as Waiehu Kou.

7. **DISBURSEMENT OF COUNTY APPROPRIATION**. The DWS shall submit to the COUNTY written Reimbursement Requests for the work performed pursuant to the executed contract for construction of the "Lower Kula Booster Pump Station and Storage Tank". Each Reimbursement Request shall be authenticated as to its accuracy by the DWS and verified by a designated official of the COUNTY. Each Reimbursement Request shall include a certification by the DWS that the work for which payment is requested was performed in accordance with the terms of this Memorandum of Understanding. The DWS shall maintain in its files, at all times, documentation certifying that the work described in any invoices, executed contracts or Reimbursement Requests sent to the COUNTY are complete, correct and in accordance with the terms of this Memorandum of Understanding.

8. **GOVERNING LAW**. This Memorandum of Understanding shall be construed and enforced in accordance with the laws of the State of Hawaii.

9. **ASSIGNABILITY**. This Memorandum of Understanding, and the rights and obligations hereunder, shall not be assigned, in whole or in part, by any of the parties hereto to any other persons

or entities without the prior written consent of all of the parties hereto, which consent may be withheld at the sole discretion of any of the parties hereto.

10. **NO THIRD PARTY BENEFICIARIES**. The execution and delivery of this Memorandum of Understanding shall not be deemed to confer any rights upon, nor obligate any of the parties hereto, to any person or entity not a party to this Memorandum of Understanding.

11. **FURTHER ASSURANCES**. Each of the parties hereto shall execute and deliver any and all additional papers, documents, and other assurances, and shall do any and all acts and things reasonably necessary in connection with the performance of their obligations hereunder and to carry out the intent of the parties hereto.

12. **AMENDMENTS**. This Memorandum of Understanding may be amended in whole or in part only by further written agreement executed by all of the parties hereto.

13. **INTEGRATION**. This Memorandum of Understanding contains all of the agreements of the parties hereto with respect to the matters covered hereby, and no prior agreements, oral or written, or understandings or representations of any nature whatsoever pertaining to any such matters shall be effective for any purpose unless specifically incorporated in the provisions of this Memorandum of Understanding.

IN WITNESS WHEREOF, this Memorandum of Understanding has been executed on the day and year first above written.

STATE OF HAWAII
DEPARTMENT OF HAWAIIAN HOME LANDS

By [signature]
KALI WATSON
Chairman
Hawaiian Homes Commission

Approved by the Chairman on

December 8, 1997 xx1997

APPROVED AS TO FORM
AND LEGALITY:

[signature]
Deputy Attorney General
State of Hawaii

BOARD OF WATER SUPPLY
OF THE COUNTY OF MAUI

By [signature]
DORVIN D. LEIS
Its Chair

COUNTY OF MAUI

By [signature]
LINDA LINGLE
Its Mayor

APPROVED AS TO FORM
AND LEGALITY:
[signature]
LILLIAN B. KOLLER
Deputy Corporation Counsel
County of Maui
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STATE OF HAWAII)
) SS.
CITY & COUNTY OF HONOLULU)

On this 8th day of December, 1997, before me appeared KALI WATSON, to me personally known, who being by me duly sworn did say that he is the Chairman of the Hawaiian Homes Commission, and that he is authorized to sign the foregoing instrument on behalf of the State of Hawaii, Department of Hawaiian Home Lands, an agency of the Hawaiian Homes Commission, and the said KALI WATSON acknowledged that he executed the said instrument as the free act and deed of said State of Hawaii, Department of Hawaiian Home Lands.

IN WITNESS WHEREOF, I have hereunto set my hand and official seal.

L.S.

[signature]
Notary Public, State of Hawaii

My commission expires: 2-20-2000

STATE OF HAWAII)
) SS.
COUNTY OF MAUI)

On this 18th day of November, 1997, before me appeared DORVIN D. LEIS, to me personally known, who being by me duly sworn did say that he is the Chairperson of the Board of Water Supply of the County of Maui, a semi-autonomous department of the County of Maui, a political subdivision of the State of Hawaii, and that the seal affixed to the foregoing instrument is the lawful seal of the said Board of Water Supply of the County of Maui, and that the said instrument was signed and sealed on behalf of said Board of Water Supply of the County of Maui, and the said DORVIN D. LEIS acknowledged the said instrument to be the free act and deed of said Board of Water Supply of the County of Maui.

IN WITNESS WHEREOF, I have hereunto set my hand and official seal.

[signature]
Notary Public, State of Hawaii

My commission expires: 4/19/98

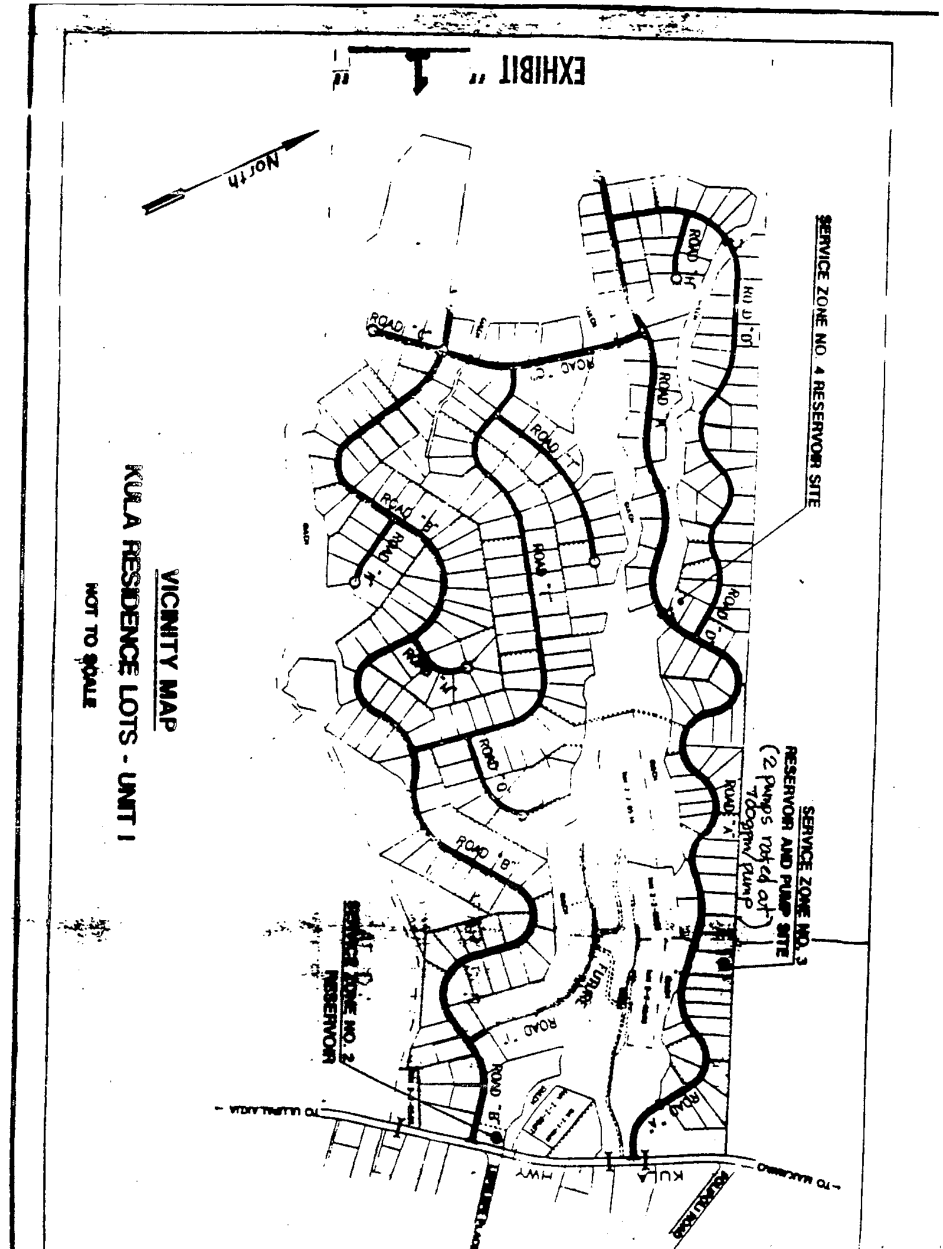
STATE OF HAWAII)
) SS.
COUNTY OF MAUI)

On this 26th day of November, 1997, before me appeared LINDA LINGLE, to me personally known, who, being by me duly sworn, did say that she is the Mayor of the County of Maui, a political subdivision of the State of Hawaii, and that the seal affixed tot he foregoing instrument is the lawful seal of the said County of Maui, and that the said instrument was signed and sealed on behalf of said County of Maui by authority of its Charter, and the said LINDA LINGLE acknowledged the said instrument to be the free act and deed of said corporation.

IN WITNESS WHEREOF, I have hereunto set my hand and official seal.

Marshall E. Cravin
Notary Public, State of Hawaii

My commission expires: 12-7-99



For: Mayor's Office
ORDINANCE NO. 2536
Effective Date: March 12, 1997

ORDINANCE NO. 2536

BILL NO. 3 (1997)

A BILL FOR AN ORDINANCE AMENDING THE BUDGET FOR THE COUNTY OF MAUI FOR THE FISCAL YEAR JULY 1, 1996 TO JUNE 30, 1997

BE IT ORDAINED BY THE PEOPLE OF THE COUNTY OF MAUI:

SECTION 1. Section 2 of Ordinance No. 2502, Bill No. 32 (1996), the "Fiscal Year 199 Budget" of the County of Maui, is hereby amended to reflect an increase of $15,792,500 i excess of budget estimates, as follows:

"ESTIMATED REVENUES

FROM TAXES, FEES AND ASSESSMENTS:		
Real Property Taxes		$ 72,954,874
Circuit Breaker Adjustment		(1,000,000)
Charges for Current Services		21,953,000
Transient Accommodation Tax		19,680,000
Licenses/Permits/Others	[11,559,696]	11,645,196
Fuel and Franchise Taxes		9,742,000
Special Assessments		2,710,240
Other Intergovernmental		6,659,500
FROM OTHER SOURCES:		
Interfund Transfers		30,489,212
Bond/Lapsed Bond	[17,578,330]	33,285,330
Carryover/Savings		20,962,627
TOTAL ESTIMATED REVENUES	[$213,289,479]	$229,081,979"

EXHIBIT "2"

5.0-64

SECTION 2. Section 3.B.9.b. of Ordinance No. 2502, Bill No. 32 (1996), the "Fiscal Ye 1997 Budget" of the County of Maui, is hereby amended to appropriate $85,500 as follows:

9. Department of Parks and Recreation

"b. Aquatics Program

(1) Provided, that disbursement for salaries and premium pay is limited to 50.5 equivalent personnel." [$ 1,948,281] $ 2,033,781

SECTION 3. Section 4.E. of Ordinance No. 2502, Bill No. 32 (1996), the "Fiscal Ye 1997 Budget" of the County of Maui, is hereby amended to appropriate $15,707,000 as follow

PROJECT TITLE	APPROPRIATION
"E. From the Bond Fund	
1. Wailuku-Kahului Community Plan District	
a. Park Improvements	$ 12,500,000
(1) Maui Central Park	
b. Wastewater Improvements	$ 137,000
(1) Wailuku-Kahului WWRF Septage Receiving Station	
[a.] c. Sanitation	$ 3,700,000
(1) Central Maui Landfill Expansion	
[b.] d. Other Projects	$ 5,950,000
(1) Waiale Affordable Rental Project	
2. Makawao-Pukalani-Kula Community Plan District	
a. Other Projects	$ 1,500,000
(1) Lower Kula Booster Pump Station and Storage Tank	
3. Kihei-Makena Community Plan District	
a. Park Improvements	$ 400,000
(1) Kihei Community Center/Swimming Pool	
[2.] 4. Lahaina Community Plan District	
a. Government Facilities	$ 600,000
(1) Grants and disbursements for Old Lahaina Courthouse Renovation	
b. Park Improvements	$ 170,000

(1) Lahaina Aquatic Center Improvements

[b.] c. Other Projects $ 500,000

(1) Grants and disbursements for Lahaina Visitor Center/Public Restrooms

[3.]5. Molokai Community Plan District

a. Park Improvements $ 1,000,000

(1) Kualapuu Community Center

[a.] b. Drainage $ 800,000

(1) Kaunakakai Drainage

[b.] c. Sanitation $ 150,000

(1) Molokai Landfill Expansion

[4.]6. Countywide

a. Other Projects $ 1,500,000

(1) Beach Access and Park Land Acquisition"

SECTION 4. Section 16. of Ordinance No. 2502, Bill No. 32 (1996) is hereby amended t increase the aggregate amount of transfers and loans which shall be unreimbursed, as follows

"SECTION 16. For the purpose of this section, "County fund" excludes pension o retirement funds, funds under the control of any independent board or commission, funds se aside for the redemption of bonds or the payment of interest thereon, park dedication funds or special purpose funds. In the event there are monies in any County fund that, in th judgment of the Director of Finance, are in excess of the amounts necessary for the immediat requirements of the respective funds, and where, in the judgement of the Director of Finance such action will not impede the necessary or desirable financial operations of the County the Director of Finance may make temporary transfers or loans therefrom without interest t the Bond Fund or the Housing Development Revolving Fund. The amount of such temporar transfers or loans shall not exceed the amount of general obligation bonds or note authorized but not issued. At any time the aggregate amount of such transfers and loan which shall be unreimbursed shall not exceed [$20,000,000] $30,000,000. Monies transferre or loaned shall be expended only for appropriations from the Bond Fund or the Housing Interi Financing and Buy-back Revolving Fund which are specified to be financed from the sale o general obligation bonds or notes. The fund from which transfers or loans are made shall b reimbursed by the Director of Finance from the proceeds of the sale of general obligatio bonds or notes upon the eventual issuance and sale of such bonds or notes. Within 30 day after each transfer or loan, the Director of Finance shall report to the Council on: (1) th amount of transfer or loan requirement; (2) the reason or justification for the transfer o loan; (3) the source of funding to reimburse or repay the transfer or loan; and (4) the tim schedule proposed for reimbursement or repayment of the transfer or loan. The transfer o loan shall be reimbursed or repaid within one year after it is made, subject to waiver b Council resolution.

At the close of each quarter, the Director of Finance shall submit to the Council Combined Statement of Cash receipts and Disbursements showing for each month for eac individual fund the cash balance at the start of the accounting period, the cash receipts an

disbursements during the period, and the cash balance at the end of the period. Within 3 days after the close of each quarter, the Director shall submit a separate report showing th accumulated balance of any fund or account which exceeds $100,000, and which would b available for appropriation upon certification by the Mayor."

SECTION 5. Total operating appropriations is amended to reflect an increase of $85,50 as follows:

"TOTAL OPERATING APPROPRIATIONS [$180,473,479] $180,558,979"

SECTION 6. Total capital improvement projects appropriations is amended to reflect a increase of $15,707,000 as follows:

"TOTAL CAPITAL IMPROVEMENT PROJECTS APPROPRIATIONS [$ 32,816,000] $ 48,523,000"

SECTION 7. Total appropriations (operating and capital improvement projects) is amende to reflect an increase of $15,792,500 as follows:

"TOTAL APPROPRIATIONS (OPERATING AND CAPITAL IMPROVEMENT PROJECTS) [$213,289,479] $229,081,979"

SECTION 8. Material to be repealed is bracketed. New material is underscored. I printing this ordinance, the County Clerk need not include the brackets, the brackete material or the underscoring.

SECTION 9. This ordinance shall take effect upon its approval.

APPROVED AS TO FORM AND LEGALITY:

BRIAN T. MOTO
Deputy Corporation Counsel
County of Maui
gk:97rev7

WE HEREBY CERTIFY that the foregoing BILL NO. 3 (1997)

1. Passed FINAL READING at the meeting of the Council of the County of Maui, State of Hawaii, held on the 7th day of March, 1997, by the following votes:

Patrick S. KAWANO Chair	James "Kimo" APANA Vice-Chair	Alan ARAKAWA	J. Kalani ENGLISH	Sol P. KAHO'OHALAHALA	Alice L. LEE	Dennis Y. NAKAMURA	Wayne K. NISHIKI	Charmaine TAVARES
Aye	Aye	Aye	Aye	Aye	Aye	Aye	Aye	Aye

2. Was transmitted to the Mayor of the County of Maui, State of Hawaii, on the 7th day of March, 1997.

DATED AT WAILUKU, MAUI, HAWAII, this 7th day of March, 1997.

PATRICK S. KAWANO, CHAIR
Council of the County of Maui

DARYL T. YAMAMOTO, COUNTY CLERK
County of Maui

THE FOREGOING BILL IS HEREBY APPROVED THIS 12th DAY OF MARCH, 1997.

LINDA CROCKETT LINGLE, MAYOR
County of Maui

I HEREBY CERTIFY that upon approval of the foregoing BILL by the Mayor of the County of Maui, the said BILL was designated as ORDINANCE NO. 2536 of the County of Maui, State of Hawaii.

DARYL T. YAMAMOTO, COUNTY CLERK
County of Maui

Passed First Reading on February 21, 1997.
Effective date of Ordinance March 12, 1997.

I HEREBY CERTIFY that the foregoing is a true and correct copy Ordinance No. 2536, the original of which is on file in the Office the County Clerk, County of Maui, State of Hawaii.

Dated at Wailuku, Hawaii, on

County Clerk, County of Maui

RECEIVED

For: Mayor's Office
ORDINANCE NO. 2537
Effective Date: March 12, 199

ORDINANCE NO. 2537

BILL NO. 4 (1997)

A BILL FOR AN ORDINANCE AMENDING ORDINANCE NO. 2504, BILL NO. 34 (1996), AUTHORIZING THE ISSUANCE OF GENERAL OBLIGATION BONDS OF THE COUNTY OF MAUI

BE IT ORDAINED BY THE PEOPLE OF THE COUNTY OF MAUI:

SECTION 1. SECTION 1 of Ordinance No. 2504, Bill No. 34 (1996), is hereby amended to increase the aggregate principal amount of general obligation bonds of the County of Maui authorized to be issued by $15,707,000, as follows:

"SECTION 1. Authorization of General Obligation Bonds. Pursuant to Chapter 47, Hawaii Revised Statutes, as amended, and particularly Part I thereof, there are hereby authorized to be issued and sold from time to time general obligation bonds of the County of Maui, State of Hawaii (the "County") in an aggregate principal amount not to exceed [$13,200,000] $28,907,000 (the "Bonds"), the proceeds derived from the sale of which shall be used to pay all or part of the cost of appropriations for the public improvements of the County described in Section 2 hereof."

SECTION 2. SECTION 2 of Ordinance No. 2504, Bill No. 34 (1996), is hereby amended to include the Maui Central Park, Wailuku-Kahului Wastewater Reclamation Facility Septage Receiving Station, Lower Kula Booster Pump Station and Storage Tank, Kihei Community Center/Swimming Pool, Lahaina Aquatic Center Improvements, and Kualapuu Community Center among the projects to be financed from the proceeds of general obligation bonds authorized to be issued thereunder, as follows:

"SECTION 2. Disposition of Bond Proceeds. All or any portion of the proceeds derived from the sale of the Bonds or any notes issued in anticipation of the Bonds shall be used to pay all or part of the cost of any of the public improvements listed below in accordance with appropriations contained in the Operating Budget and Capital Improvements Program Ordinance, including amendments and supplements thereto, duly adopted by the Council of the County for the fiscal year ending June 30, 1997; provided, however, that pursuant to Section 47-5, Hawaii Revised Statutes, the part of such proceeds which are in excess of the amounts required for the purposes for which the Bonds are initially issued from time to time, or which may not be applied to such purposes, or which this Council deems should not be applied to such purposes, may be applied to finance such other public improvements of the County as the Council of the County shall, by ordinance approved by an affirmative vote of two-thirds of all of its members, determine; and provided further that the actual use and application of the proceeds of Bonds issued pursuant to this ordinance shall not in any way affect the validity or legality of such Bonds. No proceeds of the Bonds shall be applied to any public improvement listed in this section unless and until there shall be a valid appropriation of general obligation bond proceeds in effect for such public improvement. The public improvements provided for or to be provided for in the Operating Budget and Capital Improvements Program Ordinance, to be financed with proceeds from the sale of the Bonds, are as follows:

Public Improvements:
Estimated Project Cost

A.	Wailuku-Kahului Community Plan District	
(1)	Park Improvements	$12,500,000
	a. Maui Central Park	
(2)	Wastewater Improvements	$ 137,000
	a. Wailuku-Kahului Wastewater Reclamation Facility Septage Receiving Station	
[(1)](3)	Sanitation	$ 3,700,000
	a. Central Maui Landfill Expansion	
[(2)](4)	Other Projects	$ 5,950,000
	a. Waiale Road Affordable Rental	
B.	Makawao-Pukalani-Kula Community Plan District	
(1)	Other Projects	$ 1,500,000
	a. Lower Kula Booster Pump Station and Storage Tank	
C.	Kihei-Makena Community Plan District	
(1)	Park Improvements	$ 400,000
	a. Kihei Community Center/Swimming Pool	

[B.] D.	Lahaina Community Plan District	
(1)	Government Facilities	$ 600,000
	a. Old Lahaina Courthouse Renovation	
(2)	Park Improvements	$ 170,000
	a. Lahaina Aquatic Center Improvements	
[(2)](3)	Other Projects	$ 500,000
	a. Visitor Center/Public Restrooms	
[C.]E.	Molokai Community Plan District	
(1)	Park Improvements	$ 1,000,000
	a. Kualapuu Community Center	
[(1)](2)	Drainage	$ 800,000
	a. Kaunakakai Drainage Improvements	
[(2)](3)	Sanitation	$ 150,000
	a. Molokai Landfill Expansion	
[C.]F.	Countywide	
(1)	Other Projects	$ 1,500,000
	a. Beach Access and Park Land Acquisition	

The cost of issuance of the Bonds or any series thereof, including without limitation, the initial fee of paying agents and registrars, the fees of financial consultants and bond counsel, the cost of preparation of any Official Statement relating to the Bonds, any notices of sale and forms of bid and the definitive Bonds, and the costs of publication of any notices of sale, may be paid from the proceeds of the Bonds or any series thereof and such costs shall be allocated pro rata to each of the foregoing projects financed from such proceeds."

SECTION 3. Material to be repealed is bracketed. New material is underscored. In printing this bill, the County Clerk need not include the brackets, the bracketed material or the underscoring.

SECTION 4. This ordinance shall take effect upon its approval.

APPROVED AS TO FORM AND LEGALITY:

BRIAN T. MOTO
Deputy Corporation Counsel
County of Maui
gk:97gorev2

WE HEREBY CERTIFY that the foregoing BILL NO. 4 (1997)

1. Passed FINAL READING at the meeting of the Council of the County of Maui, State of Hawaii, held o the 7th day of March, 1997, by the following votes:

Patrick S. KAWANO Chair	James "Kimo" APANA Vice-Chair	Alan ARAKAWA	J. Kalani ENGLISH	Sol P. KAHO'OHALAHALA	Alice L. LEE	Dennis Y. NAKAMURA	Wayne K. NISHIKI	Charmaine TAVARES
Aye	Aye	Aye	Aye	Aye	Aye	Aye	Aye	Aye

2. Was transmitted to the Mayor of the County of Maui, State of Hawaii, on the 7th day of March, 1997.

DATED AT WAILUKU, MAUI, HAWAII, this 7th day of March, 1997.

PATRICK S. KAWANO, CHAIR
Council of the County of Maui

DARYL T. YAMAMOTO, COUNTY CLERK
County of Maui

THE FOREGOING BILL IS HEREBY APPROVED THIS 12th DAY OF MARCH, 1997.

LINDA CROCKETT LINGLE, MAYOR
County of Maui

I HEREBY CERTIFY that upon approval of the foregoing BILL by the Mayor of the County of Maui, the sai BILL was designated as ORDINANCE NO. 2537 of the County of Maui, State of Hawaii.

DARYL T. YAMAMOTO, COUNTY CLERK
County of Maui

Passed First Reading on February 21, 1997.
Effective date of Ordinance March 12, 1997.

RECEIVED

I HEREBY CERTIFY that the foregoing is a true and correct copy c Ordinance No. 2537 , the original of which is on file in the Office c the County Clerk, County of Maui, State of Hawaii.

Dated at Wailuku, Hawaii, on

County Clerk, County of Maui

EXHIBIT "4"

5.0-75

DEPARTMENT OF WATER SUPPLY
COUNTY OF MAUI, HAWAII

CONTRACT DOCUMENTS FOR CONSTRUCTION OF

LOWER KULA
BOOSTER PUMP STATION AND TANK

JOB NO. - DWS 94-13

APPROVED BY:

DIRECTOR, DEPARTMENT OF WATER SUPPLY, COUNTY OF MAUI — DATE

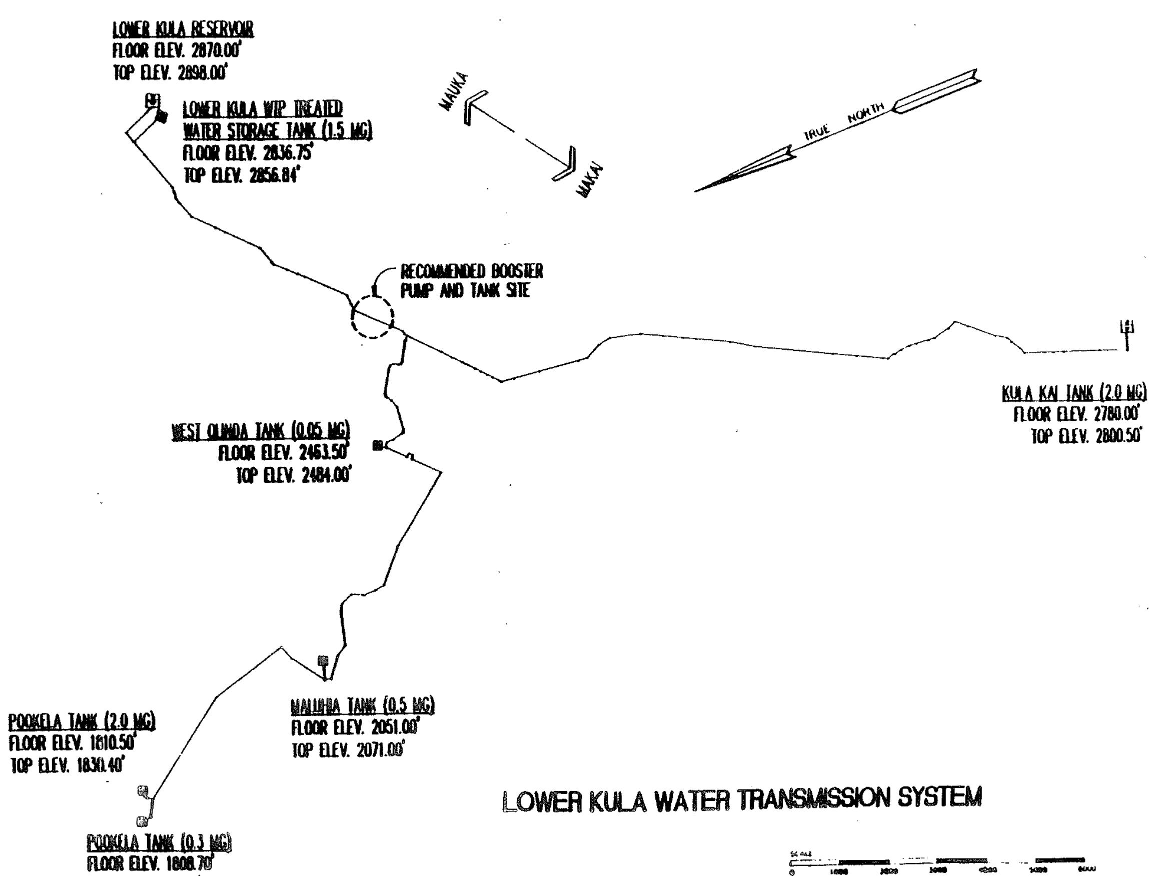
ECM Engineering Consultants

BROWN AND CALDWELL

MARCH 1996

EXHIBIT "3"

5.0-74



NOTES

DEPARTMENT OF WATER SUPPLY
COUNTY OF MAUI, HAWAII

LOWER KULA
BOOSTER PUMP STATION and TANK

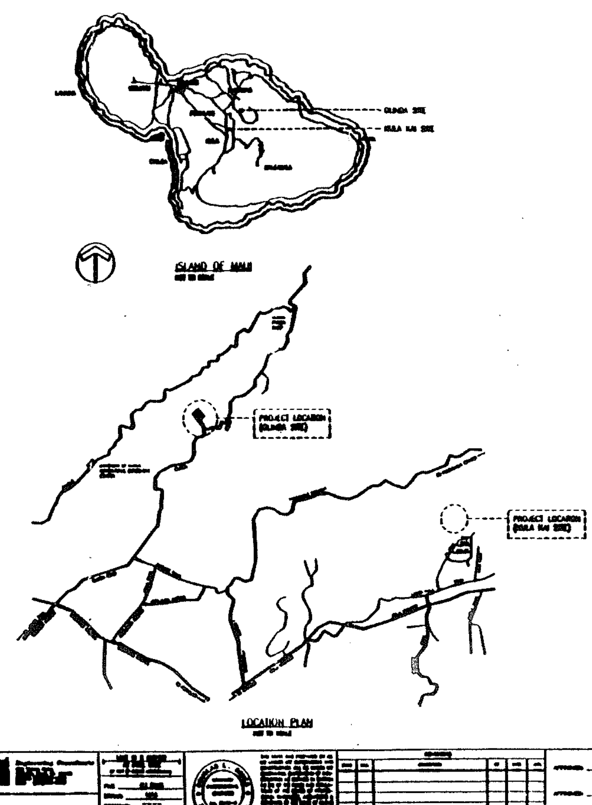
CIVIL

NOTES

C-1

BROWN AND CALDWELL

5.0-77



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DEPARTMENT OF WATER SUPPLY
COUNTY OF MAUI, HAWAII

LOWER KULA
BOOSTER PUMP STATION and TANK

GENERAL

LOCATION PLAN/VICINITY MAP
INDEX TO DRAWINGS

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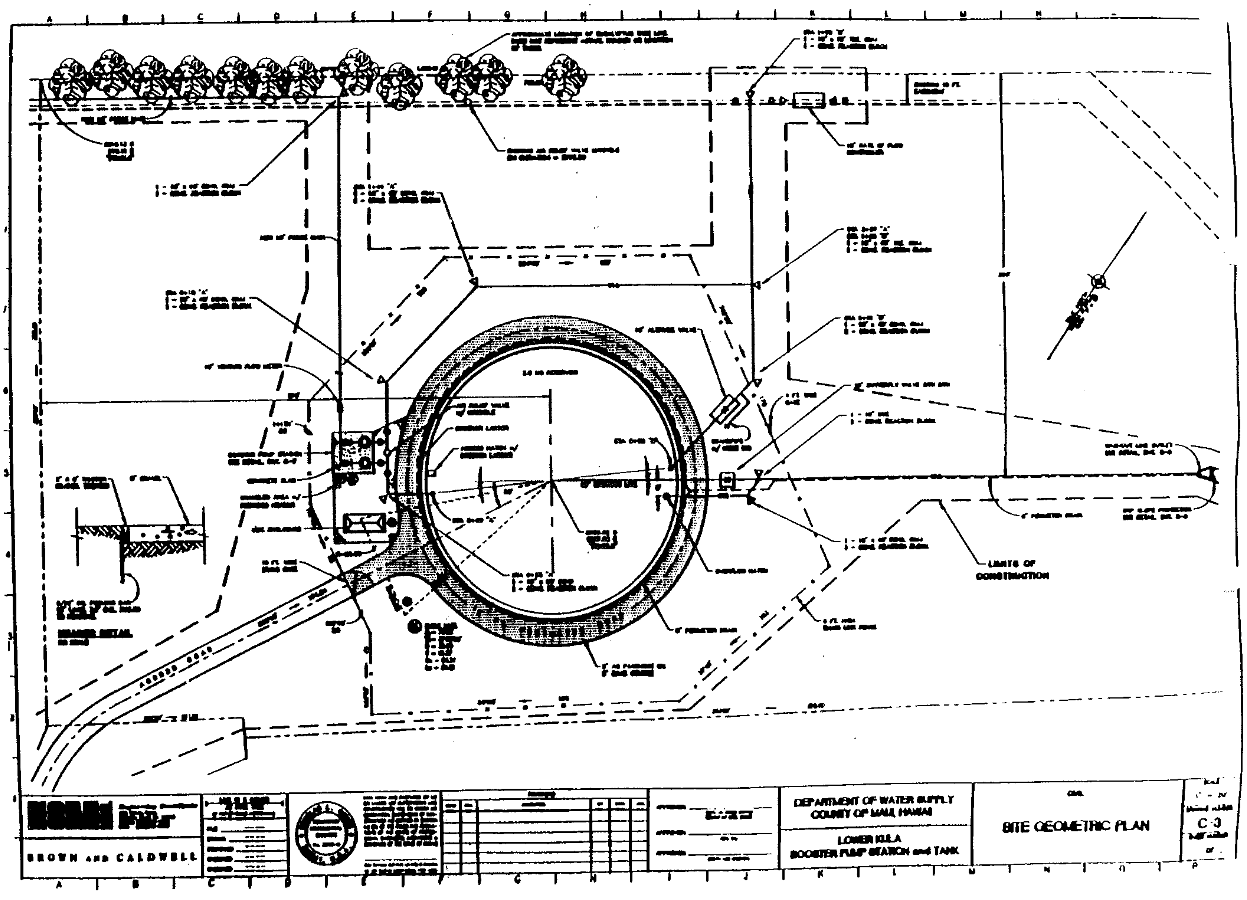
BROWN AND CALDWELL

5.0-76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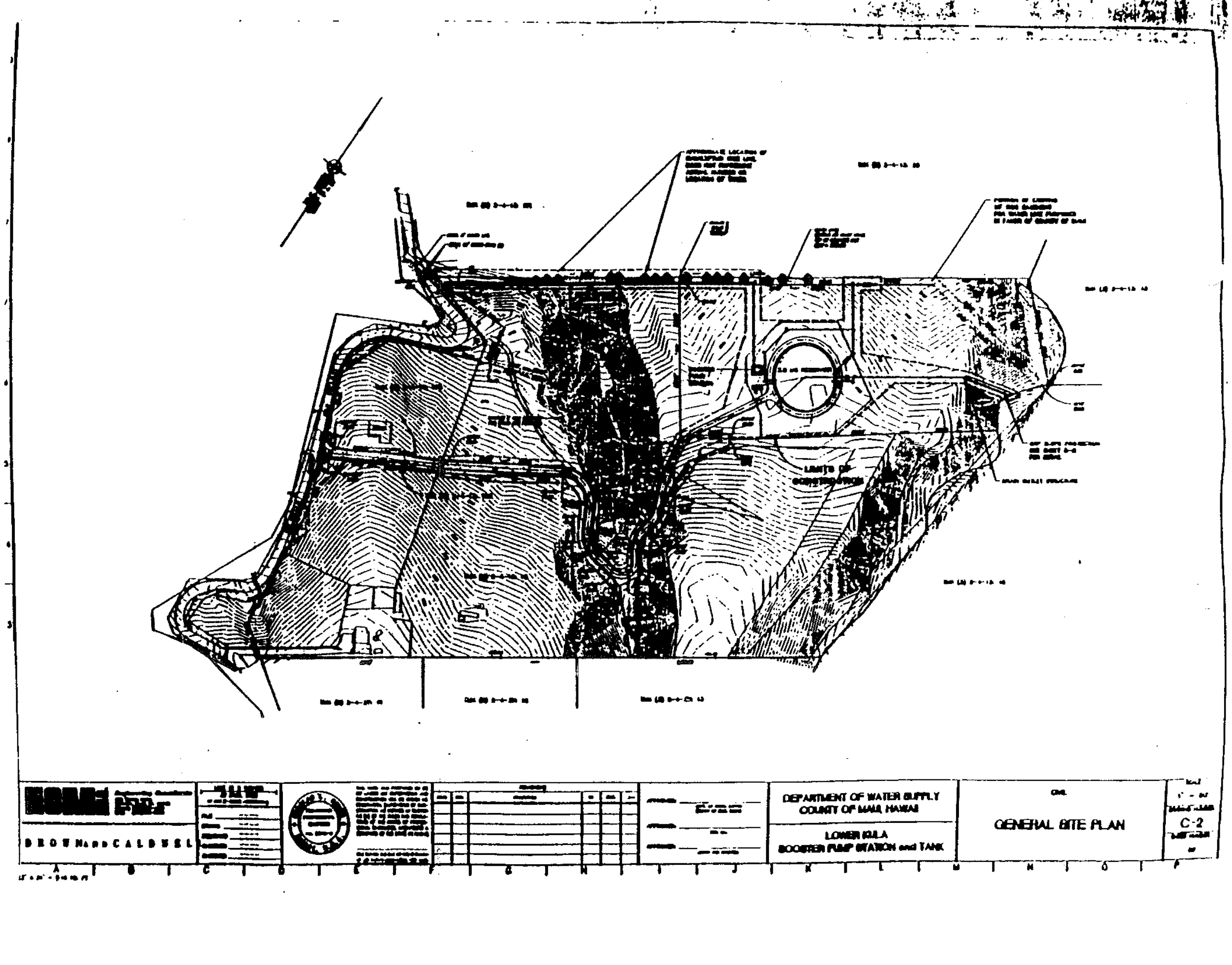
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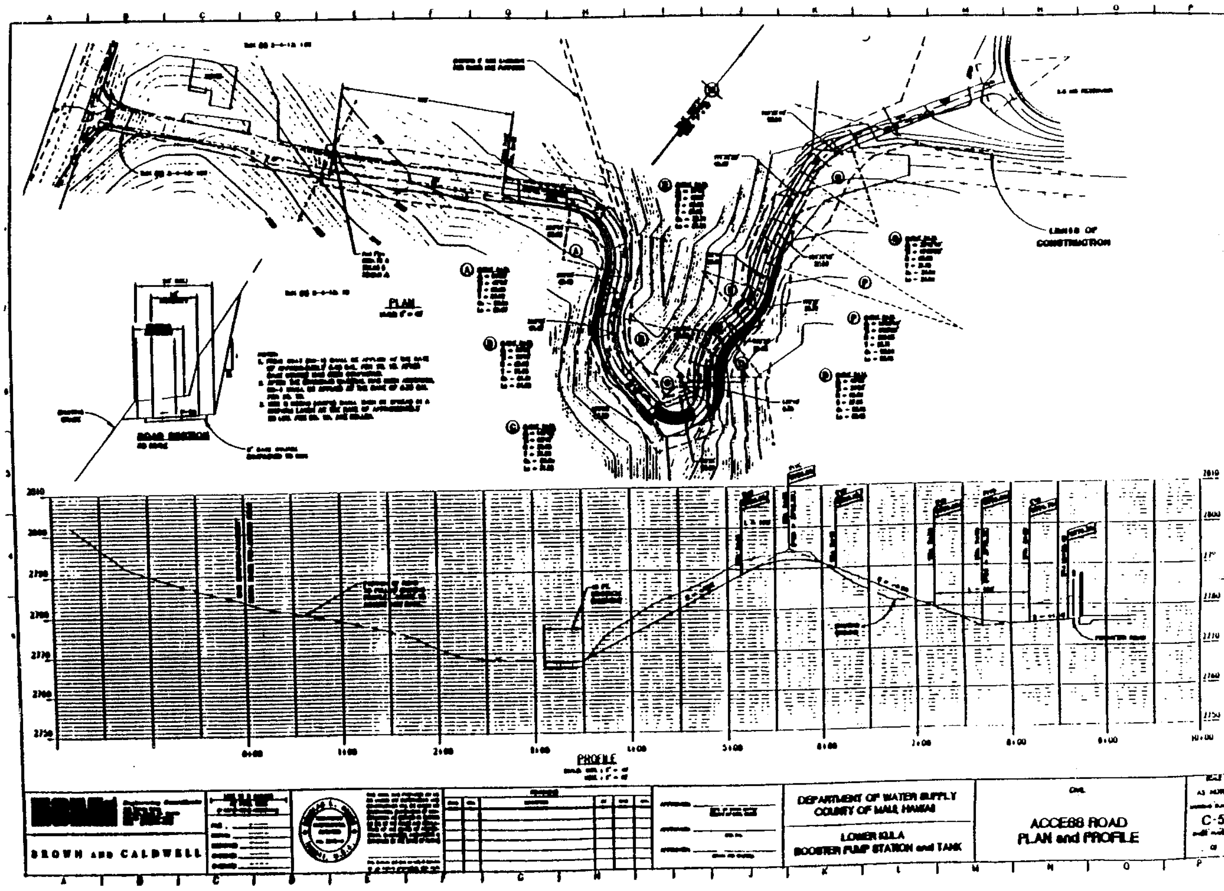
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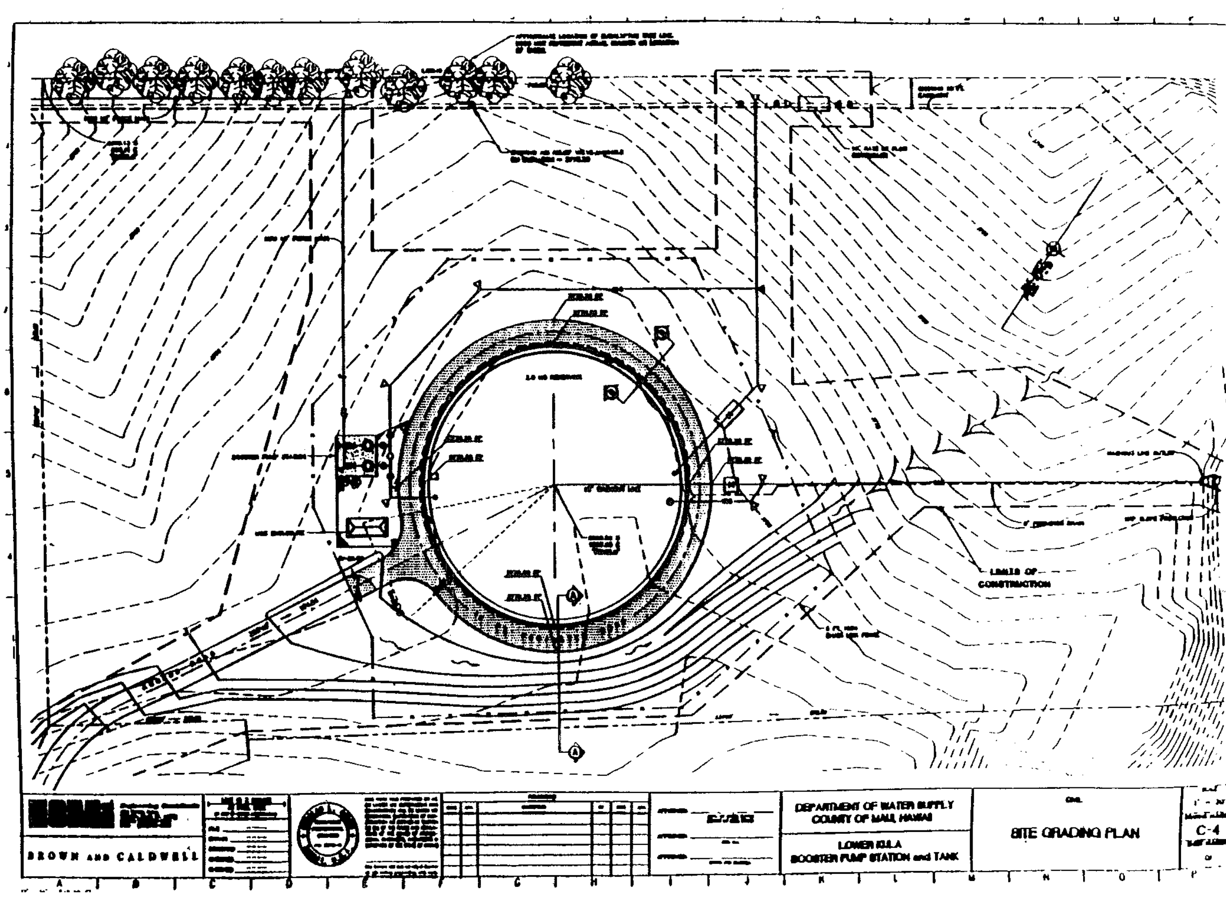
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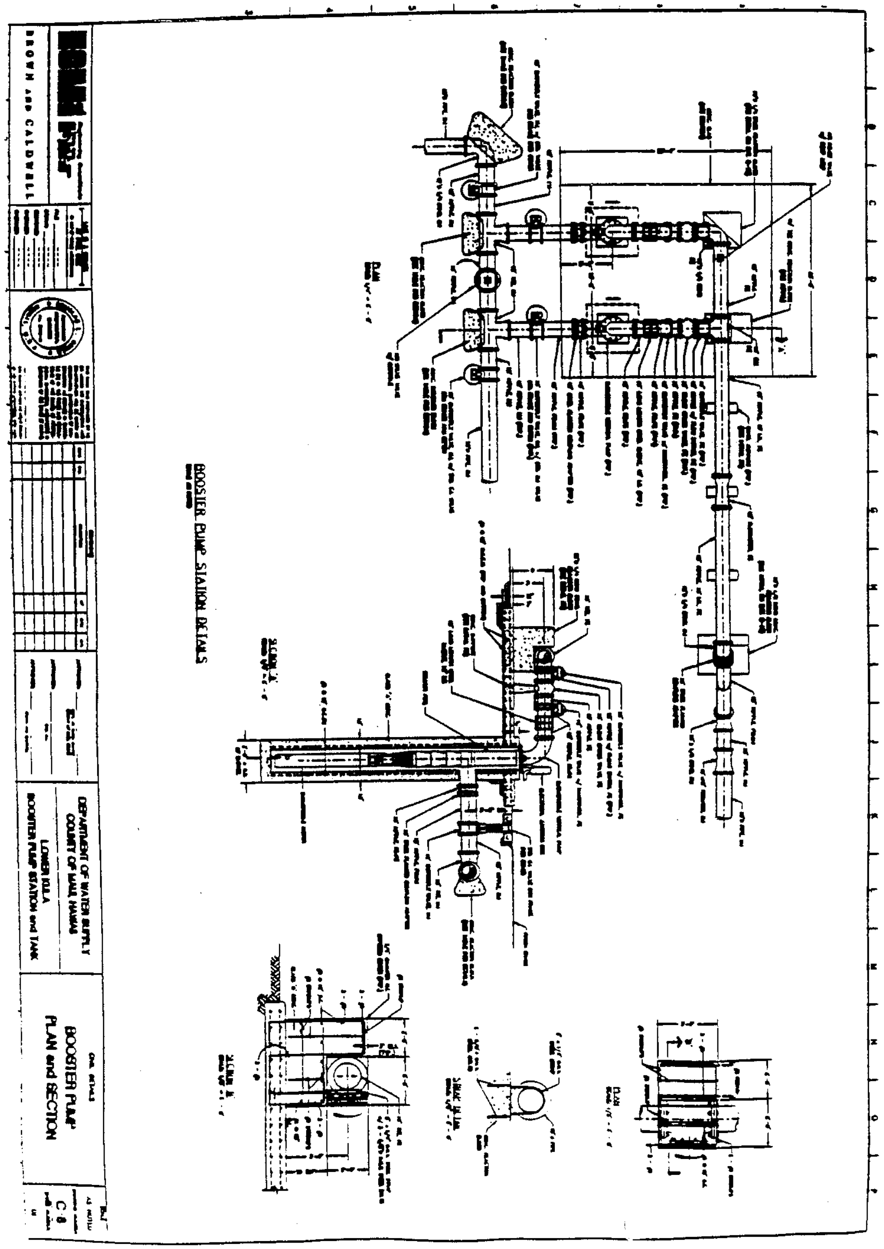
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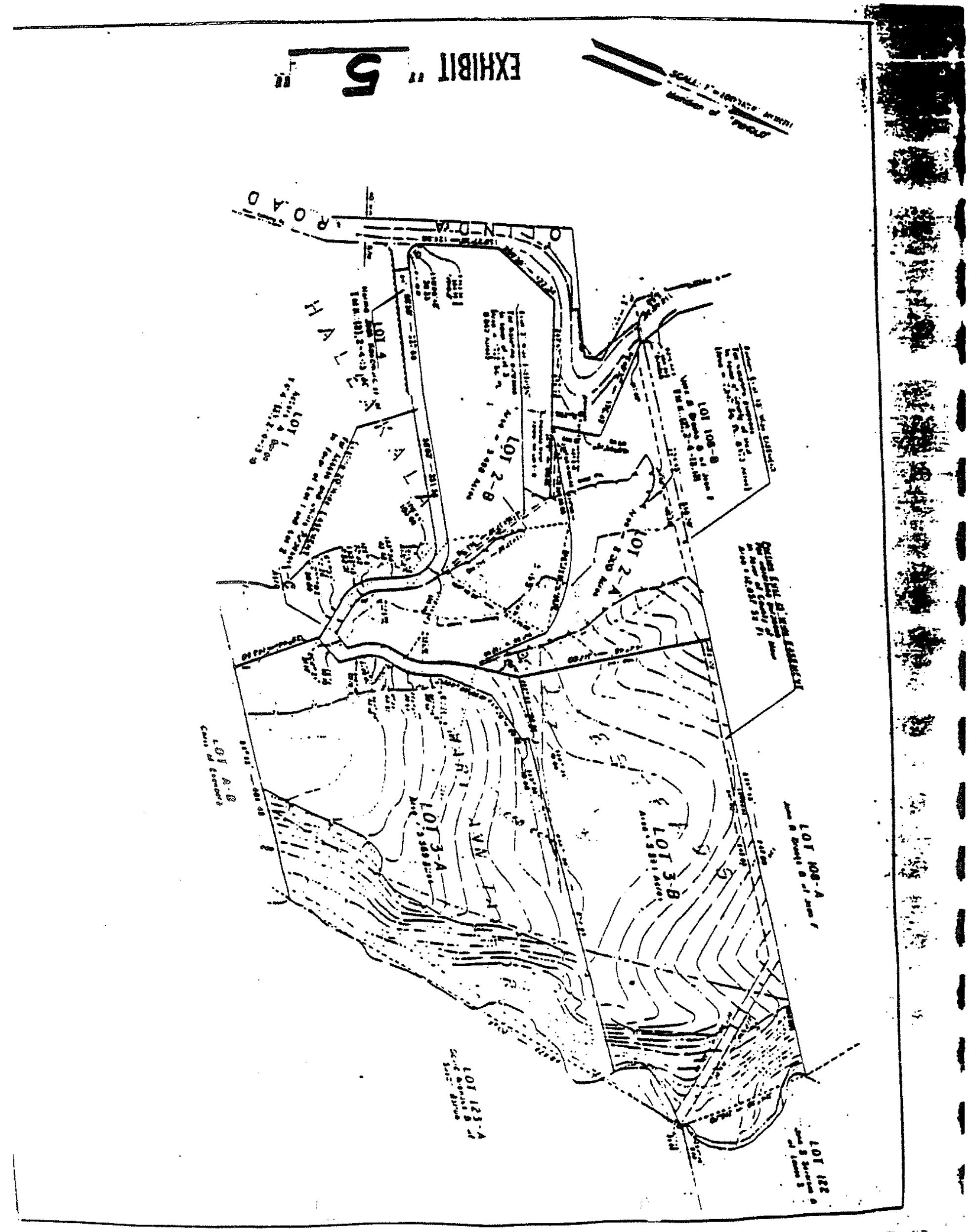
BROWN AND CALDWELL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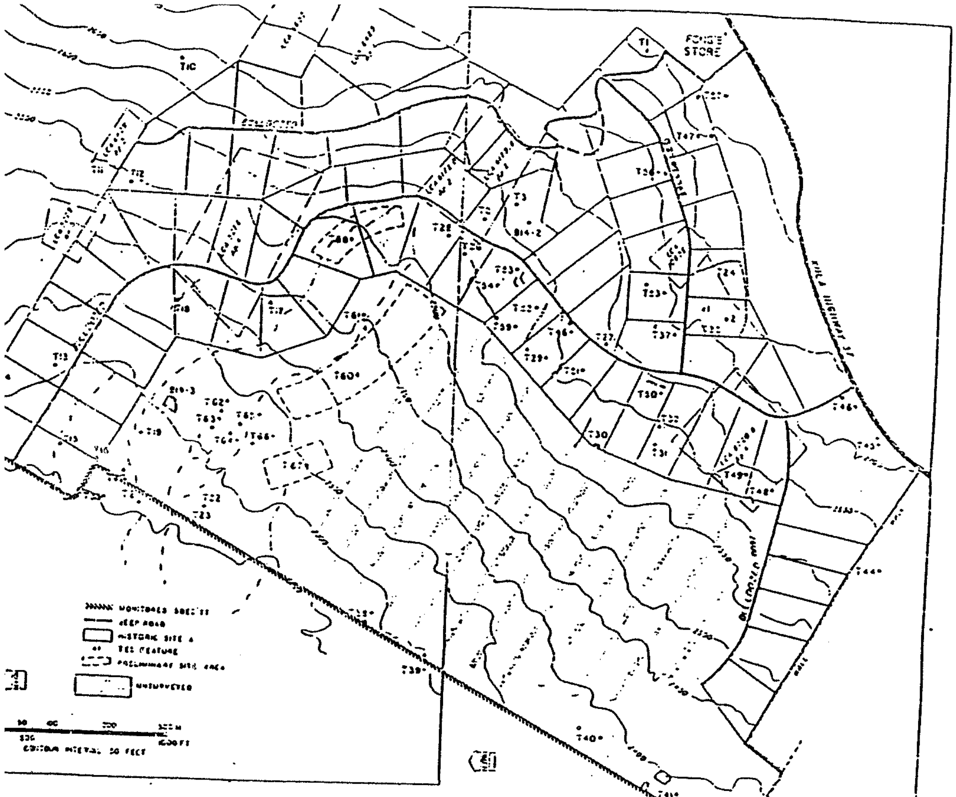
HALEAKALA
ROAD

KEOKEA AGRICULTURAL LOTS

EXHIBIT "7"



2 KEOKEA PARCEL SHOWING ARCHAEOLOGICAL SITE LOCATIONS AND LAND COMMISSION AWARDS.

5.0-85

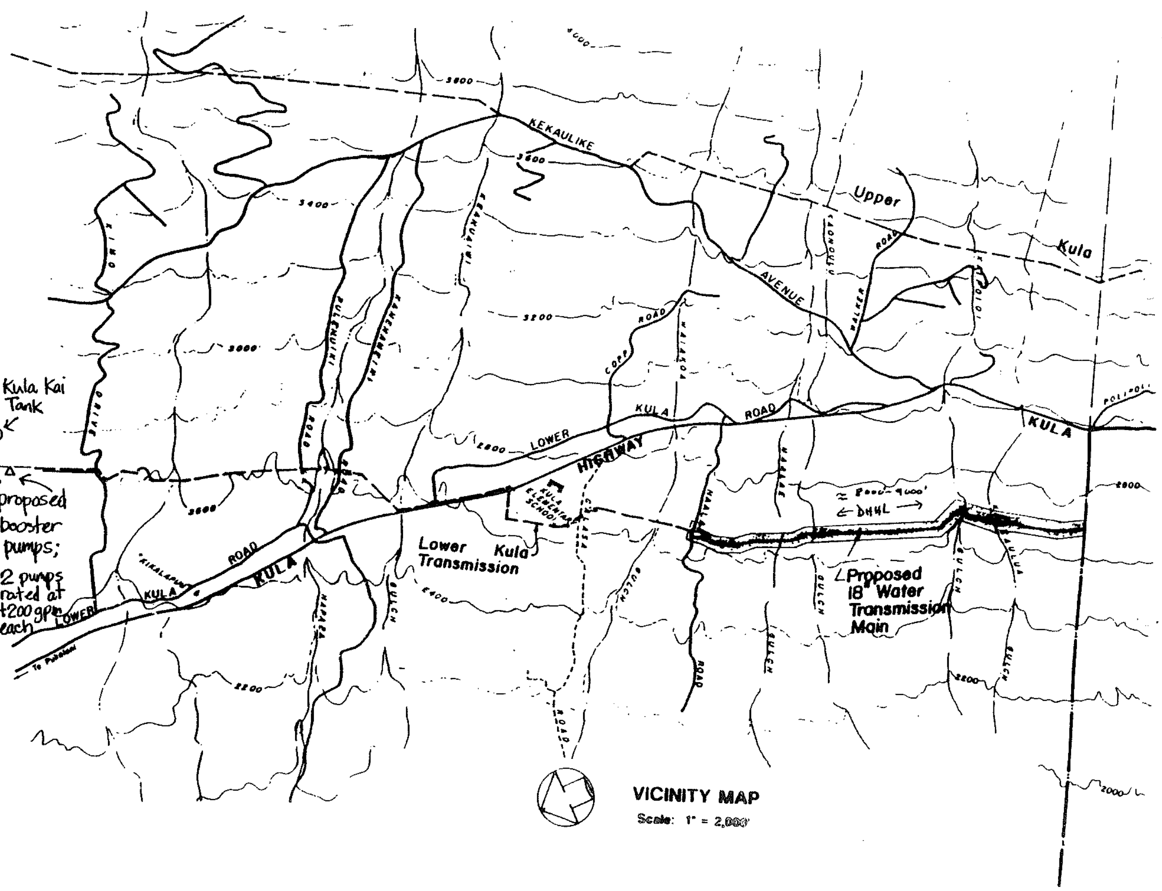
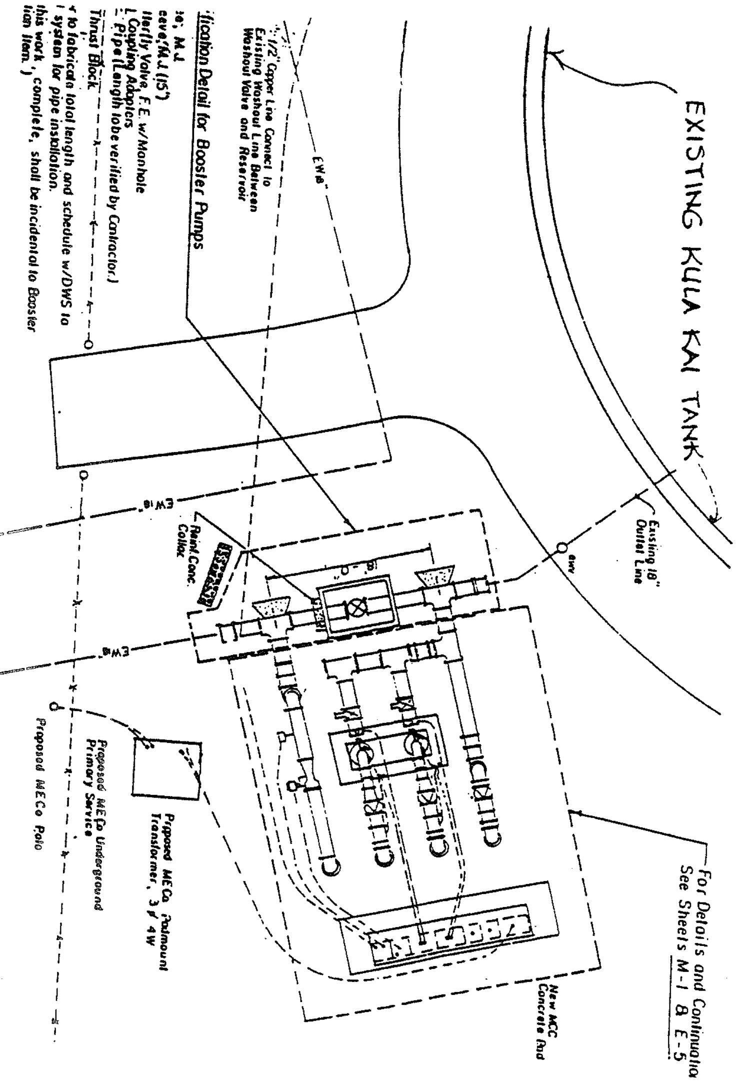


EXHIBIT "6"

5.0-84



KULA KAI BOOSTER PUMP SITE PLAN

Scale: 1" = 10'

EXHIBIT "8"

KULA AGRICULTURAL PARK WATER RESERVOIR AGREEMENT

This AGREEMENT is entered into this ____ day of ~~DEC 3 0 2002~~, 20___, by and among the COUNTY OF MAUI, a political subdivision of the State of Hawaii, whose address is 200 S. High Street, Wailuku, HI 96793 (hereinafter "County"), EAST MAUI IRRIGATION COMPANY, LIMITED, (hereinafter "EMI"), and ALEXANDER & BALDWIN, INC., through its division Hawaiian Commercial & Sugar Company (hereinafter "A&B"), collectively referred to as the "Parties."

WITNESSETH:

WHEREAS, the County, EMI, and A&B entered into that certain Memorandum of Understanding dated December 31, 1973, including all amendments thereof (hereinafter "EMI/A&B Agreement"); and

WHEREAS, one of the amendments to the EMI/A&B Agreement is that certain Kula Agricultural Park letter dated July 27, 1982; and

WHEREAS, the EMI/A&B Agreement currently gives the County, among other things, the right to withdraw from A&B's Hamakua Ditch up to 1.5 million gallons of water per twenty-four hour period to serve the needs of the Kula Agricultural Park Subdivision (the "Park"), subject to the limitations on the County's withdrawal of water set forth in the EMI/A&B Agreement (including the limitations in the Agreement Re 1973 Memorandum of Understanding, Repairs to Waikamoi Water System, Construction of Reservoir at Kamole Weir dated March 21, 1996) ; and

WHEREAS, the County wishes to have the right to use such water to serve, in addition to the needs of the Park, agricultural needs of that certain Haleakala Ranch Company property located adjacent to the Park, identified by TMK No. 2-3-02:07, to be used as an agricultural park (hereinafter "Ranch Property"); and

WHEREAS, EMI and A&B are willing to grant the County's request on the terms and conditions hereinafter set forth;

NOW, THEREFORE, in consideration of the mutual promises hereinafter set forth, the Parties hereby agree as follows:

1. This Agreement shall take effect when the County completes the anticipated upgrade of the Park water pumps and relocation of same to a new delivery point at A&B's Reservoir 40 (the "Reservoir 40 delivery point") in order to promote a more reliable flow of water.

2. Subject to the limitations on the County's withdrawal of water set forth in the EMI/A&B Agreement (including the limitations in the Agreement Re 1973 Memorandum of Understanding, Repairs to Waikamoi Water System, Construction of Reservoir at Kamole Weir dated March 21, 1996), the County shall have the right to withdraw from the Reservoir 40 delivery point up to 1.5 million gallons of water per twenty-four hour period to serve the needs of the Park lessees and the agricultural needs of the Ranch Property. The County shall cease to provide such water to any user, other than a Park lessee, in the event an alternative source of water becomes available to such user.

3. The County shall require users of water withdrawn from the Reservoir 40 delivery point pursuant to this Agreement to use their best efforts to limit their use of such water during times of water shortage.

4. This Agreement may be terminated sooner by one or more Parties with 30 days written notice to all other Parties, and shall terminate upon termination of the EMI/A&B Agreement.

5. To the extent permitted by law, the County shall release, defend, indemnify, and hold harmless EMI, A&B, and their respective officers, employees, agents, successors and assigns from any and all damages, claims, proceedings, liabilities, judgments, awards, losses, costs or expenses (including reasonable legal fees) whatsoever resulting from the County's use of the water withdrawn from the Reservoir 40 delivery point. The provisions of this paragraph shall remain valid and binding upon the County notwithstanding the expiration or termination of this Agreement.

6. Every provision of this Agreement is intended to be severable. If any term or provision hereof is illegal or invalid for any reason whatsoever, such illegality or invalidity shall not affect the validity of the remainder of this Agreement.

7. This Agreement represents the entire agreement among the Parties and shall supercede all prior or contemporaneous agreements in respect to the subject matter hereof. The Parties mutually agree that none of them has made any representation with respect to the subject matter of this Agreement, except such representations as are specifically set forth herein. This Agreement shall not be modified unless agreed to in writing by all Parties by written amendment thereto.

8. This Agreement represents the entire agreement among the Parties and shall supercede all prior or contemporaneous agreements in respect to the subject

matter hereof, and is not intended to confer upon any person other than the Parties any rights or remedies hereunder.

County of Maui

James H. Apana, Jr.
Its Mayor

East Maui Irrigation Company, Limited

By Garret W. C. Hew
Garret W. C. Hew
Its Vice President

Alexander & Baldwin, Inc., through its division
Hawaiian Commercial & Sugar Company

By Meredith J. Ching
Meredith J. Ching
Its Vice President

Approved as to Form
and Legality:

TRACI FUJITA VILLAROSA
Deputy Corporation Counsel

s:\attorney\tfv\Economic Development\KulaAgPark\Kula Ag Park water agmt5.wpd

STATE OF HAWAII)
) SS.
COUNTY OF MAUI)

On this DEC 30 2002 day of ________, 20__, before me personally appeared JAMES H. APANA, JR., to me personally known, who, being by me duly sworn, did say that he is the Mayor of the County of Maui, a political subdivision of the State of Hawaii, and that the seal affixed to the foregoing instrument is the lawful seal of the said County of Maui, and that the said instrument was signed and sealed on behalf of said County of Maui pursuant to Section 7-5.11 and Section 9-18 of the Charter of the County of Maui; and the said JAMES H. APANA, JR. acknowledged the said instrument to be the free act and deed of said County of Maui.

IN WITNESS WHEREOF, I have hereunto set my hand and official seal.

LINDA K. TAMASHIRO
Notary Public, State of Hawaii

My commission expires: 10/19/06

STATE OF HAWAII)
) SS.
COUNTY OF MAUI)

On this 23rd day of December, 2002, before me appeared GARRET W. C. HEW, to me personally known, who, being by me duly sworn, did say that he is the Vice President of EAST MAUI IRRIGATION COMPANY, LIMITED, a Hawaii corporation, and that said instrument was signed on behalf of said corporation by authority of its Board of Directors, and said officer acknowledged said instrument to be the free act and deed of said corporation.

IN WITNESS WHEREOF, I have hereunto set my hand and official seal.

L.S.

Valerie L. Nakashima
(Signature)
Valerie L. Nakashima
Notary Public, State of Hawaii
My commission expires: 5/25/04

STATE OF HAWAII)
City & ~~COUNTY~~ OF Honolulu ~~MAUI~~) SS.
)

On this 20 day of December, 2002, before me appeared MEREDITH J. CHING, to me personally known, who, being by me duly sworn, did say that she is the Vice President of ALEXANDER & BALDWIN, INC., a Hawaii corporation, and that said instrument was signed on behalf of said corporation by authority of its Board of Directors, and said officer acknowledged said instrument to be the free act and deed of said corporation.

IN WITNESS WHEREOF, I have hereunto set my hand and official seal.

SUZANNE K. MCGUIGAN
Notary Public
State of Hawaii

Suzanne K. McGuigan
(Signature)

Notary Public, State of Hawaii
My commission expires: 1/18/05

6.0 Department of Agriculture, Instream Flow Standard Assessment Report Data Needs

INSTREAM FLOW STANDARD ASSESSMENT REPORT
DATA NEEDS

Prepared for
Commision on Water Resource Management
Stream Protection and Management Branch

Prepared by:
Department of Agriculture
Agriculture Resource Management Division

May 29, 2009

CWRM DATA NEEDS
FOR
DEPARTMENT OF AGRICULTURE
UPCOUNTY MAUI IRRIGATION SYSTEM

Water Use:

- Historical trends – may indicate seasonal changes; staff may correlate with annual rainfall trends
  The Department of Water Supply (DWS) provided water consumptions in their own "Instream Flow Standard Assessment Report Data Needs". However, they were unable to calculate agriculture usage off the Olinda Water Treatment Facility for DOA's Upcountry Maui Irrigation System which is needed to develop the requested historical trends. DOA will continue to work with DWS to develop this information.
- Current use
  None, system under construction, estimated completed date, (pending funding) 2015.
- Future demands
  The watershed plan was designed to deliver 3.0 million gallons per day (peak) and service 473 acres.* It is unknown at this time as to whether future demand would be greater than this. It would be dependent on availability of water and future farming interest.

Water Use Purpose:

- Who is using the water? What is water used for?
  The Department of Water Supply (DWS) provided the different types of crops that they currently service in their own "Instream Flow Standard Assessment Report Data Needs". However, they were unable to determine which crops are located in DOA's Upcountry Maui Irrigation System. DOA will continue to work with DWS to develop this information.
- If applicable, provide the following:
  - Domestic – geographic area, number of end users
    Not applicable
  - Agriculture – number of acres, type of crop, farming practices
    473 acres (estimated future service area)*, anticipated non-exclusive crop type list*: onion, protea, head cabbage and lettuce, Chinese cabbage, romaine lettuce, and daikon, assume best farming practices for each type of crop.
  - Livestock – type of animal, number of pastures, farming practices
    Livestock was not considered in the watershed plan.*
  - Traditional – number of acres, type of crop, farming practices
    Unknown at this time. We will inform CWRM at a later date.
  - Hydroelectric – energy capacity, average amount of power generated (per day, month, and /or year), any surplus power sales, revenue generated, users of this power
    This hasn't been explored yet, but could be studied and incorporated into the irrigation system in the future.
  - Recreation/ornamental – type of recreation (golf course, landscape, water features), number of acres
    Not applicable

Water Requirement:

- Minimum water requirement
  1.0 million gallon per day.* However more would be required during the "dry" season when there is less rainfall.
- Prioritize water use purposes (i.e. if water is used for agriculture, which fields are watered first or any crop changes)
  This question is not answerable. Each farm represents an individual business. Each farm must be able to rapidly adjust to changing conditions for crop type, micro weather conditions, etc. Basing water requirements on existing cropping does not allow the farmer to move with the market and keep their operations viable.

Water Supply:

- Sources of water
  Maui Department of Water Supply. Streams known to DOA*: Haipuaena, Puohokamoa, and Waikamoi.
- Contractual obligations
  Not applicable
- Minimum amount of water supplied (i.e. via system) during drought conditions
  A future agreement with Maui DWS will be executed to determine the normal amount of water supplied to the agricultural line. Drought conditions will also be contained in the agreement. We anticipate using our existing administrative rules as a guideline which currently allows for a maximum mandatory usage reduction of 30%.
- Alternate water sources (e.g. recycled water, why/why not?)
  Potable water from the Olinda water treatment plant.

Economic Impact:

- When water supply drops 25%, 50%, 75%
  Estimated economic loss of $516,500, $1,033,000, and $1,549,500 respectively with a loss of 25%, 50%, and 75% in water availability.* If water is restricted in the dry season when water is most critical, the economic loss should be considerably higher. It should also be understood that it could take a long time for farmers to recover from severe cut backs in water or even never be able to regain the same level of production. It can be very costly to reestablish crops once a field is let go.
- Restricting off stream uses
  Restricting off stream use will eliminate the estimated 473 acres of agricultural production in the region. Annual economic loss is estimated to be approximately $2,066,000 in 1997 dollars.*

Water Use Efficiency

- Irrigation efficiency
  We can assume that best farming practices are employed as the farm is a business.
- Ways to decrease water use and water needs
  If best farming practices are being employed, there is no way to decrease water use and needs other than taking acreage out of production.
- Past experiences:
  - What has been done to cope with decreasing water supply?
    - Conversion from sprinklers to drip irrigation for certain crops that do not require overhead irrigation.
    - Reduction in crop size.
    - Cover crops, i.e. adding organic matter to soil to increase soil texture.
  - During drought conditions, what has been done to decrease water use needs?
    - Conversion from sprinklers to drip irrigation for certain crops that do not require overhead irrigation.
    - Reduce or stop plantings.
- Future demands:
  - Are there any future plans that would change water use or needs, i.e. changes in farm acreage, capacity of system, urban development, etc.
    The DOA has no current intent to increase the acreage supplied by this project. The selected alternative from the watershed plan covers 473 acres. Increasing the acreage served would require further studies. Also, any increase in water requirements would have to be negotiated with the Department of Water Supply.

*** From "Watershed Plan – Environmental Impact Statement, Upcountry Maui Watershed, Maui County, Hawaii, dated March 1997.**

7.0 Hawaiian Commercial & Sugar, Co., East Maui Instream Flow Standard Assessment Reports

June 2, 2009

Ken C. Kawahara, Deputy Director
Commission on Water Resource Management
P.O. Box 621
Honolulu, HI 96809

Re: East Maui Instream Flow Standard Assessment Reports

Dear Mr. Kawahara:

The purpose of this letter is to provide updated and additional information relevant to the Commission on Water Resource Management's consideration of the pending petitions to amend the interim instream flow standards ("IIFS") for various East Maui streams. We offer this information for inclusion in the Instream Flow Standard Assessment Reports ("IFSAR") that we understand your staff is in the process of preparing and/or updating.

The information we offer relates to Section 4.0 Maintenance of Fish and Wildlife Habitats and Section 13.0 Noninstream Uses and is relevant to all of the East Maui streams for which IIFS petitions are pending. On the presumption that most of the Section 4.0 and Section 13.0 material contained in the previously published IFSARs will be included in the other East Maui IFSARs, we offer the following amendments to those sections. (For convenience, we include some page number references, which refer to the Honopou IFSAR.)

Section 4.0 Maintenance of Fish and Wildlife Habitats

At the top of page 39 the Honopou IFSAR states:

> The maintenance, or restoration of stream habitat requires an understanding of and the relationships among the various components that impact fish and wildlife habitat, and ultimately, the overall viability of a desired set of species. These components include, but are not limited to, species distribution and diversity, species abundance, predation and competition among native species, similar impacts by alien species, obstacles to migration, water quality, and streamflow.

The immediately next sentence, however, states that "[t]he Commission does not intend to delve into the biological complexities of Hawaiian streams, but rather to present basic evidence that conveys the general health of the subject stream." [Emphasis added.] Given what is known about the native amphidromous species, a report on amphidromous populations found in one stream, without substantial discussion about the biological characteristics and wider populations of these species, is not helpful in furthering the understanding that the Commission requires when considering maintenance or restoration of stream habitat.

HAWAIIAN COMMERCIAL & SUGAR COMPANY A DIVISION OF ALEXANDER & BALDWIN, INC.
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In that context, we submit a report prepared for HC&S by SWCA Environmental Consultants entitled, "Status of Hawaiian Macrofauna in East Maui Steams and Biological Considerations for the Amendment of Interim Instream Flow Standards in Selected Streams (IIFS)." This report canvasses, summarizes and interprets the available information on the macrofauna in the East Maui Streams published by others as well as information developed by SWCA from its own field work. The following points, gleaned from the SWCA report, we believe, are crucial to any consideration of the maintenance or restoration of stream habitat:

- Contrary to what was once believed, there are no data available to suggest that any of these native species [9 amphidromous species] is at risk of either endangerment and/or extinction in East Maui streams or elsewhere throughout the Hawaiian Islands. (SWCA Report, p. 2)

- Amphidromous gobies have evolved reproductive patterns adapted to the extremely variable and unpredictable habitat conditions characteristic of Hawaiian streams (p.13); amphidromous native macrofauna are extraordinarily resilient to changing conditions within streams, and they continue to persist within the Hawaiian Islands in apparently stable metapopulations. (p. 19)

- Amphidromous species are part of statewide metapopulations, i.e., unlike salmon, they do not necessarily return to their natal stream and there is movement of individuals from stream to stream and exchange from a common inter-island oceanic larval pool. (p. 28)

HC&S believes that it is important for the IFSARs to reflect these points as the implication of the existence of "apparently stable metapopulations" of these native amphidromous species is that they don't necessarily need to be preserved in every single stream. The biological data is consistent, in other words, with an approach that takes the overall health of the streams within a region into account when determining the steps necessary for the protection of the existing "metapopulations" of these species.

As the published IFSARs note, the wealth of knowledge about native stream species continues to grow and improve (Honopou IFSAR, page 39). The SWCA Report adds to that body of knowledge with its findings and analysis of the impacts of East Maui ditch diversions on native amphidromous species. Key findings include:

- The system of water diversions in East Maui, while clearly exacerbating the dry end of the wet-dry daily cycle of stream ecology, has not been demonstrated to preclude suitable habitat conditions for sustaining populations of the amphidromous species. (p. 3)

- Of the 18 East Maui streams for which there is data, 17 were found to have amphidromous species in their upper reaches. This means that these individuals had to have migrated upstream past diversion structures to inhabit these reaches, confirming that ecological connectivity occurs under existing conditions. (p. 23)

- There is a substantial amount of suitable habitat in East Maui streams for all 9 native amphidromous species under existing diverted conditions. The data clearly show that ecological connectivity exists within and among streams of the East Maui study area. (p. 27)

- No one has yet determined the relationship between the abundance or density of native amphidromous species and habitat availability. (p. 28)

Section 13.0 Noninstream Uses

The public trust encompasses a duty to promote the use of water to maximize social and economic benefits to the people of this State. Consistent with this duty, the State Water Code requires a consideration of the economic impact of restricting noninstream uses when setting instream flow standards.

Because of the magnitude of HC&S's role in Maui's economy, we suggest that there be a separate subsection (within Section 13.0) devoted to a discussion of HC&S and the economic impact to the people of this State from restricting HC&S's use of water and that it replace the text on pages 132-139 of the currently published IFSAR (Note: The embedded information on Maui Land and Pineapple Company (MLP) and the County of Maui Department of Water Supply's use of East Maui stream water should be pulled out into their own sections).

We offer the following, which is a combination of material taken from the current pages 131-139, some of which is updated, plus some new information.

<u>HC&S Water Usage</u>

HC&S is the larger of the two remaining sugar plantations in Hawaii. The only other remaining plantation, Gay and Robinson, has announced that it will be ceasing its sugar operations in October of 2009. In 2006, HC&S produced about 81 percent of the total raw sugar in Hawaii, or approximately 173,600 tons, amounting to about 3 percent of total U.S. sugar produced (A&B, 2007). Production dropped in 2007 and 2008, however, to 165,000 and 145,000 tons, respectively, largely due to two consecutive years of severe drought conditions. HC&S also produces molasses, a by-product of sugar production, and specialty food grade sugars sold under their Maui Brand®trademark. Table 13-14 summarizes the harvest and production yields for HC&S from 2006 to 2008.

[Supplement Table 13-14 with the data for 2007 and 2008, below]

Year	Raw sugar produced (tons)	Percent of total raw sugar produced in Hawaii	Area harvested (acres)	Yield per acre (tons)	Molasses produced (tons)	Specialty food-grade sugar produced (tons)
2007	165,000	80.0	16,895	9.7	51,700	21,200
2008	145,000	75	16.691	8.6	52,200	27,500

Overall, Hawaii sugar growers produce more sugar per acre than most other sugar-producing areas of the world; however, this advantage is offset by Hawaii's higher labor costs and higher transportation costs resulting from the longer distance to the U.S. mainland market. The DEBDT State of Hawaii Data Book shows the dramatic decline in sugar crop sales as plantations have closed over the last 25 years (DBEDT, 2006). Figure 13-10 illustrates the decline of sugar, the steady value of pineapple sales, and the increase of other crops generally considered as diversified agriculture.

The HC&S sugar plantation currently consists of approximately 43,300 acres of land. Sugar is cultivated on approximately 35,000 acres. HC&S's current water needs range from 150 mgd during winter months to 250 mgd during the summer (includes water for irrigation, mill uses, electric power production, etc.). Securing water at reasonable cost is essential to HC&S's ability to grow sugarcane at yields that will enable it to remain financially viable.

In addition to importing surface water for irrigation from the EMI system and from the West Maui ditch system operated jointly by HC&S and Wailuku Water Company, HC&S supplements ditch water with water pumped from 16 brackish water wells located on the plantation.

Approximately 29,000 acres are irrigated with water delivered by EMI. The EMI system was designed and constructed to take full advantage of the gravity flow of water from higher to lower elevations, thus minimizing pumping and the additional consumption of electrical power. As a result, HC&S attempts to keep as much of the EMI delivered water as possible at the Wailoa Ditch level, where it can then be distributed by gravity to HC&S' various fields and to HC&S' hydroelectric turbines so as to maximize the energy efficient use of this water.

Approximately 13,000 of the 29,000 acres irrigated with EMI water are located at elevations where it is either physically impossible or economically impracticable to irrigate with pumped well water. These 13,000 acres are

normally very productive but are susceptible to diminished yields during drought conditions because there is no replacement water when ditch flows are low. Reductions in EMI deliveries in favor of instream flow would pose an increased risk of diminished or lost yields from these fields, particularly during the dry summer months.

Reductions in EMI water delivered to the lower fields could be offset to some degree with increased pumping of brackish well water. This would be at a cost to HC&S of increased electrical consumption and lost hydropower generation – which would diminish MECO's ability to comply with its statutory obligation to generate electricity from renewable resources.[1] Further, as previously discussed at pp. 122-123 of this report, the usefulness of the basal aquifer tapped by HC&S' wells is sustained by the fresh water recharge it receives in the form of irrigation return water from the EMI ditch system. There is a limit to the ability of the aquifer to withstand the combined demands of increased pumping and reduced fresh water recharge.

HC&S utilizes drip irrigation for most of its fields. Drip irrigation is the most efficient irrigation technology available today. In 1986, HC&S completed a 12-year project to install a drip irrigation system across its plantation – a $30 million investment in water efficiency that if made today would cost $90 million. The only fields which have not been equipped with drip irrigation are those fields irrigated with recycled mill water as drip irrigation was found to be impracticable as the particulates in the recycled mill water clog up the drip tubes. Thus, HC&S expended over $1 million in capital costs in overhead sprinklers, in lieu of drip irrigation, to be able to utilize recycled mill water in some fields.

HC&S determines irrigation needs of each field on a day-to-day basis employing a computerized water balance model, thereby ensuring the most effective and efficient use of available water. Pan ratios, established by extensive industry research and documented in Ekern and Chang[2] are used to estimate the amount of water required in various crop stages. The water balance model essentially calculates a water budget that accounts for "deposits" of water in the form of rainfall and irrigation and "withdrawals" in the form of evapo-

[1] In 2001, the State legislature enacted legislation in which it expressed the State's policy on renewable energy. Act of 2001, No. 272, § 1, 21st Leg., Reg. Sess. (2001), reprinted in Haw. Sess. Laws 834. In accordance with this policy, the legislature required that a percentage of electrical sales of electric utility companies to be represented by renewable energy. See HRS § 269-92.

[2] Ekern, Paul C. and J. Chang (1985) *Pan Evaporation: State of Hawaii 1894-1983*, DLNR Division of Water and Land Development Report 74, p. 49.

transpiration. HC&S uses its water balance model as a managerial tool to determine what needs to be irrigated thus using available water resources with the greatest efficiency.

Evaporation pans used in the past have been replaced by a system of weather stations across the plantation that provides evaporation and rainfall data. Fifteen major automated weather stations situated across the plantation transmit hourly data which is used to calculate daily evaporation data using a modified Penman equation. Rainfall data is recorded daily from 41 manual gauges. The evaporation and rainfall data, along with the data on the soil moisture storage values, irrigation flow rates and the number of irrigation hours applied for each field constitute the variables used for the water balance model. The result is the water status for each field. The model then prioritizes the field needs, indicating which field should receive water next based on the estimated soil moisture status of each field.

Adequately meeting evapo-transpiration rates has been shown to be directly correlated with crop yield potential. Ekern[3], reporting on the consumptive use of water by sugarcane, found that pan evaporation alone was a suitable parameter for estimating water use by the plant. When the cane does not have adequate water, it does not grow, does not produce sugar. Hence at the time of harvest the cane has not reached its maximum growth age, which means lower sugar production. During the final months prior to harvest, the cane is intentionally stressed to increase its sugar content and quality. Water application during this time is regimented, using the moisture status of the plant rather than evapotranspiration as the guide. During recent drought events, water was not available to provide the needed water on schedule resulting in significantly reduced cane quality at harvest. Additionally, under-irrigated cane is more susceptible to diseases, which also reduces sugar yield. Moreover, during prolonged drought conditions such as HC&S experienced over the last 15 years, replanting of harvested fields is delayed to conserve water, which then results in lost sugar production, thus reducing HC&S's total yields.

HC&S does not, in the ordinary course of its operations, calculate or use the average daily water use statistic because it can miscalculate the actual irrigation requirement of the sugarcane. HC&S's operations are geared toward meeting the specific needs of each of its fields based upon where it is in the crop cycle and real time measurements designed to monitor the soil moisture of each field on a daily basis. Irrigation water is applied based on the daily needs of each

[3] Ekern, Paul C. (1970), *Consumptive Use of Water by Sugarcane* in Hawaii Water Resources Research Center Technical Report 37, p. 58.

field, which frequently are dramatically higher or lower than what the daily average might be.

HC&S did, however, undertake an intensive effort to calculate the average daily use of its Waihe`e-Hopoi fields from 2004 to 2006 for the purpose of the Na Wai Eha Contested Case Hearing ("CCH") pertaining to the setting of Interim Instream Flow Standards. This was done by retrieving data from HC&S irrigation database on hours of operation the drip systems for the fields and then performing calculations based on flow rates and acres cultivated. For 2004, the average daily use for these fields was 6395 gpad, for 2005 it was 7831 and for 2006 it was 6,254. The average for these three years was 6826 gpad.

HC&S' use rates on the 29,000 acres irrigated with EMI water are somewhat lower than for its West Maui fields because of greater seasonable variation in stream flows (more days with insufficient water available) and HC&S' inability to supplement the upper 13,000 acres with pumped well water. Inclusive of system losses and well pumping, HC&S' average annual use per acre per day on the 29,000 acres irrigated with EMI water ranged from a low of 4,619 gpad in 2008 to a high of 6,858 gpad in 2005.

Economic Impact of Restricting HC&S' Uses of Water

The availability of surface water for diversion is essential to HC&S' ability to grow sugarcane at yields that will enable it to remain financially viable. The last two years of drought conditions have demonstrated how severe irrigation deficits diminish yields and lead to sizable financial losses. A&B's 2006 Annual Report states that A&B's four agribusiness related companies (one of which is HC&S) generated an operating profit in 2006 of $6.9 million against revenues of $127.4 million (5.4%). HC&S itself has a very slim profit margin. In 2006, HC&S earned operating profit of approximately $2.6 million. Since then, however, HC&S suffered substantial losses due in large measure to the impacts of the severe drought conditions of 2007 and 2008. In 2008, A&B's agribusiness operations reported a $13 million loss, caused entirely by losses at HC&S. See Alexander & Baldwin Inc. Form 10-K filed 2/27/09.[4] In 2009, HC&S expects its losses to be appreciably greater than in 2008, as the full negative impact of the two years of drought will be felt in the 2009 harvest. See 2009 First Quarter Earnings Call;[5] Alexander & Baldwin Inc. Form 10-Q filed 5/5/09 (***"Form 10-***

[4] The Form 10-K can be accessed at http://ccbn.tenkwizard.com/xml/download.php?format=PDF&ipage=6171597.

[5] An audio recording of the 2009 First Quarter Earnings Call can be accessed at http://www.alexanderbaldwin.com/investor-relations/events-and-presentations/event-details.php?id=2138655).

Q"), Business Outlook, Agribusiness section.[6] See Form 10-Q, Business Outlook, Agribusiness section.

Although there are a number of interrelated factors that determine the viability of any business, for HC&S (as for most agricultural endeavors), water is a critical factor. The diminishing availability and increasing cost of water exponentially affects the company's viability, i.e., the impacts of reducing water availability by 5 mgd, 10 mgd, or 15 mgd is not a linear progression. Because an important factor in the continued viability of HC&S is its economy of scale (see Laney Report), any significant contraction of the plantation to match water availability is not feasible.

If, as a result of insufficient water at reasonable cost, HC&S is no longer viable as a business, the economic impacts will be severe as HC&S employs 800 Maui residents, providing $47 million annually in wages and benefits to employees and retirees. Further, HC&S spends approximately $100 million annually in the local economy to support its operations, primarily on Maui. Indirectly, approximately 1500 jobs are dependent upon HC&S and, depending on which multiplier is used, HC&S contributes $124 million to $150 million each year to the economy.

In addition to producing sugar, the HC&S Puunene Sugar Mill provides a renewable energy alternative in the form of sugar cane bagasse, a fibrous byproduct of the sugar extraction process. Bagasse is the primary fuel used in boilers to generate steam, a requirement for sugar processing and for driving steam turbine generators to produce electricity. HC&S also produces hydroelectric power. The electricity that is not used by the sugar mill is sold to MECO for distribution, which currently amounts to approximately seven percent of MECO's power sales. The approximate oil savings to MECO amount to approximately 140,000 barrels per year. HC&S is under contract with MECO to supply, at specified rates, 12 megawatts of power from 7:00 a.m. to 9:00 p.m. daily except Sunday and 8 megawatts at all other times. The contract provides for monetary penalties if these requirements are not met by HC&S. More importantly, however, the loss of hydroelectric and biomass fueled electric generation would undermine the State's Clean Energy Initiative.

We suggest that the above description of HC&S' sugarcane plantation, water use and explanation of how HC&S actually manages its irrigation practices based on agronomic data from decades of field experiments conducted in Hawaii displaces the need for the discussion found on page 138, below figure 13-13 and continuing on page 139, describing sugarcane cultivation practices in Hawaii and an extended discussion of a computer modeling system that estimates sugarcane

[6] The Form 10-Q can be accessed at http://ccbn.tenkwizard.com/xml/download.php?format=PDF&ipage=6301800.

irrigation water requirements but has not been field tested (IWREDSS). If you elect to retain the IWREDSS discussion and calculations, we request that you balance this by including: 1) the above discussion of HC&S' actual practices; 2) a notation that the IWREDSS model was not field-tested at HC&S or anywhere else; and 3) the following paragraph which notes that HC&S' practices and irrigation rates were recently validated by the Hearings Officer in the Na Wai Eha contested case hearing in the face of a challenge utilizing IWREDSS:

> The petitioners in the recently concluded Na Wai Eha contested case hearings challenged the reasonableness of HC&S' irrigation rates with testimony from Ali Fares, Ph.D, who sought to model the irrigation needs for HC&S' West Maui fields utilizing the IWREDSS. His results purported to establish a somewhat lower water requirement than HC&S' actual use rates for calendar years 2004 through 2006. Fares admitted, however, that the model has not been validated with field data and he has done no field work concerning the irrigation of sugarcane or studied the actual usage of water for sugarcane. After lengthy cross examination and rebuttal testimony, the Hearings Officer, in his Recommended Findings of Fact, determined that HC&S' actual water use was reasonable.

Conclusion

HC&S hopes that the foregoing information along with the enclosure to this letter is of assistance to the Commission and staff with regard to their extremely important evaluation of the pending IIFS petitions. HC&S would be pleased to provide further information if needed.

Sincerely,

Christopher J. Benjamin
Plantation General Manager

Enclosure

NOTICE

Enclosed with this letter, Hawaiian Commercial & Sugar Co., also submitted the SWCA White Paper dated May 2009 and titled, *Status of Native Hawaiian Macrofauna in East Maui Streams and Biological Considerations for the Amendment of Interim Instream Flow Standards in Selected Streams (IIFS).* The SWCA White Paper was subsequently updated and submitted directly to Commission staff by SWCA Environmental Consultants on August 6, 2009. Please refer to Section 12.0 for the SWCA White Paper, Updated June 15, 2009.

8.0 Maui County Farm Bureau, Maui Farmer and Rancher East Maui Water Use Survey Results

Hawaii Farm Bureau

Maui County Farm Bureau

An Affiliate of the American Farm Bureau Federation and Hawaii Farm Bureau Federation
Serving Maui's Farmers and Ranchers

June 1, 2009

Mr. Ken Kawahara
Commission on Water Resource Management
State of Hawaii
Kalanimoku Building
1151 Punchbowl Street, Room 227
Honolulu, Hawaii 96813

Mr. Kawahara,

Thank you very much for working with us to develop a better understanding of agricultural offstream use for East Maui Streams. Since our meeting in January, Maui County Farm Bureau has sought to collect data that would provide further insight regarding offstream uses of East Maui Water. We have consulted with the Department of Agriculture and the Maui Department of Water Supply. We understand that both entities are providing use information as well as historical production statistics. We focused on obtaining specific examples and details of current and future water use from East Maui Streams. This information supplements that gathered during the Staff field trip.

Maui County Farm Bureau has participated in a long term project to provide affordable water for our farmers and ranchers. During the various hearings there has been repeated reference to the Supreme Court decision for Waiahole, stating that providing water for commercial purposes is not a public trust concern. Assuming that agriculture is just a commercial concern is not consistent with the Constitution that provides the basis for the State Water Code. The State Constitution also references the importance of agriculture for future generations. Additionally, Section 1 also references the need to protect and utilize natural resources for self sufficiency. Agriculture is an integral part of self sufficiency and so it can be interpreted that the role of agriculture as a Public Trust entitity is cited twice in the Constitution.

ARTICLE XI

CONSERVATION, CONTROL AND DEVELOPMENT OF RESOURCES

CONSERVATION AND DEVELOPMENT OF RESOURCES

Section 1. For the benefit of present and future generations, the State and its political subdivisions shall conserve and protect Hawaii's natural beauty and all natural resources, including land, water, air, minerals and energy sources, and shall promote the development and utilization of these resources in a manner consistent with their conservation and in **furtherance of the self-sufficiency of the State.**

AGRICULTURAL LANDS

Section 3. The State shall conserve and protect agricultural lands, promote diversified agriculture, increase agricultural self-sufficiency and assure the availability of agriculturally suitable lands.

Since its' enactment, the Farm Bureau has worked deligently to fulfill the intent of this Constitutional amendment. We believe the Constitutional intent requires there be a balancing of various users of streams and agriculture has a place on the balance. We do not see it as having a secondary role in all cases. The precendence setting actions of the first set of IIFS for five streams in East Maui has been a major concern for the agricultural industry across the State. The following information is provided to begin a process to ensure that ramifications of decisions on IIFS to offstream uses by agriculture is thoroughly understood during the deliberation process. We found many challenges in obtaining this information and stress that there is much work remaining. We will continue to gather more information to be submitted as we obtain them. We appreciate the Staff's visit to the farms in April. We hope the onsite visits provided a valuable understanding of the role of water for Maui agriculture. Despite our best efforts, getting farmers and ranchers to a meeting proved difficult. There was some misunderstanding regarding the meeting and some of our farmers and ranchers believed they did not have to be there due to the surveys that had been sent out. We wish to emphasize again, that we will continue to work with the farmers and ranchers to provide a more comprehensive picture of agriculture's offstream uses. Assistance in recruiting information from the Commission would help emphasize the critical nature of this project. A press release or other public notice that information is being requested by CWRM will greatly assist in our communication efforts.

The surveys sent out by the Farm Bureau focused on getting details about current and future water needs, the practices used and alternative options. Hawaii, unlike the Western United States, does not have a massive agricultural irrigation systems funded by the Federal government. Maui is unique among the various islands, in not having a State Agricultural Water System. Most of our systems were built using private funds. The majority of farmers on Maui are dependent upon potable water for irrigation water needs provided by the Department of Water Supply. The only nonpotable system(outside of HC&S) is water provided to the County Kula Agricultural Park. The water is delivered by HC&S and ultimately distributed by the County DWS to the farmers in the Ag Park. These farmers are totally dependent upon water that enters through the HC&S Waialoa Ditch system.

Most of the water systems on Maui date back to agriculture. They were built to supply agriculture with society's needs coming along for the ride. During the 1970s and 80s as societal needs grew, agriculture underwent massive conservation efforts, with the savings used to meet the needs of the growing communities. Many of the drip irrigation technologies used around the world was developed by Hawaii's sugarcane industry. Hawaii sugarcane was the first field row crop to be drip irrigated. When drip was first invented, the use was focused on perennial crops such as trees. Hawaii led the world in using it for a field crop and many of the developments such as sanitation of water to reduce plugging of the drip systems was developed in Hawaii. The designs of the sandfilters and drip tubing to withstand exposure to sunlight were all developed here. Hawaii's agriculture has led the nation in identifying means to conserve water as the rest of the nation continued to expand its' source development to meet community needs. Even as conservation opportunities exist, States such as California continue to expand on source development. The recent Economic Stimulus package included millions of dollars for source development for the Colorado River system. Hawaii's late entry to the Union limits our participation in the Bureau of Reclamation to drought mitigation and wastewater reuse with earmark appropriations. We respectfully request CWRM to include aggressive actions including seeking assistance from the Bureau of Reclamation towards mitigating offstream impacts as part of the IIFS proceedings. This is even more critical as new uses such as irrigated pastures may be a critical component to Hawaii's increased self sufficiency. Consumer demand for leaner beef has led our ranchers to direct their efforts towards range fed beef in place of feeding imported grain. This means pasture grass must be available year round. Under dry conditions, this means irrigating pastures, a practice that is not common at this time. Current water usage data reflects curtailment of planting by farmers during the summer expecting water shortages. There are also farmlands that sit idle that can be cultivated. If Maui is to move to increasing local beef production using grassfed cattle and expand vegetable production to meet local consumption needs, where will this water come from? During drought periods, we already reallocate water within the agricultural

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sector. HC&S goes without water so the Kula Ag Park can continue to have water. We need to find ways to increase the total water available to meet everyone's needs – agriculture, other offstream users and instream uses.

An ongoing project to provide agricultural water to farmers on the Upper System in Kula is also dependent on water from East Maui. This Federal-State-County project is currently installing transmission lines to provide nonpotable water to agricultural users. This will provide dual water systems to these farms. The use of the system is subject to water availability and during times of drought, these farmers and ranchers will be the first ones to be cut off. While the intent of this use is to exchange current potable water use and to reduce the loading of the water treatment plant, the conditions of use is not conducive to encouraging long term investment in the industry. Therefore, additional source development to provide greater assurance of water supply is critical for future agriculture on Maui. We are currently working with the USDA Natural Resources Conservation Service to do an evaluation of the potential for further Stormwater capture for agricultural use. The study was funded by the State Legislature through CWRM.

The responses of the surveys are very diverse. However, a common theme is that there already have been impacts on their viability due to current droughts. Additional reductions would bring their ability to operate under question. Loss of viability of existing farms and ranches will undermine Hawaii's efforts towards self sufficiency and sustainability.

If there are any questions, please contact me at 2819718. MCFB is commited to continue working with you to provide the best possible information. We respectfully request for your assistance in obtaining the needed information.

Sincerely yours,

Warren K. Watanabe

Warren K. Watanabe
Executive Director
MCFB

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ATTACHMENT 1

Maui Farmer and Rancher East Maui Water Use Survey Results

Collected by Maui County Farm Bureau and County Office of Economic Development

6/1/2009

If there are questions, please contact Warren Watanabe at 2819718

A few months ago decisions were made regarding the amount of water than needed to remain in streams at diversions in streams in East Maui. During that time, some of the water that was diverted was ordered to be left in streams for fish as well as taro growers. In the near future other decisions will be made on other streams in East Maui. This is to comply with requirements for the establishment of Interim Instream Flows as mandated by the Water Code. The Water Code specifically states that :

> (D) In considering a petition to adopt an interim instream flow standard, the commission shall weigh the importance of the present or potential instream values with the importance of the present or potential uses of water for noninstream purposes, including the economic impact of restricting such uses;

All farms and ranches on East Maui receive their waters from streams in East Maui. It is important that the Commission understand your need of water. - IS IT TRUE THAT *ALL* EAST MOUNT FARMS AND RANCHES RECEIVE THEIR WATER FROM STREAMS? AS I UNDERSTAND IT, WELLS SERVE THE KA'ELEKU AREA AS WELL AS HANA TOWN. MANY OF THE FARMS IN HANA ARE LOCATED IN THE KA'ELEKU AREA.

1) How water is used on your farm - We use water to wash our flowers. Occassionally we need to irrigate when we do not have enough rain. We wash down our equipment periodically. Water is available in case of emergency.

2) If changes have occurred on your farm because of water availability - do you avoid planting during certain periods due to uncertainty of water availability? We have not yet experienced the need to adjust our planting due to water constraints. We have limited our use by choice however, in an effort to conserve. We also installed aerators on our faucets and hoses.

3) What practices are done to make best use of water - We limit our use as much as possible in an effort to conserve. We installed aerators on our faucets. We recycle our water from our wash tub to water our plants when necessary. We do not change the water in our wash tub every day. Only as necessary. We also use catchment water to fill our washtub whenever possible. We also consider types of plants we plant based on their water requirements. We limit planting of plants that need a great deal of water.

4) The agricultural value and other values that result from the use of the water - We could not possibly operate our farm to the shipping standards required without the use of water. All flowers need to be washed to be bug free and free of molds, aphids, etc. If we were not able to wash our flowers properly, we would not be able to ship them out of the state.

5) If you are planning investments and what your assumptions are on the availability of water - I make no assumptions that public water services will always be available at an efficient cost. We try to be conservative as possible with our use of water because we respect the environment and understand the balance that is required to sustain adequate water supply. Our future expansion includes the use of catchment water for all of our farm needs. We need to add a larger storage system for our catchment water.

6) What will happen if your access to water was reduced - We would do our best to sustain ourselves by expanding our water catchment system.

7) If you have greater assurance of water, will you expand? - YES, We are already planning to expand our flower farm by 1 acre and we are adding vegatable gardening as well as pohole, squash, fern, & other food products.

It is critical that reasonable in stream water flow standards must be adopted and be based on reality. It is also imperative that we take personal responsibility for conserving water use wherever possible. Each farm should be required to install a minimum water catchment system for non-potable water use. There is no reason why a simple catchment system can not be installed on each and every farm and for each and every household for that matter. A small system that holds a minimum amount of water for again, non-potable uses, is simple and cost efficient. It is not essential to have a huge water tank that takes up yard space and can be unsightly, however, a small system, especially in areas where there is more rainfall, would be cost effective and would certainly help with water conservation. We can not continue to take water for granted.

I would welcome an opportunity to work on any water conservation project for East Maui farmers.

Farmer #1

From: " Framer #2
Date: April 22 2009 9:47:35 AM HST
To:
Subject: Re: Please Resond: Water

1 How water is used on your farm - **to water Pohole/flowers /herbs**
2. If changes have occurred on your farm because of water availability - do you avoid planting during certain periods due to uncertainty of water availability? **yes**
3. What practices are done to make best use of water - **conserve**
4. The agricultural value and other values that result from the use of the water **production...**
5. If you are planning investments and what your assumptions are on the availability of water - **We do water caught system with 75 gallon of water in 3 tanks**
6. What will happen if your access to water was reduced **We will be out of water out of business**
7. If you have greater assurance of water, will you expand? **We have enough storage.**

From: Farmer #3
Sent: Tuesday, May 19, 2009 10:08 AM
To: ____
Subject: Re: CWRM questions

Good Morning Warren

Thank you for the heads up about the survery concerning water usage on our farm. Maui Floral grows protea on 8 acres in the Waiakoa area of Kula. Additionally, we consolidate flowers, farm gate, with over 10 Protea growers in Kula and Olinda. So, from our vantage point, we see many farms and farmers that need water for their income and jobs.

As our plants (shrubs and small trees actually) grow, their water requirements increase. During wet periods we don't water much but during the dry summer periods, when the plants are getting ready to flower, we do. Most of us use water efficiently with a combination of drip irrigation underneath a weed mat or ground cover which reduces evaporation.

Proteas are a long term crop; we don't plant multiple times during the year, but we do replant every year to replace plants that have died or to replace older plants. We are continuing to plant our land and expect to have the 8 acres planted within 12 - 16 months. Since it takes so long for the cuttings to root we have to plan ahead.

As with all agriculture we depend on water. Agriculture is defined as using water and land to grow products. We are proud to have been growing and exporting Proteas from Maui to customers all over the world for almost 35 years. Maui Floral employees over 15 full time people even during this economic downturn.

Water Usage Report for Upcountry Coffee Farmers
May 27, 2009

The following report was compiled to address issues of water availability and usage as requested by Committee on Water Resource management (CWRM). It has been prepared by Farmer #4 behalf of the Maui Coffee Association.

Introduction: Coffee is grown in a variety of settings in East Maui ranging from Kipahulu through Hana and Huelo into the Haiku and Kula regions. Coffee normally requires at least 60 inches of rain a year; in Kipahulu through parts of Haiku there is sufficient natural rainfall to meet the needs of this crop. In areas starting in Haiku and across the Kula region of Haleakala, rainfall can range from 80 inches a year to less than 20 inches. Irrigation is required to meet the needs for those farms located in Kula especially from Olinda Road south to Ulupalakua. Some coffee farmers in Haiku have noted a decrease in rainfall over the last 15 years and the need for irrigation may increase.

Coffee is a perennial tree that bears fruit called cherries between October and May with considerable variation in the timing of fruit set and maturation across the Kula growing area reflecting the influence of elevation and rainfall. Coffee was introduced to Hawaii in 1813 and has naturalized in the gulches of Maui. It has been farmed in East Maui for over 20 years and we are seeing a resurgence in this crop. Most farms in East Maui range in elevation between 1200 and 3400 feet. Water is critical in the development of mature coffee cherries. For example during the recent drought in Haiku one farmer lost more than 30% of his crop as "floaters", incompletely formed coffee beans that float in water during processing; these beans must be removed from the picked and processed coffee before roasting or they will impart an undesirable grassy taste to the coffee. Coffee farms in East Maui are generally small between one half to 2 acres. According to the data from the Maui Coffee Association as well as state DOA data, there are about 30 farms for a total acreage of about 20 acres. Determining water usage specifically for this crop is difficult because most farmers have integrated coffee into orchards or farms that contain other cash crops (vegetables, fruit, etc.). Nonetheless using an approximate acreage of 20 acres for Kula coffee farms and 60" a year minimum (considering the effects of evapotranspiration which is higher at lower elevations), one can estimate that about the annual water needs are about 32.4 million gallons as a maximum (20 acres times 60 inches per year equals 1200 acre-inches per year times 27,000 gallons per acre inch). This number will vary depending on rainfall and location and should be considered a maximum.

The following answers to the survey questions are based on the water usage of Kupa'a Farm, a typical mixed crop coffee farm at 2000 ft elevation in Kula, as well as familiarity with other Upcountry irrigated coffee farms.

1) *How water is used on your farm?* Water for coffee and most other crops is provided through drip lines. Vegetative covers (perennial peanut) and shade trees are used in the coffee to decrease water loss due to evaporation and limit tree stress. Most farms in Kula use drip irrigation and either a vegetative or inorganic (weed mat) ground cover. Impact sprinklers are used infrequently, mostly in very dry areas to increase leaf surface moisture during the summer.
2) *If changes have occurred on your farm because of water availability - do you avoid planting during certain periods due to uncertainty of water availability?* During a normal winter we turn off the irrigation for coffee between the months of December through April. Because coffee

is a perennial orchard crop we have to continue to water through the dry season (April through November) to maintain plant vigor and proper bean development. Decisions about planting are based on a long term plan for the farm. In the winter we use natural irrigation to grow cover crops within the coffee which improves soil organic matter content and water holding capacity.

3) *What practices are done to make best use of water?* Our farm is similar to most coffee farms that use drip irrigation to minimize water needs and loss to evaporation. We also make extensive use of mulch (living and dry) as well as shade trees. This practice varies from farm to farm.

4) *The agricultural value and other values that result from the use of the water?* For strictly cash value of coffee for 20 acres in Kula we can estimate about $400,000 value in retail sales (20 acres with 800 trees per acre which yield one pound roasted coffee per tree which sells for $25). Kupa'a Farm also has fruit and vegetable production as do many other farms and sales data are not readily available for that.

5) *If you are planning investments and what your assumptions are on the availability of water.* The Maui Coffee Association has held workshops for small growers each of the last two years. We have seen an enthusiastic response from the community and our membership has grown and most of the new members are growers or are planning on planting coffee. If water was unavailable for these potential farms, then obviously the lands would not be farmed for coffee.

6) *What will happen if your access to water was reduced?* It depends on the degree of reduction. On our farm we have applied voluntary reductions of 10% in water use during the last 2 summers by not planting cover crops and reducing some of the row crop plantings of vegetables. In turn we maintained water rates to our orchard crops. As described above it is critical to make sure that coffee has enough water to for complete development of the coffee bean. A well cared for coffee tree can live for over 50 years so it is not an insignificant long term investment.

7) *If you have greater assurance of water, will you expand?* Coffee is gaining popularity as a crop in Kula because of the high quality of the coffee. The Maui Coffee Association sees Kula as being at the start of an expansion of coffee especially if water needs can be met.

TO: MAUI COUNTY FARM BUREAU

FROM: Ranch #1

DATE: 5/28/2009

SUBJECT: AGRICULTURAL WATER USE SURVEY

Below are the responses from Ranch #1 to the specific questions posed in this survey.

"How is water used on your farm/ranch?"

Ranch #1 uses both county potable water and reclaimed water from the Kihei Wastewater Treatment Plant to provide drinking water for our livestock. We also use water from the county system for a variety of other ranch needs ranging from equipment wash down to supplying water for our ranch offices and homes.

"If changes have occurred on your farm/ranch because of water availability do you avoid planting?"

As a ranch, we do not normally plant crops. Unlike farmers with a 60 to 120 day crop, ranches cannot make short term decisions. Our cows are pregnant for nine months, market animals are in pasture for as long as 2 years. Short-term water losses are not easily dealt with and long-term water reductions will result in herd downsizing.

Currently, we are looking into planting supplemental forage plants and grasses to increase nutritional levels in order to facilitate our goals for grass finishing cattle. We will be targeting our plantings to take advantage of seasonal rains. We also schedule our breeding and calving seasons in accordance with seasonal rains to provide the highest nutritional levels for our cows and calves.

"What practices are done to make best use of water?"

Our field staff makes water checks in their respective pasture areas 3 times a week. The goal is to make sure we do not have leaks in the system that could waste water. We have relined reservoirs and put in several new water storage tanks and have several new tanks still to install. We have been using discarded large cane hauler tires when placing or replacing our water troughs, many of which are 30 to 50 year old cement troughs that were starting to leak. We also have plans to implement a telemetric reporting system in order to monitor and regulate water use in remote locations.

"Agricultural value and other values that result from the use of the water?"

Without the water that is currently available, we would have to cut back on our operations and herd numbers to a point where the business may no longer be viable. Livestock cannot survive without water, and any sustained reduction in availability would result in animal deaths if we attempted to maintain the minimum herd size required for operational and land management purposes.
In addition to the commercial contributions of the livestock industry to the local community, such operations provide an important aesthetic component that contributes to the unique culture and character of Maui.

Additionally, operations like Ranch #1 provide very significant invasive species control and soil preservation benefits via managed, multi-species grazing. Several highly invasive plants have become established in the pastures and forests of upcountry Maui. Without aggressive management, these plants will completely erode the commercial and aesthetic values of the region. The only effective approach for dealing with invasive plants on this scale is via a multi-faceted control strategy – a critical component of which is multi-species grazing. Any reduction in water availability to the region will severely compromise the ability of ranches to maintain these critical land management programs.

"If you are planning investments and what your assumptions are on the availability of water?"

In conjunction with its partner ranches at Ranch #2 Ranch #1 is transitioning to a pasture grass finished beef product. This is a significant strategic change that is critical for the survival of the livestock industry on Maui. The implications of this shift for the individual ranches of Ranch #2 are increased investments in genetic improvement, additional fencing and water infrastructure. The grass-finishing process will require cattle to be pastured for longer periods of time. Thus, the underlying assumption in planning for this new direction is that, at the very least, current levels of water availability will be maintained with opportunities for increased use. Stated another way, the survival of an historic and important agricultural industry on Maui is contingent upon current and increasing amounts of available water.

"What will happen if your access to water is reduced?"

As mentioned, any reduction in available water will severely compromise critical operational and land management functions of Ranch #1

"If you have greater assurances of water, will you expand?"

Greater assurances of existing available water resources will provide expansion opportunities for Ranch #1 operations.

Water use by cattle operations on Maui and water use/needs;

June of 2009

Estimated Acreage for Cattle Operations:

Ranch:	Acres	Water East Maui	Source Other
#1	27,000	27,000	
#3	6,000	6,000	
#4	20,000	20,000	
#5	6,000	3,600	2,400
#6	3,000	3,000	
#7	18,000		18,000
#8	3,200		3,800
#9	13,000	9,100	3,900
Totals	96,200	68,700	28,100

Other livestock needs- based on water originating from EMI/East Maui Sources System

Ranch	Goats	Horses	Sheep	Elk	Feral-goats/deer/pigs
#1	400	40	400		5,500
#3	150	30	150		1,500
#4	80	50	15	100	4,000
#5		12			1,000
#6		3			1,100
#7		20			1,000
#8		40			
#9	1,000	800	200		4,000
Totals	1630	995	765	100	18100

Cattle Counts

Ranch:	Cattle All Types	Water East Maui	Source Other
#1	4,000	4,000	
#3	2,500	2,500	
#4	4,000	4,000	
#5	1,000	600	400
#6	1,000	1,000	
#7	2,500		2,500
#8	2,200		2,200
#9	2,500	1,750	750
Totals	19,700	13,850	5,850

Resulting Water Needs, Other Livestock

Ranch	Goats @ 3gpd	Horses @ 20gpd	Sheep @ 3gpd	Elk @ 10 gpd	Feral-goats/deer/pigs @ 5 gpd	Total
#1	1200	800	1200	0	27500	30700
#2	450	600	450	0	7500	9000
#4	240	1000	45	300	20000	21585
#5	0	240	0	0	5000	5240
#6	0	60	0	0	5500	5560
#7	0	400	0	0	5000	5400
#8	0	800	0	0	0	800
#9	3000	16000	600	0	20000	39600
Totals	4890	19900	2295	300	90500	117885

Water Consumption- Cattle

Ranch:	Cattle All Types	Water East Maui	Source Other
#1	80,000	80,000	Other
#3	50,000	50,000	0
#4	80,000	80,000	0
#5	20,000	12,000	8,000
#6	27,700	27,700	
#7	50,000		50,000
#8	44,000		44,000
#9	50,000	35,000	15,000
Totals	401,700	284,700	117,000

Water Consumption- All requirements (Cattle, Goats, Sheep, Feral, Horses)

Ranch:	Cattle All Types	Water East Maui	Source Other
#1	92,800	92,800	0
#3	59,000	59,000	0
#4	101,585	101,585	0
#5	20,120	12,072	8,048
#6	27,700	27,700	
#7	55,400		55,400
#8	44,000		44,000
#9	89,600	62,720	26,880
Totals	490,205	355,877	134,328

Warren,
Here is a response that is very similar to most of the livestock producers responses, and can be added to the Livestock information we submitted with the original request in March. Most people would expand if the land and "water" was available. Another thought is what will happen to the water use data not collected for fallow plantation lands.
I will send you a couple more responses as they come in. Thanks, Ranch #10

1) How water is used on your farm-We have a small cattle operation. We depend on the stream flow through our gulch for water for our horses and cattle. In the last years, there has been less and less flowing through and we are concerned for the future when the water may dry up entirely. Also on our leased pastures, we are thoroughly dependent on rainfall at this time. We would prefer to have some sort of water storage to help us get through the longer and longer dry spells that we are experincing here on Maui.

2) If changes have occurred on your farm because of water availability - do you avoid planting during certain periods due to uncertainty of water availability?
We have had to dramatically reduce our herd in past years due to long drought periods. In addition, we have had to curtail the growth of our operation to try and avoid future "dumping at a loss"operations.

3) What practices are done to make best use of water

4) The agricultural value and other values that result from the use of the water-Our "natural"beef operation has really been a blessing to the many families of Maui who have been able to enjoy a healthy and reasonably priced alternative to Costco beef. They love the idea of having beef that was raised here by a person they can actually know and trust. It is unfortunate that our fear of drought keeps us from adequately responding to the very real demand that exists.

5) If you are planning investments and what your assumptions are on the availability of water

6) What will happen if your access to water was reduced-As previously expressed, if the stream in our gulch dries up again, we will be forced into moving these farm animals-horses and cows-to other pastures that are also drying up and then we will have to cut our herd at a loss again. Then we are stuck trying to build up again in order to supply our customers. We risk losing the existing customer base when we are unable to be dependable in our supply.

7) If you have greater assurance of water, will you expand?
Absolutely! We would love to get a water storage system going on our lands that could provide irrigation water as well as water for the cattle. This is essential if we are to be able to sustain our herd and continue to grow. Please take agriculture needs seriously. No local food base or a greatly reduced local food base is a scary thing for us all.
Sincerely

Ranch #11

THE IMPORTANCE OF WATER TO EAST MAUI AND THE RESULTING IMPACT OF WATER DIVERSION

BY

Farmer #5 NAHIKU' FARM
LOCATED ON THE HANA HIGHWAY
IN THE NAHIKU HOMESTEADS

For millennia, the flora and fauna of the Hana District has relied heavily upon the natural occurrence of rain and the resulting stream water to develop the natural beauty of the area that both locals and visitors have come to rely and depend on and expect in this day and time.

Diverting water from the area streams would certainly be detrimental to the area as we have come to know it. Locals depend on the stream water for their taro, their flowers and their food crops. Visitors and tourism would be greatly affected as well, as many make the drive to Hana to witness the sheer beauty of the waterfalls and the vivid lushness of the rainforest and flowers as they too, would suffer greatly from water deprivation. Tourism would be greatly affected and diminished as explained later. Indigenous plants, trees, animals and birds would also be greatly affected should water ever be restricted from the natural flow in their environment. The natural levels of the underground aquifer would fall drastically, resulting in detriment to the water availability and quality in the utility wells serving selected areas. There would be so many facets of the Maui economy and ecology adversely affected by such further restriction and/or diversion of stream water, some of which we may never know until it is too late.

Prime examples in farming would be in looking at the economies of taro and flower production. While taro is a most important crop to the local economy of the farmers, it also is extremely important to the heritages of the Hawaiian People and to the Hawaiian Islands. However, Maui Farmer #5 which is mainly isolated to the Nahiku and Hana areas of East Maui, depend heavily on water not only for plant survival, but in washing the flowers to meet agricultural regulations in order to ship off the islands to the mainland and the rest of the world. For us, it is our only economy. For Maui, it is an important economic crop.

FROM : FAX NO. : Jun. 10 2008 10:48PM P1

Business Name: Farmer #6

Address:

Phone:

Contact:

Water Use

Historical Trends:
(Seasonal Changes)

Current Use: average $39000/month 49,000 highest month
Gallons/Month 29,000 lowest month.

Future Demands: Slightly higher
Gallons/Month

Water Use Purpose:

Crop: Orchid / tropical plant nursery

Acreage: 14,000 sq. ft + landscape

Economic Impact: please see attached

When water availability/supply drops

25%

50%

75%

FROM : FAX NO. : Jun. 10 2008 10:45PM P2

Farmer #6

INC

28 May 2009

SURVEY ON WATER USE:

Water Use: Monthly Average: 39,000/gal month. 49,000 highest month
29,000 lowest month

Future Demands: Same to slightly higher, weather dependent

Water Use Purpose: Orchid & Tropical Plant Nursery
14,000 square feet

Economic Impact: During the last water restriction period, we cut our home water usage in order to allow for water use in nursery (Water system tied to owners home). We also cut nursery water time and limited spraying, both had a detrimental effect on our crop. Unlike other crops, orchids take upwards of 3-8 years from seedling to finished stock, planting times can be very specific and not planting due to water supply interruptions can have extreme negative economic impact. It can be impossible to plan planting times with water shortage, and limiting water use can destroy many years of labor investment.

Agricultural value and other values that result from the use of the water: A portion of our business is US Mainland export the remainder is local retail. All of our supplies are purchased in Hawaii supporting local businesses; to date we have invested well over $1,000,000 in the Hawaii economy. We also work with other Hawaii nurseries and share orchid hybrids, expanding our states ability to be competitive in the national market, as well as purchasing finished stock for resale, supporting other nurseries wholesale lines.

Future investments and water availability: Because of the current economic downturn, we are desperately trying to stay afloat. We would like to invest in water catchment systems, taking advantage of water run-off. However, when investigating government financing we were told that there were no programs/funds available for small farm operations, most were geared to large-scale operations. Therefore, any water saving systems will have to wait until the economy will support such efforts.

Future water interruptions: Any significant reduction in water availability would greatly impact our operation and make it impossible for us to continue functioning in Hawaii.

Respectfully submitted,

Farmer #6

Name Farmer #7

Farm ______

Primary Production Vegetables & Fruits

1) How water is used on your farm to grow all crops

2) If changes have occurred on your farm because of water availability - do you avoid planting during certain periods due to uncertainty of water availability?

No water no plant

3) What practices are done to make best use of water we use drip irrigation

4) The agricultural value and other values that result from the use of the water

Crops grow and our farm stays in business.

5) If you are planning investments and what your assumptions are on the availability of water

We would be more open to investing more into our farm if we were certain about the availability of water.

6) What will happen if your access to water was reduced Loss of income & crops. Closure of farm.

7) If you have greater assurance of water, will you expand? If the opportunity presents itself.

Name Farmer #8

Farm ______

Primary Production vegetables

1) How water is used on your farm

irrigate crops, clean & wash produce

2) If changes have occurred on your farm because of water availability - do you avoid planting during certain periods due to uncertainty of water availability?

no

3) What practices are done to make best use of water

drip irrigation

4) The agricultural value and other values that result from the use of the water

all crops irrigated, cannot be done otherwise

5) If you are planning investments and what your assumptions are on the availability of water

no

6) What will happen if your access to water was reduced

not sure

7) If you have greater assurance of water, will you expand?

yes

871-5432

Farmer #9

Maui County Farm Bureau

County of Maui Office of Economic Development

We need your assistance with determining our industries water usage from the East Maui Watershed. The State Commission of Water Resources Management is in the fact finding stage prior to designation of waters diverted from East Maui. The information our industry provides will be utilized to justify and protect our current and future water allocation.

If you have any questions please don't hesitate to contact me.

5-27-09

– Here is our info on water

Mahalo,

Business Name: Farmer #10
Address:
Phone:
Contact:

Water Use

Historical Trends: MONTHLY USE FOR ORCHIDS, Palms BamBoo & Landscape
(Seasonal Changes) WATER NEEDED ALL YEAR LONG – POT PLANTS

Current Use: 1,000,000
Gallons/Month

Future Demands: 1,500,000
Gallons/Month

Water Use Purpose:

Crop: ORCHIDS, Palms, BamBoo, ornamentals, Domestic

Acreage: 26.7

Economic Impact:

When water availability/supply drops

25% WE LOSE our customers, cut Farm Help 25%

50% WE ARE OUT of Business, All our Employees ARE GONE

75% OUR AREA BECOMES A DESERT

FROM : MAIN FAX NO. : May. 26 2009 02:01PM P1
09 34 60 05-26 2009 3/4

Business Name: Farmer #11
Address:
Phone:
Contact:

Water Use
Historical Trends: 3,000 per day to 4,700 per day
(Seasonal Changes) We are using more in Summer less in Winter
Vary as much as 50%

Current Use: 200,000
Gallons/Month

Future Demands: 210,000
Gallons/Month

Water Use Purpose:
Crop: Orchids in Pot
Acreage: 2 acres

Economic Impact:
When water availability/supply drops
25% Crop loss of 20% for a minimum of 5 years. Lay-off 1/2 employees 8 total employees 4 laid off.
50% Crop loss of 50% for 7 seven years All employees laid off. Total 8.
75% No Farming

Business Name: Farmer #12
Address:
Phone:
Contact:

Water Use
Historical Trends: AVE. ≈ 1800 GAL. PER DAY or 54,000 GAL PER 30 DAY MONTH
(Seasonal Changes) NONE UNLESS RAINING

Current Use: 54,000 GAL.
Gallons/Month

Future Demands: DEPENDS ON EXPANSION
Gallons/Month

Water Use Purpose:
Crop: POTTED NURSERY STOCK
Acreage: 3 ACS
MOST OF IRRIGATION IS ON DRIP

Economic Impact:
When water availability/supply drops MUST STILL IRRIGATE
25%
50%
75%

Business Name: Farmer #13
Address:
Phone:
Contact:

Water Use

Historical Trends:
(Seasonal Changes) ± 25% approx.

Current Use: 180,000 g/mo.
Gallons/Month

Future Demands: 200,000/mo.
Gallons/Month

Water Use Purpose:
Crop: Potted plant ornamentals/greenhouse grown
Acreage: 3/4

Economic Impact:
When water availability/supply drops
25% Direct co-relation to reduction in revenue/sales
50%
75%

ORCHIDS OF OLINDA, Inc.
P.O. BOX 115
MAKAWAO, MAUI, HI 96768

Phone: (808) 572-0839
Fax: (808) 572-1421
Email: olinda@tiki.net

DATE 6-1-09

THIS FAX CONSISTS OF 2 PAGES (INCLUDING COVER SHEET)

TO: WARREN WATANABE FAX# 871-9723

REMARKS:
HERE IS MY REPORT.

PLEASE CALL WITH
ANY QUESTIONS OR CONCERNS

DAN

Aloha,

Dan Judson

Business Name: Farmer #14
Address:
Phone:
Contact:

Water Use

Historical Trends: INCREASE SUMMER USAGE
(Seasonal Changes) 4000 GPD - SUMMER 2000 GPD - WINTER

Current Use: 4000 GPD
Gallons/Month 124,000 GPM

Future Demands: SAME
Gallons/Month

Water Use Purpose:

Crop: BLOOMING ORCHID PLANTS

Acreage: 10,000 SQ FT GREENHOUSE

Economic Impact:

When water availability/supply drops

25% LESS FLOWER PRODUCTION

50% OUT OF BUSINESS

75% OUT OF BUSINESS

9.0 Maui Office of Economic Development, Water Supply Improvements to the Kula Agricultural Park, Preliminary Engineering Report

WATER SUPPLY IMPROVEMENTS TO THE KULA AGRICULTURAL PARK

PRELIMINARY ENGINEERING REPORT

Prepared for:

County of Maui
Department of Economic Development

November 2006

Fukunaga and Associates, Inc.
Consulting Engineers
1388 Kapiolani Boulevard, 2nd Floor
Honolulu, Hawaii 96814
(808) 944-1821

WATER SUPPLY IMPROVEMENTS TO THE KULA AGRICULTURAL PARK
PRELIMINARY ENGINEERING REPORT

ISLAND OF MAUI
STATE OF HAWAII

PREPARED FOR:

COUNTY OF MAUI
OFFICE OF ECONOMIC DEVELOPMENT

PREPARED BY:

FUKUNAGA AND ASSOCIATES, INC
1388 KAPIOLANI BLVD., 2ND FLOOR
HONOLULU, HAWAII 96814

November 2006

ROYCE S. FUKUNAGA
LICENSED PROFESSIONAL ENGINEER
No. 2107-C
HAWAII, USA

This work was prepared by me
or under my supervision

Royce S. Fukunaga

I. PURPOSE

The purpose of this preliminary engineering report is to investigate various options to provide a more reliable supply of irrigation water to the Kula Agricultural Park (the Park).

II. BACKGROUND

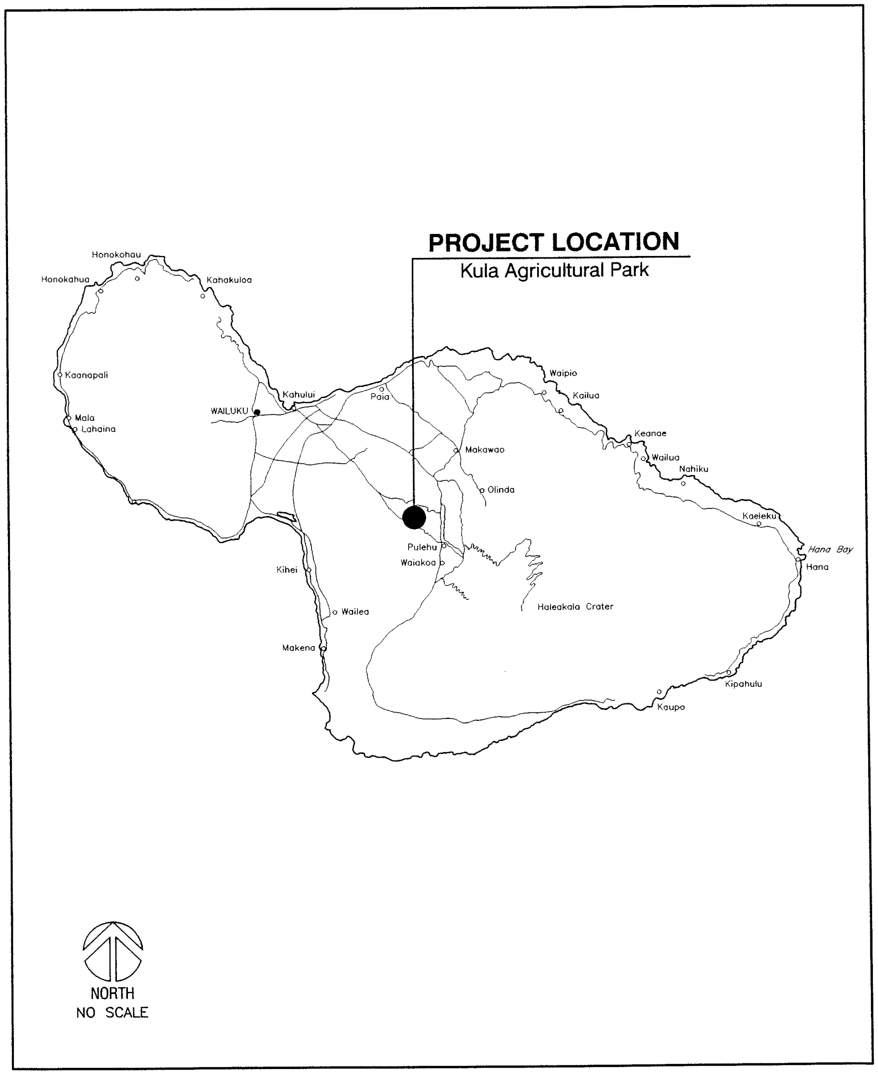
A. Kula Agricultural Park

The Kula Agricultural Park was originally constructed by the County of Maui in 1982. The land that the park is located on was obtained from Maui Land and Pineapple (MLP) in exchange for County land in Napili. The Park is located on the western slope of Haleakala, as indicated on Figure 1. The Park was created to promote the development of diversified agriculture. The park consists of 31 farm lots, which are rented out to individual farmers. The lots range in size from 7 acres to 29 acres for a total area of 445 acres. Irrigation water is currently supplied to the Park by pumping water from the Hamakua Ditch (the Ditch) to two storage reservoirs located in the Park. The two reservoirs have a total storage capacity of approximately 5.4 million gallons (MG). Potable water is scarce on Maui and is generally not used for irrigation of crops.

B. Irrigation System

The County of Maui currently has an agreement with Alexander & Baldwin (A&B), through its division Hawaiian Commercial & Sugar (HC&S), and East Maui Irrigation (EMI) to withdraw up to 1.5 million gallons of water per day (mgd) from the Hamakua Ditch to provide irrigation water to the Park and the adjacent Haleakala Ranch property. Water may also be available for use at the adjacent MLP land. A&B is the owner of the Hamakua Ditch, which is the source of irrigation water for the Park. EMI maintains and manages the Ditch and delivers water to the users. The Hamakua Ditch system consists of a series of ditches, tunnels, and flumes that can collect and transport up to 450 mgd. The system also includes several reservoirs to store water.

The County currently withdraws water from the Hamakua Ditch and conveys water to the Kula Agricultural Park with a pump station. The intake for the pump station is just upstream of A&B's Reservoir 40. The pump station at Reservoir 40 conveys water to the lower reservoir at the Park. A pump station at the lower reservoir pumps water to the upper reservoir at the Park. Both the upper and lower reservoirs are used for irrigation at the Park. Figures 2 and 3 show the existing irrigation system.

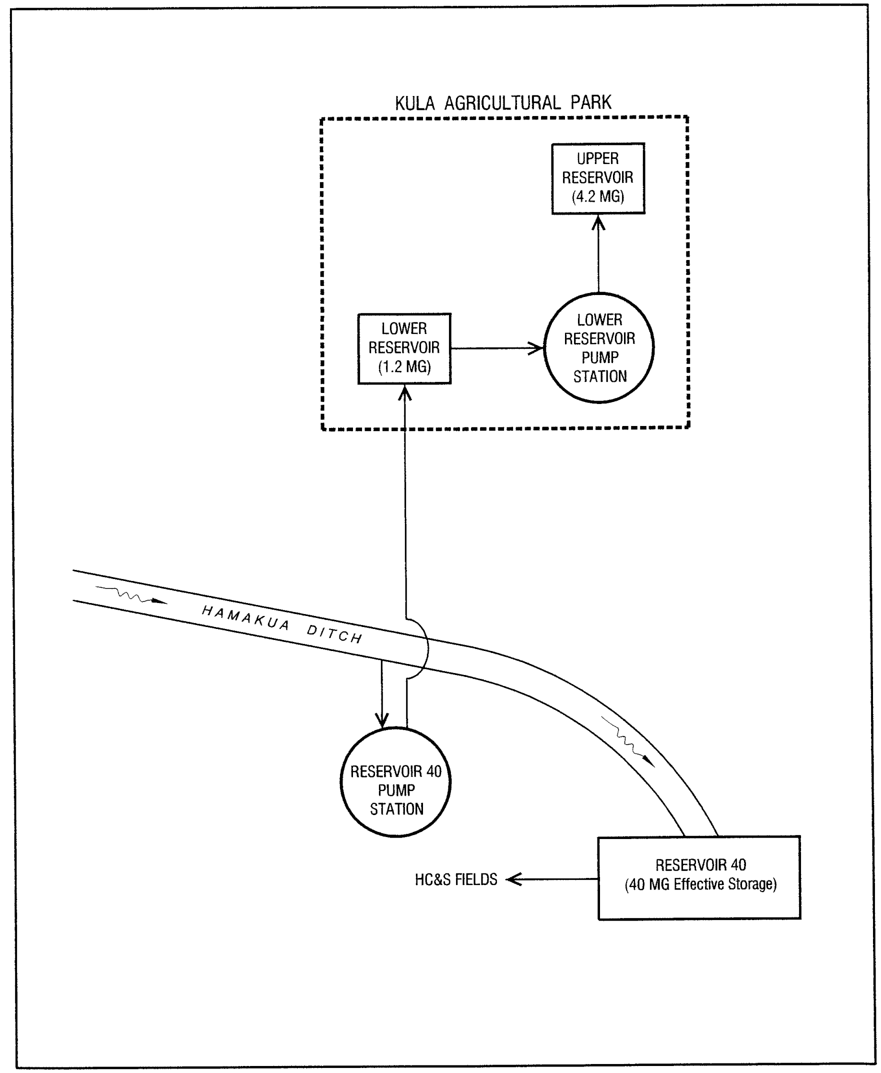


MAUI COUNTY

Kula Agricultural Park

LOCATION MAP - Island of Maui

FIGURE 1

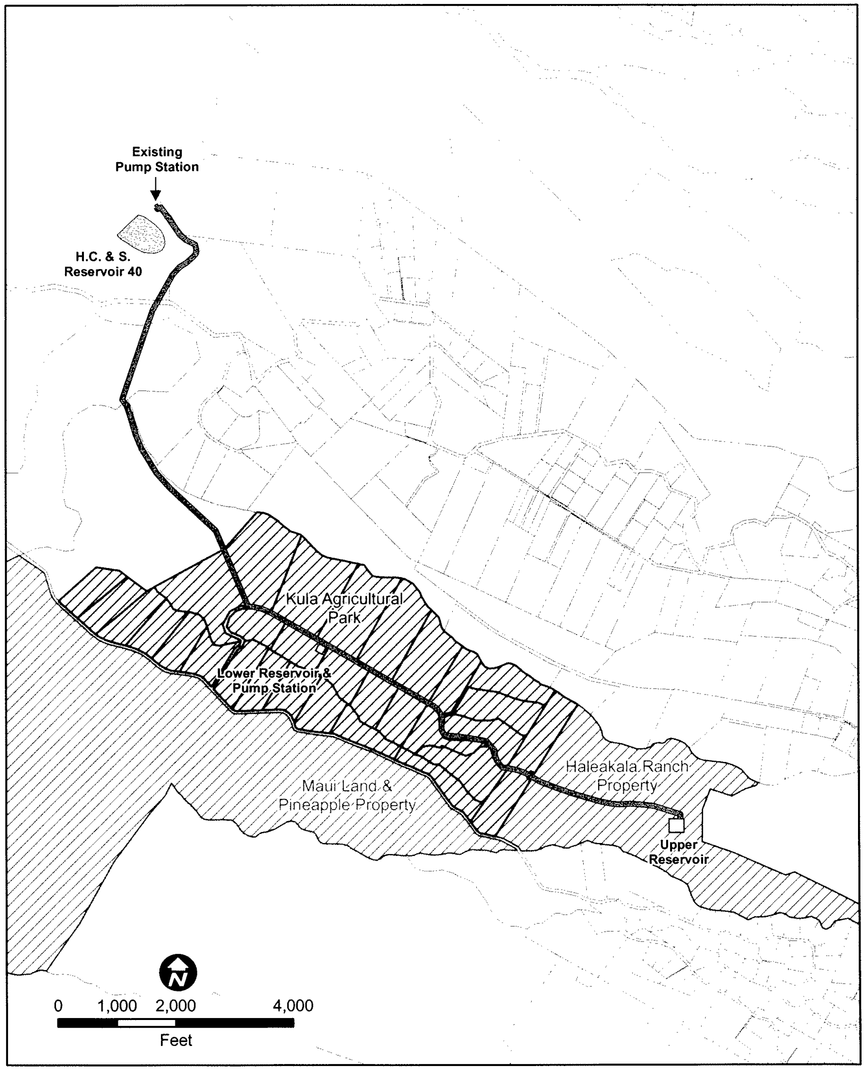


MAUI COUNTY

Kula Agricultural Park

EXISTING IRRIGATION SYSTEM SCHEMATIC

FIGURE 2



MAUI COUNTY
Kula Agricultural Park

EXISTING IRRIGATION SYSTEM: PLAN VIEW
FIGURE 3

i. Pump Stations

The pump stations at Reservoir 40 and at the lower reservoir each have two pumps. Both pump stations were originally constructed in 1982, at the same time as the Park. The pump station at Reservoir 40 currently has 2 vertical turbine pumps, each with a rated capacity of 750 gpm (approximately 1.08 mgd). The pump station was designed to accommodate a third pump, but it has not been installed. The pump station at Reservoir 40 has a screening system to remove silt and other large objects from the influent water from the Ditch. The screens are manually cleaned every day by Department of Water staff, but they occasionally get plugged when a large amount of sediment accumulates overnight. If the screens are completely plugged, water cannot enter the pump station wet well and cannot be pumped to the reservoirs at the Park. The pump station at Reservoir 40 conveys water to the lower reservoir at the Park through a 20-inch diameter ductile iron pipeline. A pump station at the lower reservoir conveys water to the upper reservoir at the Park. The pump station at the lower reservoir has two pumps, one has a capacity of 1,750 gpm (2.52 mgd) and the other has a capacity of 1,850 gpm (2.66 mgd). Table 1 provides a summary of the existing irrigation system pump stations.

Table 1: Existing Pump Stations
Kula Agricultural Park
Maui County, Office of Economic Development

Pump Station Location	Number of Pumps	Capacity (gpm)
Reservoir 40	2	750, each
Kula Ag Park Lower Reservoir	2	1 @ 1,750 1 @ 1,850

Each pump station has an electrical building to house the motor starters and controls for the pumps. The pumps at Reservoir 40 turn on and off according to the water surface elevation in the lower reservoir. The pumps at the lower reservoir turn on and off according to the water surface elevation in the upper reservoir. The pumps have been operating satisfactorily, but the pump stations are relatively old and some equipment is outdated. Finding replacement parts for the electrical equipment can be difficult due to the age of the system. Both pumps at Reservoir 40 need to be operating to pump the maximum water allotment of 1.5 mgd. If both pumps are operating, there is no standby unit. If one of the pumps is out of service for repair or maintenance, the pump station will not be able to convey 1.5 mgd to the Park.

ii. Reservoirs

The water stored in Reservoir 40 is used to irrigate fields owned by HC&S. The reservoir has not been cleaned in over 20 years; and there is a substantial amount of silt accumulated at the reservoir bottom, which reduces the storage capacity. To remove the accumulated silt would require draining the reservoir and allowing the silt to dry before it is removed. This process would require the closure of the reservoir for several months. During this time, the Park would not receive irrigation water. There are other cleaning options available that can be accomplished without shutting down the reservoir, but these options are more expensive.

The water stored in the upper and lower reservoirs is used by tenants of the Park and MLP for irrigation. The lower reservoir is located within the Park, and the upper reservoir is located above the Park on Haleakala Ranch property. There is an easement through Haleakala Ranch property for the transmission pipeline and upper reservoir. Table 2 summarizes the storage capacity of the reservoirs in the existing irrigation system.

Table 2: Existing Reservoirs
Kula Agricultural Park
Maui County, Office of Economic Development

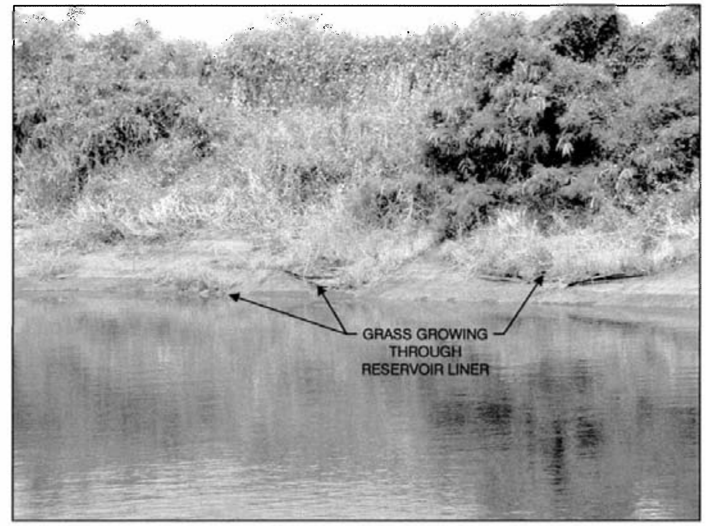
Reservoir	Storage Capacity (million gallons)
Reservoir 40[1]	40[2]
Kula Ag Park Lower Reservoir	1.2
Kula Ag Park Upper Reservoir	4.2

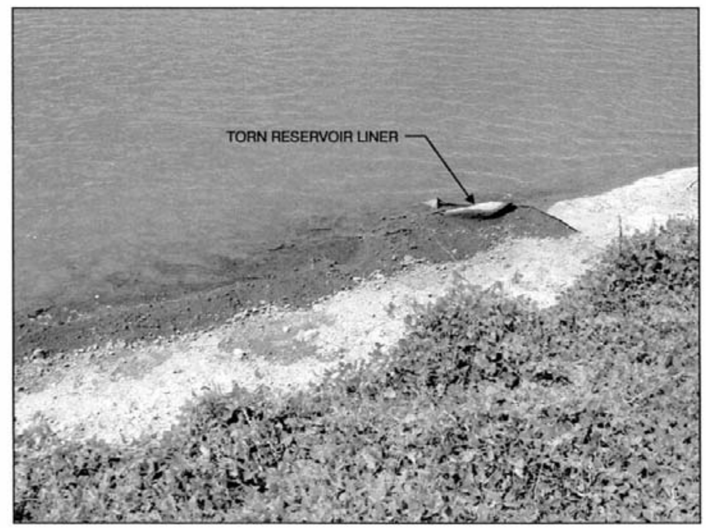
1) Property of A&B.
2) Effective storage capacity, due to silt accumulation. Original capacity = 60 MG.

A visual inspection of the upper and lower reservoirs by the Department of Water Supply revealed tears in the reservoir liners above the water surface. In some areas, grass can be seen growing through the liner, as shown in Figure 4. The reservoirs were filled at the time, so it was not possible to determine if there were any tears in the liner below the water surface. Tears in the reservoir liner may allow water to leak out of the reservoir and seep into the ground. This will reduce the amount of water available for irrigation, and may saturate the soil beneath the reservoir. If the soil beneath the reservoir is saturated, it may not have sufficient strength to support the reservoir. The status of the existing liners at the reservoirs should be investigated.

C. Water Usage

Per Department of Water Supply records for 2003-04, the average daily water use at the Park was approximately 0.55 mgd. This water usage included tenants at the Park and users on the adjacent MLP property. MLP usage consisted of approximately 16-20% of the total water use. Peak usage occurred during the summer, with the highest water use between July and September. The peak water usage during 2003-04 occurred in September 2004, with an average daily consumption of approximately 0.88 mgd (including water usage on MLP land). Table 3 summarizes the storage capacity of the existing reservoirs at the Park based on water usage.





MAUI COUNTY
Kula Agricultural Park

TEARS IN EXISTING RESERVOIR LINERS
FIGURE 4

Table 3: Storage Capacity of Existing Reservoirs
Kula Agricultural Park
Maui County, Office of Economic Development

Item	Value
Total Reservoir Storage (MG)	5.4
Storage Capacity @ 0.55 mgd (days)$^{(1,2)}$	9
Storage Capacity @ 1.5 mgd (days)$^{(1,3)}$	3

1) Assumes reservoirs are full.
2) Existing average day demand.
3) Maximum allowed irrigation water withdrawl.

D. Water Supply Issues

During drought periods when water levels in the Hamakua Ditch are low, there is little water available for the pump station at Reservoir 40 to send to the Park. When the water level in the Ditch is low, there is not sufficient water entering the pump station to satisfy the water demands for the Park. Unfortunately, this tends to occur during the hotter, dryer, summer months when water demand is the highest. A more reliable water supply system is required to rectify this problem.

EMI performs maintenance on the Hamakua Ditch at least once a year. While the ditch is shut down for maintenance, which may be for a week, no water is being pumped to the Kula Agricultural Park reservoirs. The existing reservoirs do not have sufficient storage to provide irrigation water during the entire duration of the maintenance work. EMI does not schedule maintenance to the ditch system during drought periods. An alternate water supply system or additional storage facilities are required to rectify this problem.

The pumps at the lower reservoir have a much higher capacity than the pumps at Reservoir 40. This may cause the lower reservoir pumps to turn on and off more frequently than the Reservoir 40 pumps.

III. REQUIRED ACTIONS

The following actions should be performed to provide a more reliable water supply to the Kula Agricultural Park irrigation system, and to protect the safety of the Park tenants.

A. Repair Existing Upper and Lower Reservoirs

Tears to the existing liner above the water surface at the upper and lower reservoirs have been observed. The liners for both reservoirs should be inspected and the condition of the reservoirs assessed. If the liners below the water surface have been torn or there are signs of leaking, the soil below the liner will need to be inspected. The soil beneath the liner needs to provide sufficient support for the reservoir. If the liners below the water surface have been torn, a geotechnical investigation of the soils beneath the reservoirs should be performed to ensure the soil is still suitable to support the reservoir. Any other

improvements will be ineffective if the existing liners are leaking through tears beneath the water surface.

i. Work Required

The inspection of the existing liners below the water surface will require draining the existing reservoirs. The length of time the reservoirs will remain empty and the required repairs will depend on the status of the liners below the water surface. If the reservoir liners are torn below the water surface, a geotechnical investigation of the soils beneath the reservoir is required to check the stability of the soil. The geotechnical investigation will determine if any work is required to stabilize the soil beneath the reservoirs.

ii. Costs

The cost of the repairs to the upper and lower reservoirs will depend on the status of the existing liners. The costs to rectify any problems will be based on the recommendations of the soils report, if required.

IV. PROPOSED SOLUTIONS

The following proposals are intended to provide a more reliable water supply to the Kula Agricultural Park irrigation system. These proposals are intended to be done in conjunction with the repairs at the existing upper and lower reservoirs.

A. Pump Station at Reservoir 40 Outlet

A report by Wai Engineering in 2004 recommended the construction of a new pump station at the outlet of Reservoir 40. This pump station is intended for intermittent use, when the ditch is out of service for maintenance work or the water surface in the Ditch is low. The new pump station would pump water from the Reservoir 40 outlet to the intake of the existing pump station, a distance of approximately 1,000 feet. The existing pump station would then pump water up to the lower reservoir. The capacity of the new pumps would match the capacity of the existing pumps at Reservoir 40. The pump station would not necessarily be used during drought periods. During drought periods, all water users would be expected to cut back on their water usage. The Wai Engineering report recommended the new pump station discharge to the Ditch, upstream of the existing pump station intake. However, in this configuration, not all of the water pumped by the new pump station will enter the existing pump station intake. Some of the water will flow past the intake structure and re-enter Reservoir 40. Therefore, it is recommended to connect the new pump station discharge to the existing pump station intake pipe.

If this option is pursued, the existing pump station will be the limiting factor in the system. The existing pump station does not have reliable capacity to pump 1.5 mgd to the Park. Adding a third pump to the existing pump station is recommended to provide reliable capacity. The existing pump station has provisions for a third pump to be installed.

i. Required Work

The suction for the new pump station will connect to the existing 24" pipe at the Reservoir 40 outlet, upstream of the existing gate valve. The new pump station will consist of two solids handling non-clog pumps. One pump will operate as the duty pump and the other will be an emergency standby. The duty pump should be alternated to reduce wear on the pumps. The discharge for the new pump station will connect to the existing 20" influent line to the existing pump station. A check valve will be installed at this connection point to prevent water from flowing to the new pump station while it is not in use. The new pump station will not have a screening facility and the solids handling pumps will convey any debris from Reservoir 40 to the existing pump station. The manually cleaned screening system at the existing pump station will continue to be used. See Figures 5 and 6 for schematic and plan views of the system.

A new electrical building will be required for the new pump station. This building will house the motor starters and the controls for the new pumps. The new pump station will have an antenna and remote terminal unit (RTU) to communicate with the existing pump station. The new pump station will be programmed to operate based on the water surface elevation in the wet well of the existing pump station at Reservoir 40.

If a third pump is added to the existing pump station, mechanical and electrical provisions must also be added to the existing facilities. This includes piping, valves, motor starters, wiring, SCADA programming, and other appurtenant equipment.

ii. Maintenance

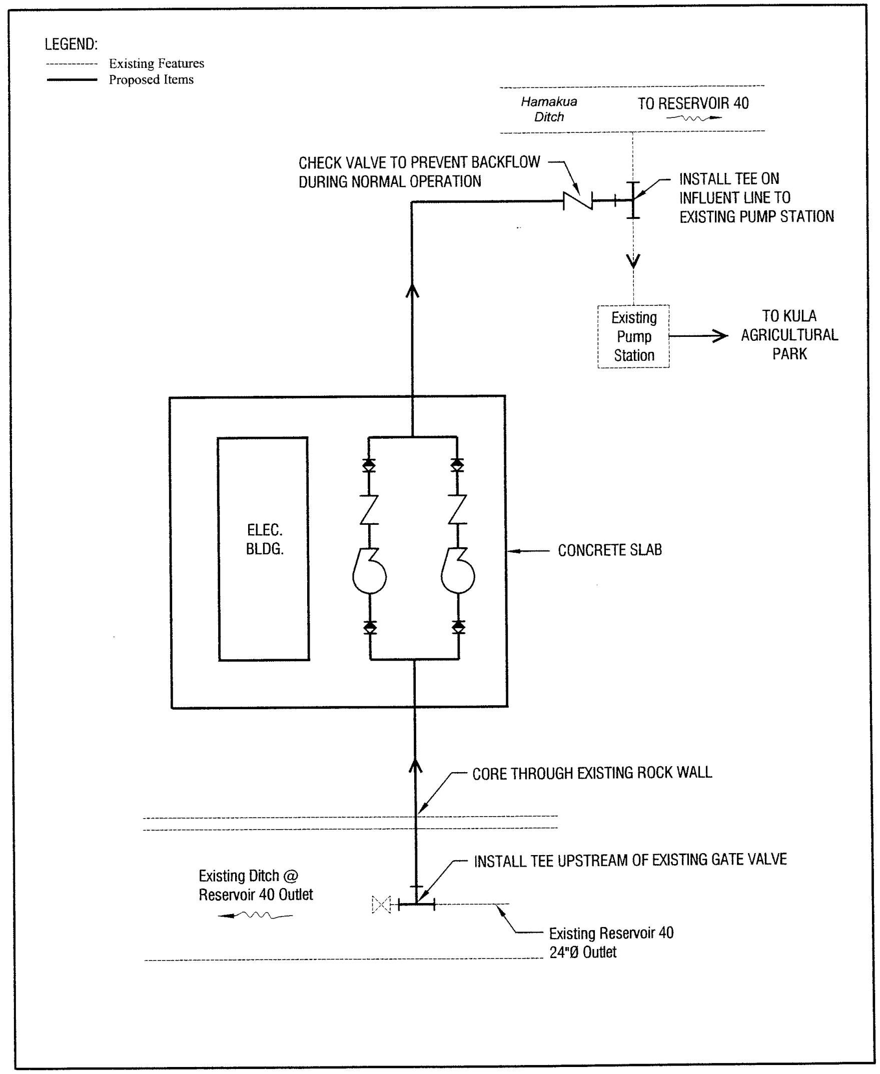
Although this pump station is intended for intermittent use, regular maintenance is still required. After use, the pumps and pipeline should be cleaned to prevent silt from accumulating in the pipeline and on the internal parts of the pump. The pumps and valves should be exercised regularly to ensure they are operating properly. Regular maintenance at the existing pump station will continue to be performed, including cleaning the existing screens daily.

iii. Advantages

This alternative is relatively inexpensive when compared to other alternatives.

iv. Disadvantages

There will be two pump stations at Reservoir 40, increasing manpower required for maintenance. The existing pump station will continue to age and replacement parts will be increasingly difficult to find. The existing pumps will not have reliable capacity to convey the maximum allowable flow of 1.5 mgd to the Park. To rectify this, a third pump would need to be added to the existing pump station. This will provide standby capacity



MAUI COUNTY

Kula Agricultural Park

PUMP FROM RESERVOIR 40 OUTLET TO EXISTING PUMP STATION (Schematic)

FIGURE 5

MAUI COUNTY

Kula Agricultural Park

PUMP FROM RESERVOIR 40 OUTLET TO EXISTING PUMP STATION (PLAN)

FIGURE 6

if either of the existing pumps is out of service. If a third pump is added to the existing pump station, the pumps at the new pump station should each have a capacity of 1.5 mgd. The screening system at the existing pump station will still be vulnerable to plugging when the pump station is not manned.

v. Cost

The estimated cost to construct this new pump station is $460,000. This includes the pumps, piping, valves, equipment slab and electrical work. If a third pump is added to the existing pump station, the additional cost would be approximately $440,000, for a total cost of $900,000.

B. Replace Existing Pump Station at Reservoir 40

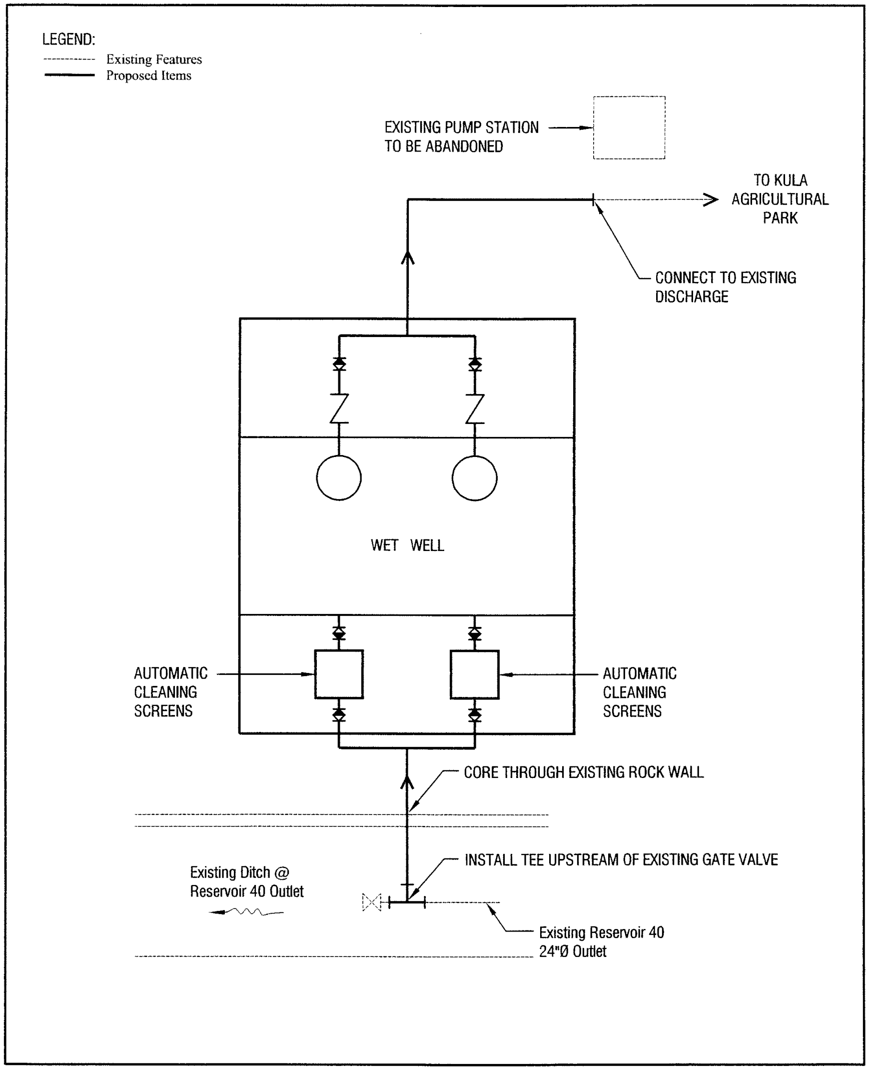
Another option is to replace the existing pump station at the Reservoir 40 inlet with a new pump station located at the outlet of Reservoir 40. This new pump station will pump water from the Reservoir 40 outlet up to the lower reservoir of the Park. This pump station would be used daily to provide water to the Park. During drought periods the new pump station will still be able to provide water to the Park, but Park tenants may be asked to reduce water usage or pumping to the Park may be reduced.

i. Required Work

The suction for the new pump station will connect to the existing 24" pipe at the Reservoir 40 outlet, upstream of the existing gate valve. The new pump station will consist of two vertical turbine pumps. Vertical turbine pumps are recommended because of the high pressure required to pump up to the Park. One pump will operate as the duty pump and the other will be an emergency standby. The new pump station will be located at a lower elevation than the existing pump station, so the new pumps will require more head than the existing pumps. Each pump should have a capacity of approximately 1.5 mgd (1,050 gpm), which matches the maximum amount of water allowed to be withdrawn from the Ditch. The duty pump should be alternated to reduce wear on the pumps. The discharge for the new pump station will connect to the existing effluent line from the existing pump station.

The new pump station will need a screening facility to remove silt, leaves, branches, and other objects that may fall into the ditch or reservoir. The screening system should have an automated cleaning system to clear the screen while the pump station is not manned. This will keep the screening system from plugging and overflowing while the pump station is not being manned. Vertical turbine pumps are more suitable for clean water, so an efficient screening system is required.

The existing power supply would need to be extended to a new electrical building at the new pump station. The new pumps will have larger motors than the existing pumps and the existing motor starters are old and outdated. Therefore, new electrical equipment should be installed. See Figures 7 and 8 for a schematic and plan view of the system.



MAUI COUNTY
Kula Agricultural Park

REPLACE EXISTING PUMP STATION (Schematic)
FIGURE 7

MAUI COUNTY
Kula Agricultural Park

REPLACE EXISTING PUMP STATION (PLAN)
FIGURE 8

ii. Maintenance

Department of Water staff should continue to visit the new pump station on a daily basis. Although an automated cleaning system is recommended, the screenings should be collected daily to prevent accumulation of large amounts of screenings.

iii. Advantages

Replacing the existing pump station will provide new mechanical and electrical equipment. The automatic cleaning system for the screening facility will keep the influent screens from plugging while the pump station is not manned. The new pumps would have reliable capacity to convey 1.5 mgd to the Park.

iv. Disadvantages

This alternative is a more expensive option.

v. Cost

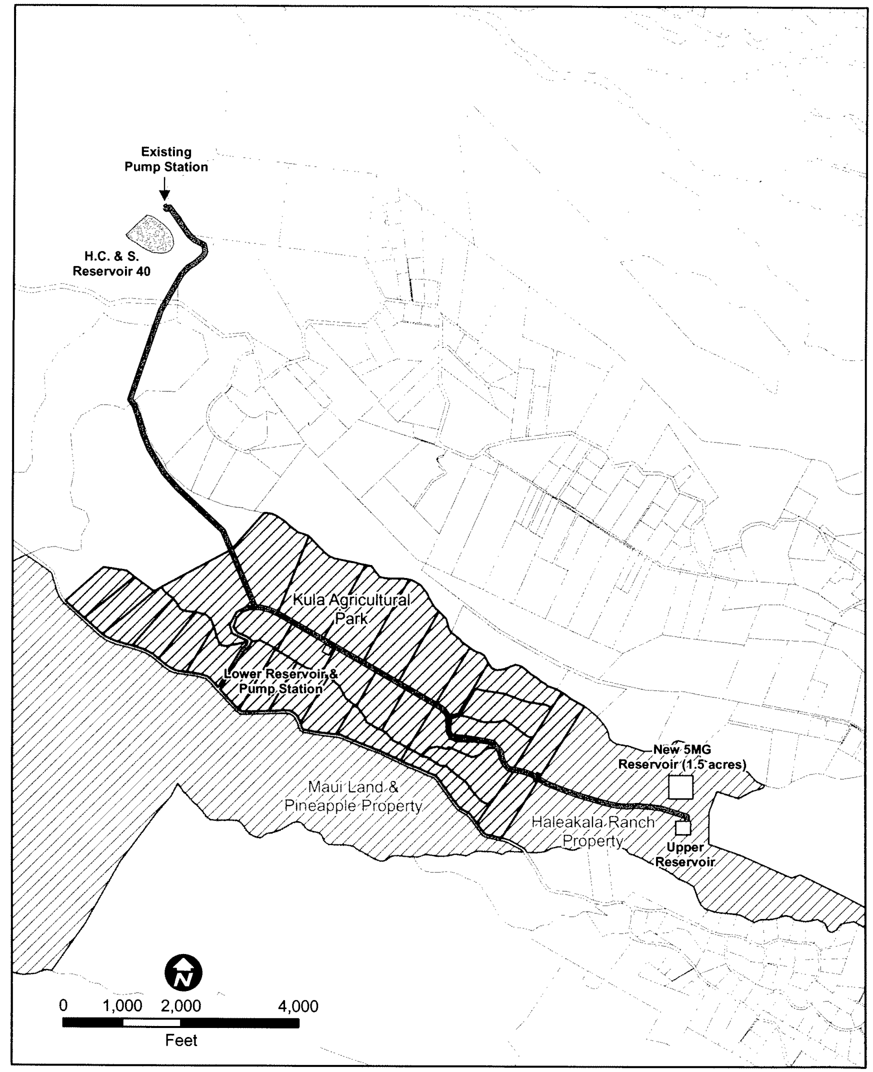
The estimated cost to replace the existing pump station at the Reservoir 40 inlet with a new pump station at the Reservoir 40 outlet is $3.0 million.

C. Increase Reservoir Storage

The existing reservoirs at the Park do not have sufficient storage capacity when the Ditch is closed for maintenance. Increasing the storage capacity within the Park would help during drought periods, times when the Ditch is closed for maintenance, and any other occurrences that may restrict or stop pumping from the Reservoir 40 pump station to the Park. Constructing a new reservoir with a storage capacity of approximately 5 MG will almost double the storage capacity at the Park. A new 5 MG reservoir would require approximately 1.5 acres of land. The new reservoir should be located at approximately the same elevation as the existing upper reservoir. This will allow the pump station at the lower reservoir to pump water to the new reservoir and not require the construction of a new pump station. This assumes that the land adjacent to the existing upper reservoir, which is owned by Haleakala Ranch, is available for lease or purchase for the new reservoir. See Figure 9 for an approximate location of the new reservoir.

i. Required Work

A new reservoir would be lined to prevent water from seeping into the ground. This will maximize the amount of water available for irrigation. A new reservoir would be enclosed with fencing to keep unauthorized people or animals from entering the area. A new reservoir would need level sensors to monitor the water surface elevation. The pumps at the lower reservoir pump station would turn on and off based on the water surface elevation at the new reservoir as well as the existing upper reservoir. Construction



MAUI COUNTY — CONSTRUCT NEW RESERVOIR

Kula Agricultural Park — FIGURE 9

of a new reservoir can be done in conjunction with the construction of a new pump station (either of the previous options), or it can stand alone as a separate project.

ii. Maintenance

The new reservoir, as well as the existing upper and lower reservoirs should be regularly inspected. The condition of the liners for all the reservoirs should be inspected for tears. Inspection of the reservoir liners will require that the reservoirs be drained. Timing for the inspections should be coordinated with Park tenants to ensure there is sufficient water for irrigation while each reservoir is drained. Grass around the reservoirs should be maintained to prevent overgrowth. The condition of the level sensors and transmitters should also be inspected.

iii. Advantages

Constructing a new reservoir will provide additional storage of irrigation water. This will help when the Ditch is being serviced, during drought periods, and any other occurrences that would reduce pumping to the Park.

iv. Disadvantages

Construction of a new reservoir is expensive and requires the acquisition of additional land.

v. Costs

The estimated cost to construct a new 5 MG reservoir is $2.4 million. This does not include the cost of land acquisition. This cost assumes that there is land available in close vicinity to the upper reservoir that would require minimal electrical and mechanical work to connect to the new reservoir to the existing system.

V. FUTURE CONSIDERATIONS

The following issues are not considered viable near term solutions for a more reliable source of irrigation water at the Park. However, these options should be considered in the future.

A. Connect to County Potable Water System

Using potable water to supplement the existing Ditch water system would provide a more reliable source of irrigation water to the Park. Temporary potable waterlines from the Department of Water Supply were previously used to supplement the reservoirs at the Park. These lines were removed several years ago and another supplemental system has not been implemented. The potable water lines in the area are small and would not be expected to provide 1.5 mgd of irrigation water to the Park. The potable water lines would provide whatever water is available to keep the reservoirs from becoming empty.

These potable water lines would only be used when the Ditch is closed for maintenance and would not be done during drought periods. Residential properties would have priority over the Park. However, the County has a long waiting list of property owners waiting for potable water service. The Department of Water Supply is not likely to allow potable water to be used for agricultural purposes, even if it would only be used in emergency situations. If more potable water sources are developed in the future, this option could be pursued in the future.

B. County Dual Water System

In an effort to preserve potable water, the County is planning a dual water system. This system intends to use reclaimed water from the wastewater treatment plants for irrigation and other non-potable uses. Using reclaimed water for non-potable uses will allow more potable water to be available for residential users. Treated wastewater would be pumped up to storage reservoirs and distributed to users via gravity flow. This is a very large project, and it is still in the planning phase and will not be completed for several years. Using the dual water system as a source for irrigation water at the Park should be investigated in the future.

VI. SUMMARY

The Kula Agricultural Park does not receive sufficient irrigation water when the Hamakua Ditch is shut down for maintenance or when the water surface in the Ditch is low. A more reliable source of irrigation water is required. Furthermore, the liners for the existing upper and lower reservoirs at the Park have evidence of tearing above the water surface. The status of the liners below the water surface needs to be checked to determine if an investigation of the soil beneath the reservoirs is required. At a minimum, the existing liners need to be repaired.

To provide the Kula Agricultural Park with a more reliable source of irrigation water, several scenarios are available. These scenarios include: construction of a new pump station to pump from the outlet of Reservoir 40 to the existing pump station, construction of a new pump station at the outlet of Reservoir 40 to replace the existing pump station, and construction of a new 5 MG reservoir at the Kula Agricultural Park.

Construction of a new pump station to pump from the outlet of Reservoir 40 to the existing pump station is the least expensive option. However, the existing pump station will be the bottleneck in the system. Addition of a third pump to the existing pump station is recommended. However, the existing components of the pump station are relatively old and will continue to create maintenance problems. Department of Water staff will also have to maintain two pump stations instead of one.

Construction of a new pump station at the outlet of Reservoir 40 to replace the existing pump station is a more expensive option, but will rectify deficiencies of the existing pump station. If the existing pump station is replaced with a new pump station, all the equipment will be new and the screening system will be cleaned automatically.

The construction of a new reservoir will provide more storage at the Park, which will help during times when pumping to the Park is stopped or restricted. The construction of a new reservoir can be done in conjunction with the construction of a new pump station at Reservoir 40, or it can stand alone as a separate project. Combining the construction of a new reservoir with the construction of a new pump station to replace the existing pump station will provide the best solution to provide a more reliable source of irrigation water, but it is the most expensive solution.

Table 4 summarizes the options to produce a more reliable source of irrigation water to the Park and the associated costs. This includes the scenarios listed above, as well as combinations of the scenarios. If any of these options are implemented, they should be done in addition to the investigation and repair of the existing upper and lower reservoirs.

Table 4: Summary of Options for More Reliable Source of Irrigation Water
Kula Agricultural Park
Maui County, Office of Economic Development

Option	Item	Cost[1,2]
IA	Construct new pump station to pump from Reservoir 40 outlet to existing pump station.	$460,000
IB	Construct new pump station and add third pump to existing pump station.	$900,000
II	Replace existing pump station at Reservoir 40 inlet with new pump station at Reservoir 40 outlet.	$3.0 million
III	Construct new 5 MG reservoir at Kula Ag Park.	$2.4 million
IVA	Construct new pump station to pump from Reservoir 40 outlet to existing pump station and construct new 5 MG reservoir.	$2.86 million
IVB	Construct new pump station to pump from Reservoir 40 outlet to existing pump station, add third pump to existing pump station, and construct new 5 MG reservoir.	$3.3 million
IVC	Replace existing pump station at Reservoir 40 inlet with new pump station at Reservoir 40 outlet and construct new 5 MG reservoir.	$5.4 million

1) See Appendix A for breakdown of costs.
2) Does not include cost to repair upper and lower reservoirs.

The options listed above are solutions that can be initiated now. There are other options that should be further investigated in the future. This includes the use of potable water lines to fill the reservoirs and connection to the County dual water system that is still in the planning phase.

Appendix A: Cost Estimate

Fukunaga & Associates, Inc.	**COST ESTIMATE**			DATE:	23-Oct-06	SHEET		1 of 2
Activity and Location:	Contract Number:					Job Number:		
Maui County: Kula Ag Park	Spec:					ID#:		
Project:	Estimated By: WM		Checked By:			Category:		
Water Intake Project	Status of Desig	Planning	PM Approval:			Job Order:		
Item Description:	QUANTITY		MATERIAL COST		LABOR COST		ENGINEERING ESTIMATE	
New Pump Station @ Reservoir 40 Outlet	NO	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
DIVISION 3: CONCRETE								
Concrete Pad	12	CY	$550.00	$6,600.00	$375.00	$4,500.00	$925.00	$11,100.00
Subtotal Concrete								**$11,100.00**
DIVISION 11: EQUIPMENT								
Centrifugal pumps	2	EA	$10,000.00	$20,000.00	$5,000.00	$10,000.00	$15,000.00	$30,000.00
Electrical	20	%						$6,000.00
Subtotal Equipment								**$36,000.00**
DIVISION 15: MECHANICAL								
8" HDPE pipe (DR17)	1000	LF	$10.00	$10,000.00	$30.00	$30,000.00	$40.00	$40,000.00
Trench & backfill	300	CY					$200.00	$60,000.00
6" swing check valve	2	EA	$2,000.00	$4,000.00	$250.00	$500.00	$2,250.00	$4,500.00
8" swing check valve	1	EA	$2,500.00	$2,500.00	$250.00	$250.00	$2,750.00	$2,750.00
6" PV	4	EA	$800.00	$3,200.00	$450.00	$1,800.00	$1,250.00	$5,000.00
24" GV	1	EA	$18,200.00	$18,200.00	$1,000.00	$1,000.00	$19,200.00	$19,200.00
8" DIP	30	LF	$150.00	$4,500.00	$200.00	$6,000.00	$350.00	$10,500.00
6" DIP 90 Elbow	4	EA	$300.00	$1,200.00	$200.00	$800.00	$500.00	$2,000.00
6" DIP 45 Elbow	2	EA	$300.00	$600.00	$200.00	$400.00	$500.00	$1,000.00
10x10x8 tee (DIP)	2	EA	$750.00	$1,500.00	$200.00	$400.00	$950.00	$1,900.00
24x24x6 tee (DIP)	1	EA	$3,400.00	$3,400.00	$1,200.00	$1,200.00	$4,600.00	$4,600.00
20x20x8 tee (DIP)	1	EA	$1,900.00	$1,900.00	$1,000.00	$1,000.00	$2,900.00	$2,900.00

Revised Cost Est pump to exist PS 10/23/2006

9.0-25

Fukunaga & Associates, Inc.	**COST ESTIMATE**			DATE:	23-Oct-06	SHEET		1 of 1
Activity and Location:	Contract Number:					Job Number:		
Maui County: Kula Ag Park	Spec:					ID#:		
Project:	Estimated By: WM		Checked By:			Category:		
Water Intake Project	Status of Desig	Planning	PM Approval:			Job Order:		
Item Description:	QUANTITY		MATERIAL COST		LABOR COST		ENGINEERING ESTIMATE	
Construct New 5 MG Reservoir	NO	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
DIVISION 2: SITE WORK								
Reservoir Excavation	30000	CY			$35.00	$1,050,000.00	$35.00	$1,050,000.00
Reservoir Liner	60000	SF					$5.00	$300,000.00
Fencing	1100	LF			$40.00	$44,000.00	$40.00	$44,000.00
20" DIP	1000	LF	$120.00	$120,000.00	$240.00	$240,000.00	$360.00	$360,000.00
DIVISION 16: ELECTRICAL								
Level Sensors	1	EA	$1,000.00	$1,000.00	$1,500.00	$1,500.00	$2,500.00	$2,500.00
SCADA programming	1	LS					$1,500.00	$1,500.00
Contingency	20	%						**$351,600.00**
Neighbor Island Factor	15	%						**$263,700.00**
Subtotal New Reservoir*								**$2,373,300.00**
*Does not include cost of land acquisition							say	**$2,400,000.00**

Revised Cost Est reservoir 10/23/2006

9.0-24

Fukunaga & Associates, Inc.	COST ESTIMATE	DATE: 31-Oct-06	SHEET 1 of 2
Activity and Location: Maui County: Kula Ag Park	Contract Number: / Spec:		Job Number: / ID#:
Project: Water Intake Project	Estimated By: WM / Status of Desig Planning	Checked By: / PM Approval:	Category: / Job Order:

Item Description: **Add 3rd Pump at Existing Pump Station**	QUANTITY NO	UNIT	MATERIAL COST UNIT COST	MATERIAL COST TOTAL	LABOR COST UNIT COST	LABOR COST TOTAL	ENGINEERING ESTIMATE UNIT COST	ENGINEERING ESTIMATE TOTAL
DIVISION 11: EQUIPMENT								
Vertical Turbine Pump	1	EA	$115,000.00	$115,000.00	$100,000.00	$100,000.00	$215,000.00	$215,000.00
Electrical	20	%						$43,000.00
Subtotal Equipment								**$258,000.00**
DIVISION 15: MECHANICAL								
10" BFV	1	EA	$1,000.00	$1,000.00	$500.00	$500.00	$1,500.00	$1,500.00
10 x 12 Reducer	1	EA	$1,500.00	$1,500.00	$750.00	$750.00	$2,250.00	$2,250.00
12" Check valve	1	EA	$5,500.00	$5,500.00	$2,700.00	$2,700.00	$8,200.00	$8,200.00
12" Gate Valve	1	EA	$2,500.00	$2,500.00	$1,200.00	$1,200.00	$3,700.00	$3,700.00
1" Air/Vacuum Valve	1	EA	$1,500.00	$1,500.00	$750.00	$750.00	$2,250.00	$2,250.00
16 x 12 Tee	1	EA	$500.00	$500.00	$250.00	$250.00	$750.00	$750.00
Subtotal Mechanical								**$18,650.00**
DIVISION 16: ELECTRICAL								
Motor starters	1	EA	$5,000.00	$5,000.00	$5,000.00	$5,000.00	$10,000.00	$10,000.00
Disconnect switch	1	EA	$2,000.00	$2,000.00	$1,000.00	$1,000.00	$3,000.00	$3,000.00
SCADA programming	1	LS					$1,000.00	$1,000.00
Subtotal Electrical								**$14,000.00**
Site Work (10% of total)	10	%						**$29,065.00**

9.0-27

Fukunaga & Associates, Inc.	COST ESTIMATE	DATE: 23-Oct-06	SHEET 2 of 2
Activity and Location: Maui County: Kula Ag Park	Contract Number: / Spec:		Job Number: / ID#:
Project: Water Intake Project	Estimated By: WM / Status of Desig Planning	Checked By: / PM Approval:	Category: / Job Order:

Item Description: **New Pump Station @ Reservoir 40 Outlet**	QUANTITY NO	UNIT	MATERIAL COST UNIT COST	MATERIAL COST TOTAL	LABOR COST UNIT COST	LABOR COST TOTAL	ENGINEERING ESTIMATE UNIT COST	ENGINEERING ESTIMATE TOTAL
Pipe supports	8	EA	$500.00	$4,000.00	$250.00	$2,000.00	$750.00	$6,000.00
ARV	1	EA	$1,000.00	$1,000.00	$500.00	$500.00	$1,500.00	$1,500.00
Support 24" pipe	1	LS	$1,000.00	$1,000.00	$1,000.00	$1,000.00	$2,000.00	$2,000.00
8" Core through wall	1	LS					$1,000.00	$1,000.00
Subtotal Mechanical								**$164,850.00**
DIVISION 16: ELECTRICAL								
Building	100	SF		$0.00		$0.00	$150.00	$15,000.00
Trench & backfil	20	LF		$0.00		$0.00	$50.00	$1,000.00
Concrete for duct	2	CY	$130.00	$260.00	$120.00	$240.00	$250.00	$500.00
Panels	2	EA	$500.00	$1,000.00	$500.00	$1,000.00	$1,000.00	$2,000.00
Motor starters	2	EA	$1,000.00	$2,000.00	$1,500.00	$3,000.00	$2,500.00	$5,000.00
Disconnect switch	2	EA	$2,000.00	$4,000.00	$1,000.00	$2,000.00	$3,000.00	$6,000.00
1" PVC conduit	100	LF	$0.30	$30.00	$2.70	$270.00	$3.00	$300.00
Primary power feed	1	LS					$80,000.00	$80,000.00
SCADA RTU	1	EA	$2,000.00	$2,000.00	$1,500.00	$1,500.00	$3,500.00	$3,500.00
SCADA programming	1	LS					$1,000.00	$1,000.00
Subtotal Electrical								**$114,300.00**
Site Work (10% of total)	10	%						**$32,625.00**
Contingency	20	%						**$71,775.00**
Neighbor Island Factor	15	%						**$53,831.25**
TOTAL								**$451,856.25**
							say	**$460,000.00**

9.0-26

Fukunaga & Associates, Inc.	COST ESTIMATE				DATE:	23-Oct-06	SHEET	1 of 2
Activity and Location:	Contract Number:					Job Number:		
	Spec:					ID#:		
Project:	Estimated By: WM			Checked By:		Category:		
Kula Ag pump station	Status of Desig	Planning		PM Approval:		Job Order:		
Item Description:	QUANTITY		MATERIAL COST		LABOR COST		ENGINEERING ESTIMATE	
Replace Existing PS	NO	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
DIVISION 2: SITE WORK								
Structural excavation	600	CY					$150.00	$90,000.00
Shoring	2300	SF	$10.00	$23,000.00	$20.00	$46,000.00	$30.00	$69,000.00
Subtotal Site Work								**$159,000.00**
DIVISION 3: CONCRETE								
Concrete	150	CY	$550.00	$82,500.00	$375.00	$56,250.00	$925.00	$138,750.00
5x3 hatch	1	EA	$1,200.00	$1,200.00	$300.00	$300.00	$1,500.00	$1,500.00
Stairs	25	EA					$500.00	$12,500.00
Subtotal Concrete								**$152,750.00**
DIVISION 11: EQUIPMENT								
Screens	2	EA	$20,000.00	$40,000.00	$10,000.00	$20,000.00	$30,000.00	$60,000.00
VTP	2	EA	##########	##########	$75,000.00	$150,000.00	$200,000.00	$400,000.00
Electrical	20	%						$92,000.00
Subtotal Equipment								**$492,000.00**
DIVISION 15: MECHANICAL								
Trench & backfill	350	CY					$200.00	$70,000.00

9.0-29

Fukunaga & Associates, Inc.	COST ESTIMATE				DATE:	31-Oct-06	SHEET	2 of 2
Activity and Location:	Contract Number:					Job Number:		
Maui County: Kula Ag Park	Spec:					ID#:		
Project:	Estimated By: WM			Checked By:		Category:		
Water Intake Project	Status of Desig	Planning		PM Approval:		Job Order:		
Item Description:	QUANTITY		MATERIAL COST		LABOR COST		ENGINEERING ESTIMATE	
Add 3rd Pump at Existing Pump Station	NO	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
Contingency	20	%						**$63,943.00**
Neighbor Island Factor	15	%						**$47,957.25**
TOTAL								**$431,615.25**
							say	**$440,000.00**

9.0-28

Fukunaga & Associates, Inc.	COST ESTIMATE			DATE:	23-Oct-06	SHEET		2 of 2
Activity and Location:	Contract Number:					Job Number:		
	Spec:					ID#:		
Project:	Estimated By: WM			Checked By:		Category:		
Kula Ag pump station	Status of Desigı Planning			PM Approval:		Job Order:		
Item Description:	QUANTITY		MATERIAL COST		LABOR COST		ENGINEERING ESTIMATE	
Replace Existing PS	NO	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
12" swing check valve	3	EA	$5,000.00	$15,000.00	$2,500.00	$7,500.00	$7,500.00	$22,500.00
12" PV	6	EA	$2,000.00	$12,000.00	$1,000.00	$6,000.00	$3,000.00	$18,000.00
24" GV	1	EA	$18,200.00	$18,200.00	$1,000.00	$1,000.00	$19,200.00	$19,200.00
16" DIP	1100	LF	$300.00	##########	$250.00	$275,000.00	$550.00	$605,000.00
16" DIP 90 Elbow	4	EA	$1,100.00	$4,400.00	$600.00	$2,400.00	$1,700.00	$6,800.00
12x12x16 tee (DIP)	1	EA	$700.00	$700.00	$400.00	$400.00	$1,100.00	$1,100.00
16x16x16 tee (DIP)	1	EA	$1,600.00	$1,600.00	$800.00	$800.00	$2,400.00	$2,400.00
24x24x16 tee (DIP)	1	EA	$3,800.00	$3,800.00	$1,200.00	$1,200.00	$5,000.00	$5,000.00
Connect to existing 16" pipe	1	LS					$1,000.00	$1,000.00
Pipe supports	8	EA	$500.00	$4,000.00	$500.00	$4,000.00	$1,000.00	$8,000.00
ARV	2	EA	$1,000.00	$2,000.00	$500.00	$1,000.00	$1,500.00	$3,000.00
Support 24" pipe	1	EA	$1,000.00	$1,000.00	$1,500.00	$1,500.00	$2,500.00	$2,500.00
16" Core through wall	1	LS					$2,000.00	$2,000.00
Subtotal Mechanical								**$766,500.00**
DIVISION 16: ELECTRICAL								
Electrical Distribution System	25	%						**$400,062.50**
Subtotal Electrical								**$400,062.50**
Site Work	10	%						**$200,031.25**
Contingency	20	%						**$400,062.50**
Neighbor Island Factor	15	%						**$300,046.88**
TOTAL								**$2,900,453.13**
							say	**$3,000,000.00**

10.0 Maui County Farm Bureau, U.S. Department of Agriculture, National Agriculture Statistics Service Data

USDA, NASS, HAWAII FIELD OFFICE
"Fact Finders for Hawaii Agriculture"

United States Department of Agriculture - National Agricultural Statistics Service
In cooperation with Hawaii Department of Agriculture - Agricultural Development Division

March 26, 2009

Maui County Farm Bureau Federation
75 Kawehi Place
Kula, HI 96790

Maui County Farm Bureau,

The most complete and comprehensive agricultural production data published is the Census of Agriculture. This data is published at the State and County level, but not at the zip code level. Data summarized by zip code would relate to the farm operator's mailing address which is not necessarily the area where their farm commodities were grown or raised. For this reason, only farm and ranch numbers will be published by zip code in July of this year.

Zip code level of precision is compromised because the data is summarized based on mail delivery location, not by tax map key (TMK) location. We also had to insure individual operational data was not disclosed or the breakouts would not disclose data from the remaining Maui County zip code records.

After conducting extensive research, consulting with our National Office, and checking to ensure that individual operational data was not disclosed we have estimated the aggregate totals for value of sales, harvested land irrigated, and other land irrigated. Our estimates for the combined totals for Haiku (967080), Kahului (96732 and 96733), and Kula (96790) are:

Total value of agricultural sales: $24 million in 2007, $17 million for 2002.
Total crop value of sales: $20 million in 2007, $14 million for 2002.
Total livestock value of sales: $4 million in 2007, $3 million for 2002.
Harvested land irrigated: 1,000 acres in 2007, 1,000 in 2002.
Pastureland, rangeland, abandoned cropland, and other land irrigated: 1,400 acres in 2007 and 1,100 for 2002.

We could not access the 1997 Census of Agriculture by zip code due to formatting differences. This Census of Agriculture used the Commerce Departments system which is not compatible.

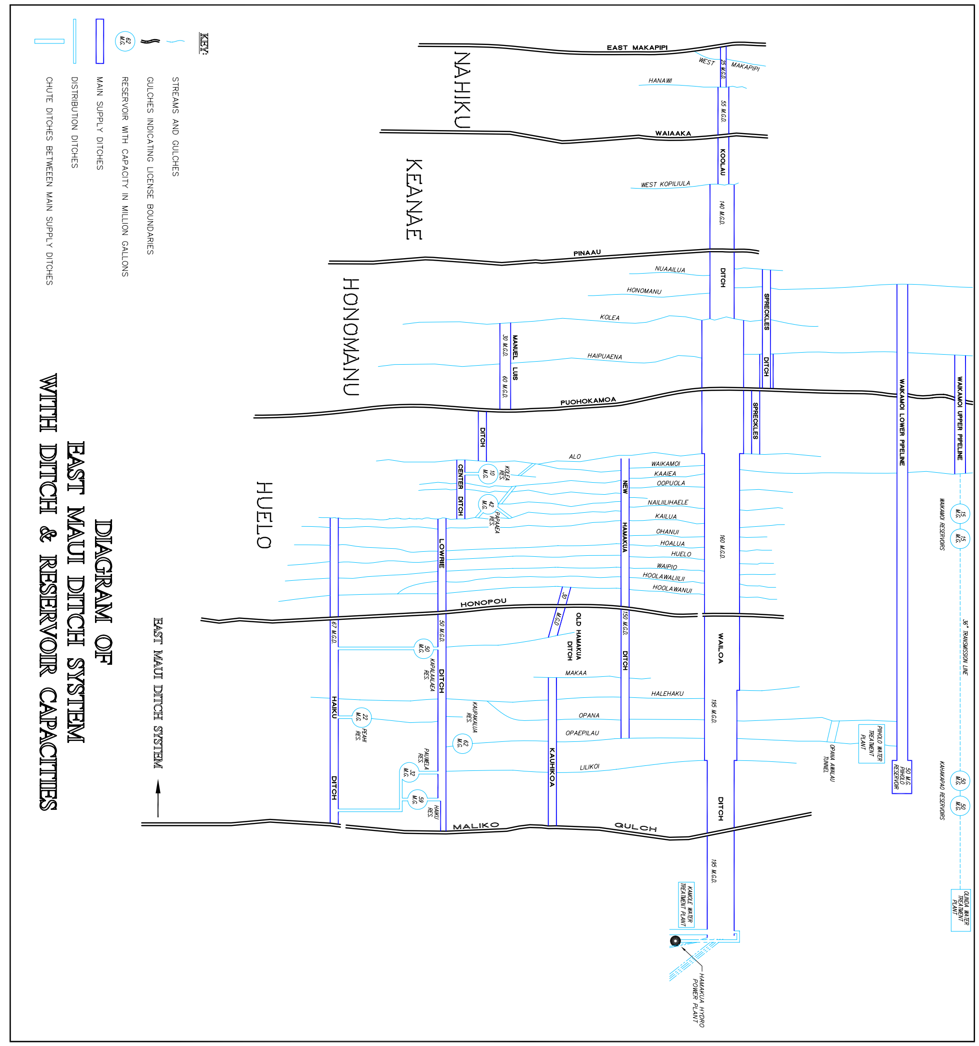
Please call our office if you have questions or need additional help at 1-800-804-9514.

Thank you,

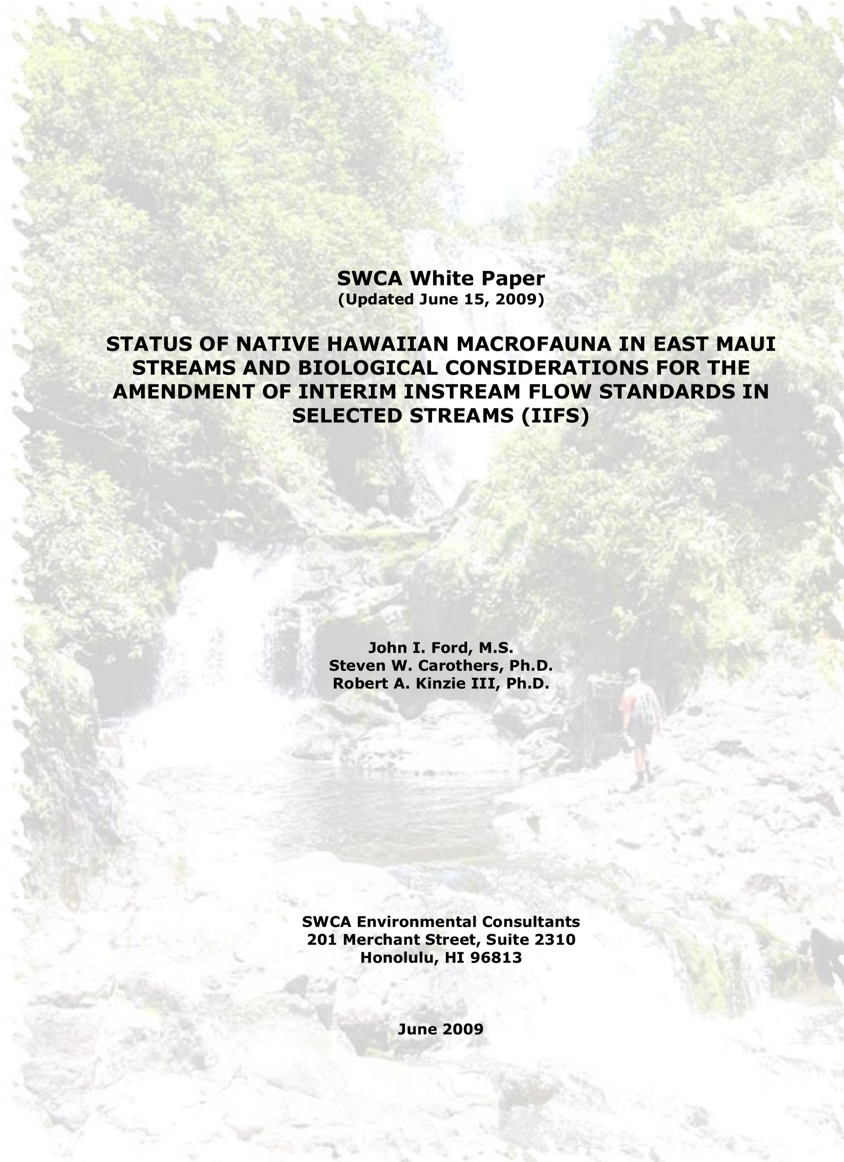
Mark E. Hudson
Director, USDA NASS Hawaii Field Office
State Statistician for Hawaii State Department of Agriculture

1428 South King Street ◇ Honolulu, HI 96814-2512 ◇ TEL: (808) 973-9588 ◇ FAX: (808) 973-2909

11.0 Hawaiian Commercial & Sugar, Co., Diagram of the East Maui Ditch System, with Ditch & Reservoir Capacities



12.0 Hawaiian Commercial & Sugar, Co., SWCA White Paper (Updated June 15, 2009), Status of Native Hawaiian Macrofauna in East Maui Streams and Biological Considerations for the Amendment of Interim Instream Flow Standards in Selected Streams (IIFS)



SWCA White Paper
(Updated June 15, 2009)

STATUS OF NATIVE HAWAIIAN MACROFAUNA IN EAST MAUI STREAMS AND BIOLOGICAL CONSIDERATIONS FOR THE AMENDMENT OF INTERIM INSTREAM FLOW STANDARDS IN SELECTED STREAMS (IIFS)

John I. Ford, M.S.
Steven W. Carothers, Ph.D.
Robert A. Kinzie III, Ph.D.

SWCA Environmental Consultants
201 Merchant Street, Suite 2310
Honolulu, HI 96813

June 2009

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EXECUTIVE SUMMARY

> *Little is known about the relationship between stream flows and the ecological systems of streams. Too many extraneous factors have been introduced to enable a one-to-one causal relationship between flow and stream viability. Watersheds have radically changed with the introduction of non-indigenous trees shrubs and grasses, altering the absorption characteristics of the watersheds' soil and the amounts and patterns of water released into the streams… some streams that have been severely degraded through reduced base flows, changes in their watersheds, and introduced aquatic species still support viable and thriving native species, while other comparable or even less degraded streams are nearly devoid of native life. (Miike 2004)*

The 1,600-year history of human habitation within the Hawaiian Islands has resulted in the loss and/or endangerment of an unusually high proportion of the archipelago's indigenous plant and animal species. By the time Captain James Cook visited the islands in 1778 the coastal areas and low lying forests of most islands had already been cleared and heavily settled (Kirch 1982, Cuddihy and Stone 1990, Burney et al. 2001, Athens et al. 2002, Burney and Flannery 2005). Most of the natural Hawaiian ecosystems, including streams, were transformed by humans and the invasion of exotic species centuries before the present. The combination of habitat loss, introductions of non-native competitive and predacious species and diseases have resulted in remarkably high numbers of extinct and threatened and endangered species throughout the Hawaiian Islands. In fact, the Hawaiian Islands are widely known as the endangered species capital of the world, and federal and state agencies and NGOs spend millions of dollars every year in attempts to eliminate non-native species and restore native flora and fauna.

One group of animals that shares a unique lifestyle, specifically several species of native freshwater macrofauna characteristic of Hawaiian streams, have survived the steady onslaught of ecological change and continue to thrive. They persist today in streams throughout the main Hawaiian Islands, including those streams that have been substantially modified for over a century of water diversions for taro and sugar cane irrigation as well as other human uses. The native stream species of concern discussed in this paper include four native Hawaiian gobies, or ʻoʻopu (*Lentipes concolor*, *Sicyopterus stimpsoni, Awaous guamensis, and Stenogobius hawaiiensis*), an eleotrid (*Eleotris sandwicensis*); two gastropod mollusks, including hīhīwai (*Neritina granosa*) and hapawai (*Neritina vespertina*); a prawn (*Macrobrachium grandimanus*); and a shrimp, or ʻopae kalaʻole (*Atyoida bisulcata*). These animals have been selected for assessment because of their importance in traditional and customary Hawaiian gathering and subsistence fishing. These nine species share a common life history strategy called *amphidromy* that involves migration from the freshwater streams to the ocean for larval development and return. There is ample anecdotal evidence to indicate that decades ago many of these species were more abundant than they are today (Titcomb 1972, Pukui 1983, Bell 1999). Contrary to what was once believed; however, there are no data available to suggest that any of these native species are at risk of either endangerment and/or extinction in East Maui streams or elsewhere throughout the Hawaiian Islands (Parham et al. 2008). In fact, East Maui streams are recognized among the most important habitats for native Hawaiian stream animals in the State under current diverted conditions (National Park Service Nationwide Rivers Inventory 1982, Hawaiʻi National Park Cooperative Studies Unit 1990).

The objective of this paper is to present biological information that can be utilized in determining equitable, reasonable, and beneficial in-stream and off-stream uses of the limited surface water resources of northeast Maui. By analyzing the current status of the native stream species we believe that missing critical information can be made available to decision makers, and an equitable distribution of the limited amount of water can be based on biological facts rather than perceptions. We summarize the scientific literature on Hawaiian stream ecosystems, the overall status of native amphidromous species, and the presence or absence of biological factors indicating the need for flow restoration to enhance these species' ecological survival. We offer insight regarding the persistence of the native amphidromous species in the region following 120 years of water development in East Maui and a millennium of human impacts to the landscape. The findings offered in this report are based upon stream research conducted by SWCA Environmental Consultants in East Maui and throughout the state, and an assessment of the published research by the United States Geological Survey, Hawaiʻi Division of Aquatic Resources, and other investigators.

It had generally been assumed that over a century of water diversion from East Maui streams has resulted in irreparable ecological damage to some elements of native Hawaiian flora and fauna. Some also postulate that a suspension of water diversions will effectively restore stream ecosystems to the benefit of native stream species, especially those with the amphidromous lifestyle. While we believe opportunities do exist to enhance some of the stream systems to benefit native wildlife, our findings do not support acceptance of the blanket assertion that the amphidromous species of the region are currently declining in numbers, and that suspension of water diversions in East Maui is needed to sustain healthy populations of these species.

Our review illustrates how hardy amphidromous species are despite historical stream modifications, including significant areas of intermittent dewaterment. Existing flow levels in streams with a long history of water diversions continue to provide habitat and ecological connectivity[1] sufficient to sustain native aquatic life, as recognized by Miike (2004) and as documented elsewhere on Maui (SWCA 2004, 2005, 2007, 2008; Parham et al. 2008). Of the total 106 linear kilometers (66 mi) of stream channels within the study area (as defined by Gingerich and Wolff 2005), SWCA has calculated that 57 percent of the total stream length has retained 75-100 percent of aquatic habitat at base flow relative to the estimated undiverted conditions.

The longitudinal distribution of native fishes, crustaceans, and mollusks in diverted East Maui streams generally mirrors the normal patterns of these species in unaltered streams. Moreover, our findings indicate that in the East Maui streams for which distributional data are available, most have known populations of amphidromous species both above and below diversion structures, and amphidromous species are well represented with self-sustaining populations throughout the entire East Maui Region and the State. In fact, 17 of 18 East Maui streams for which data exist have amphidromous species reported from their upper reaches. This confirms that ecological connectivity occurs under existing diverted conditions. Even though there are reliable distributional data for these East Maui streams, there are few or no quantitative data on population size or density.

Amphidromous species worldwide have evolved reproductive patterns adapted to the extremely variable and unpredictable flow conditions characteristic of ephemeral streams and are perfectly adapted to naturally ephemeral torrential flash floods and subsequent periods of decreasing flow (McDowall 1993). Larval hatching, downstream drift to the sea, and later migration into upstream habitats where they can survive, even in standing water pools, under conditions of base flow are strongly correlated to periods of torrential flow (Lindstrom 1998). This is an evolutionary strategy that has allowed these native species to endure while so many other native species have faced extirpation. The system of water diversions in East Maui, while clearly exacerbating the dry end of the wet-dry daily cycle of stream ecology, has not been demonstrated to preclude suitable habitat conditions for sustaining populations of the amphidromous species.

1.0 INTRODUCTION

1.1 Background

Since the Hawai'i Supreme Court handed down its substantive interpretation of the State Water Code in *Waiahole Ditch Combined Contested Case Hearing* in September 2000, the Commission on Water Resources Management (CWRM, or Water Commission) has been under increasing pressure to fulfill its responsibilities in establishing instream flow standards. In its Waiahole decision, the court directed the Water Commission to establish permanent instream flow standards for windward streams "with utmost haste and purpose."

The Waiahole issue demonstrated the increasing public interest and concern over the status of Hawaiian stream ecosystems. However, following testimony by numerous scientists, including Dr. Anne Brasher, Dr. John Maciolek, Dr. Mike Fitzsimons, Dr. Ken Bovee, Mr. Bill Devick, Mr. Mark

[1] Dams, diversions, lakes, impoundments, and similar man-made structures can disturb longitudinal or linear connectivity of habitats within a stream ecosystem. With respect to Hawaiian stream ecosystems, we use 'ecological connectivity' to describe the interconnected nature of aquatic habitats that support populations of native amphidromous (migratory) stream macrofauna throughout their normal ranges within a given watershed. Hence, ecological connectivity exists if stream flows of sufficient volume and frequency allow the normal distribution of native amphidromous species within a given watershed.

Hodges, and Mr. Ron Englund, the Court concluded that information on Hawaiian stream biology and stream flow requirements of native Hawaiian species was incomplete and inconsistent. Within the past decade, over 20 petitions have been filed with the CWRM calling for flow restoration in the East Maui streams that have been diverted for off-stream uses over the past 120 years. In 2002, the CWRM commissioned the United States Geological Survey (USGS) Water Resources Division in Honolulu to evaluate the biological impacts of the East Maui Irrigation Company (EMI) ditch system on East Maui streams to assist CWRM in establishing amended Interim Instream Flow Standards (IIFS) for those streams. The USGS (Gingerich 2005, Gingerich and Wolff 2005) applied the PHABSIM model (Bovee 1982, Bovee et al. 1998) to estimate the amount of aquatic habitat available for the amphidromous species, and develop habitat duration statistics that provide estimates of the amount of increased habitat that would accrue with streamflow restoration (cessation or reduction of withdrawals). State funding support for USGS studies in East Maui streams continues today.

Gingerich and Wolff (2005) found that aquatic habitat values in East Maui streams today average 58 to 60 percent of natural, undiverted conditions. What this essentially means is that the withdrawal system has been taking, on average, for well over a century, approximately 40 percent of the base stream flow. USGS was not tasked with an evaluation of the current status of the target species within the streams so this important information is still unknown. Recent longitudinal surveys conducted by Hawai'i Division of Aquatic Resources (DAR) biologists in five East Maui streams (including two within the USGS study area) attribute reduced native aquatic insect diversity to dewaterment of the middle reaches of these streams (DAR testimony before CWRM, September 2, 2008).

On 24 September 2008 the CWRM voted to return an average total of approximately 12 million gallons per day (mgd) of diverted water in 8 of the 27 East Maui streams that were subjects of the citizens' petitions. CWRM staff indicated that the selected instream flow standards are based largely on the USGS's hydrology and habitat availability studies (Dawson 2006). While some of the returned water was provided for the benefit of downstream taro farmers, it was stated that the releases were also to benefit other elements of traditional gathering practices and to restore natural habitats.

The streams affected by the CWRM's decision are Waiokamilo, Palauhulu, Honopou, Wailuanui, Hanehoi and Huelo. Subsequent flow monitoring by CWRM staff has revealed that flow restoration has not met the desired intent in at least two of these streams. In Waiokamilo Stream, restored flow disappears into the streambed above Dam 3 and has yet to be shown to benefit to either taro growers or the stream ecology (CWRM Field Investigation Report FI2009021005, 10 February 2009). In the Palauhulu tributary of Pi'ina'au Stream some flow may be lost to the streambed between 800 ft and 300 ft elevation (Gingerich 2005). This unfortunate outcome demonstrates the importance of thorough pre-implementation studies and the value of post-implementation monitoring as part of the adaptive management approach.

The Hearing Officer's Proposed Finding of Facts, Conclusions of Law, and Decision and Order in the Nā Wai 'Ehā contested case hearing (Case No. CCH-MA06-01) provides guidance for physical and biological studies that could be conducted to validate and/or refine the proposed IIFS. As stated on page 179 of the document, the Hearing Officer "chose a relatively small range of flows, from the minimum recorded flows up to the Q90 flows." His reasoning appears to be based on an assumption that some percentage of natural low flows is the minimum that could be considered as an IIFS, even though he acknowledges that the first amounts of water returned to a dry channel have the most benefit. Secondarily, the Hearing Officer argues that a continuously wetted channel from mauka to makai "provides the best conditions for re-establishing the ecological and biological health of the waters of the Nā Wai 'Ehā" (page 172).

In relying solely on a percentage of natural flow, the recommendations did not address either how much benefit is provided by the recommended flows in the Nā Wai 'Ehā stream channels or how the recommended flows relate to achieving a continuously wetted channel (except for the Waikapu where it is not expected in any case). Answering these questions was integral to the recommendations of both experts for the Hawaiian Commercial & Sugar Company (HC&S), Tom Payne and John Ford. Tom Payne suggested using the demonstration flow assessment to evaluate the physical effects of various releases, and John Ford suggested releasing smaller but sequentially increasing amounts of water to evaluate the corresponding biological effects. It is not known whether or not the flow recommendations are efficient at achieving their stated objectives. Based on the steep, cobbleboulder character of the Nā Wai ʻEhā stream channels (that wet quickly with small amounts of water), it is likely that the recommended flows would provide more water than actually needed to have continuous flow mauka to makai. Addressing these data gaps both in Nā Wai ʻEhā and East Maui streams is likely to benefit both the decision making process of the CWRM and the flow diversion needs of offstream users by measuring the efficiency of water releases in achieving the primary objectives of the recommendations.

1.2 Objective

The objective of this paper is to present biological information that can be utilized in determining equitable, reasonable and beneficial in-stream and off-stream uses of the limited surface water resources of northeast Maui. We offer insight regarding the persistence of the native amphidromous species in the region following 120-years of water development in East Maui and a millennium of human impacts to the landscape. By analyzing the current status of the native stream species we believe that missing critical information can be made available to decision makers, and an equitable distribution of a limited amount of water can be based on biological facts rather than perceptions. We also summarize the scientific literature on Hawaiian stream ecosystems, the overall status of native amphidromous species, and the presence or absence of biological factors indicating the need for flow restoration to enhance these species' ecological survival. The findings offered in this report are based upon stream research conducted by SWCA in East Maui and throughout the state, and our assessment of the published research of USGS, DAR, and other investigators.

1.3 Significance in Hawaiian Culture

Spiritual, cultural and natural resources are one and the same to the Hawaiian people. Waiʻola, living waters, are recognized as the source of life and have a strong spiritual connotation (Pukui 1983). In pre-western contact Hawaiʻi prior to the reign of Kamehameha, inalienable titles to water rights did not exist (Handy and Handy 1972). High chiefs (*aliʻi*) held in trust all lands, waters, fisheries, and other natural resources extending from the mountain tops to the depths of the ocean (Maly and Maly 2001a). The *ahupua'a*, or principal political subdivisions of lands, helped ensure that native planters had access to a share of subsistence resources, including ability to harvest ʻoʻopu, ʻōpae, and hīhīwai from streams. The right to use these resources was given to the native tenants at the prerogative of the *ali'i* and their representatives or *konohiki* (Maly and Maly 2001a). The breakdown of the traditional Hawaiian method of sharing flowing water, beginning with western influences upon Kamehameha through modern case law, has left a confusing and controversial legacy (Miike 2004).

Native oral traditions indicate a close relationship between Hawaiian and amphidromous species; for example, most of the nine amphidromous species addressed in this report were an important part of the native food base, traditions that continue today in East Maui (Titcomb 1972, 1978; Group 70 et al 1995: Maly and Maly 2001a and 2001b). Many Hawaiian proverbs, oral traditions, and nuances of language involve these species (see Pukui 1983, Maly and Maly 2001a and 2001b, Miike 2004). Hawaiian oral tradition is replete with accounts of concentrations of theses species during "hinana runs" where the post-larval fish were so numerous that they could be caught by hand (Titcomb 1972): "*ka iʻa mili i ka poho o ka lima*" (the fish fondled by the palm of the hand) (Pukui 1983).

Many other *ʻōlelo noʻeau*, or proverbs, clearly demonstrate that the Hawaiians understood aspects of the ecology of amphidromous species: "*Ka iʻa a ka wai nui i lawe mai ai*" (the fish borne along by the flood); "*ka ia hāhā i kahawai*" (the fish groped for in the streams); "*ka iʻa hoʻopumehana i ka weuweu*" (mountain ʻōpae, cling to weeds and grasses along the banks of streams when cloudbursts occur in the uplands); "*ka iʻa huli wale i ka pohaku*" (the fish that turns over the stones, referring to the necessity of rolling over cobbles to catch hīhīwai); "'*aʻohe loea i ka wai ʻōpae"* (it is no feat to catch shrimp during a freshet) (all from Pukui 1983).

The Hawaiians also recognized the interdependencies of their physical environment: "*huli ka lau o ka ʻamaʻu i uka, nui ka wai o kahawai*" (when the winds blow the leaves of the ʻamaʻu fern inland, floods will follow); *ʻo ka makani ke ala o ka ʻino*" (wind drives rain clouds that bring torrential floods); "*ka wai makamaka*ʻ*ole*" (the water with no friends, referring to the danger of floods) (Pukui 1983). Group 70 et al (1995) and Maly and Maly (2001a) provided interesting narratives of resident kupuna within the East Maui study area, who share stories of their relationship to the land, streams, and ocean. Maly and Maly (2001a and 2001b) report a general perception of area residents that there is less water

flowing in East Maui streams today than flowed several decades ago (cf. Oki 2004), and that this has resulted in fewer ʻoʻopu, ʻopae, and hīhīwai. However, individual kūpuna suggest that traditional gathering continues in East Maui streams. This practice is said to be most successful for residents who know where to find these resources.

1.4 Brief Overview of the Literature

Few scientific papers about Hawaiian stream life, other than original species descriptions, were published prior to 1939. Classical scientific studies on these aquatic resources began in the first decade after statehood. At that time the then Hawaiʻi Division of Fish and Game conducted statewide stream surveys primarily to assess the feasibility of introducing non-native game fishes. Many of these surveys, supported with Federal Dingle-Johnson Act program funds, were conducted by pioneering aquatic biologists Stan Shima and Kenji Ego.

What follows is a general summary of the major research directions in Hawaiian stream ecology since 1960. It is not meant to be a comprehensive bibliography. In the late 1960s and throughout the 1970s, John Maciolek and his students at the University of Hawaiʻi Cooperative Fishery Research Unit initiated studies on life histories and distribution of native aquatic species, and began cataloging the extent of human alterations to streams throughout the state. Through the 1970s and 1980s, research led by Maciolek and Kinzie and their students focused on life history and population biology of amphidromous species, contaminants in fish tissues, and the applicability of methods to assess fish habitat utilization and preference (Ford and Kinzie 1982, Kinzie et al. 1988, Kinzie 1991). During this period the United States Fish and Wildlife Service (USFWS) (Dodd et al. 1985) listed ʻoʻopu hiʻukole (*Lentipes concolor*) as a Candidate Endangered Species, based on limited distribution and abundance data. Two other species, *Awaous guamensis* (ʻoʻopu nākea) and *Sicyopterus stimpsoni* (ʻoʻopu nopili) were also listed along with *L. concolor* by both the American Fisheries Society (Deacon et al. 1979) and the IUCN Red List of Threatened and Endangered Species™. Both *Lentipes* and *Awaous* were listed on the 2003 IUCN Red List of Threatened Species™ as being Data Deficient, and *S. stimpsoni* was listed as lower risk but close to qualifying for threatened status.

The past two decades of research and discovery has provided a new understanding of Hawaiian stream ecosystems. Bill Devick and Robert Nishimoto of DAR and Mike Fitzsimons of Louisiana State University began collaborating in the early 1990s to conduct comprehensive statewide inventories of stream fauna, and expanded their studies on the ecology of amphidromous species in relation to stream flow. The methods pioneered by DAR biologists during the statewide surveys are still being used and refined today. Following an initial round of study, Fitzsimons (1990) advised the USFWS that *Lentipes concolor* "represent healthy, actively breeding populations in no apparent need of special protection." Devick et al. (1992) stated that populations of *L. concolor* "appear to be stable or increasing as direct impacts of agriculture and urban development have eased." Subsequently, the USFWS delisted *L. concolor* as candidate endangered species in 1996 in response to statewide stream surveys. Yet just four years later, in his testimony during the Waiahole stream hearings in 1996, Devick stated that populations of the five characteristic species of native Hawaiian stream animals had "…declined dramatically throughout the islands as a direct result of diversion of stream waters."

There has been no statewide effort to monitor the abundance or population trends of any of the amphidromous stream animals since that time (Polhemus, DAR, personal communication), and no efforts have been undertaken by any resource agency to consider any of the amphidromous species for threatened or endangered species status or for specific measures to ensure their continued survival.

Beginning in the early 1990s, Anne Brasher, Steven Anthony, and Reuben Wolff of USGS conducted quantitative research into the impacts of human activities on Hawaiian stream ecosystems for the USGS Water Resources Office in Honolulu. Mike Fitzsimons, Robert Nishimoto, and Mike Kido gave us an insight on the recovery of amphidromous species in streams following floods and landslides associated with Hurricane Iniki (Fitzsimons and Nishimoto 1995, Kido 1996a, 1997a). Scott Larned, Scott Santos, Robert Kinzie and others expanded our understanding of stream energetics and the response of stream communities to diversion and flow restoration (Larned 2000, Larned and Santos 2000, Larned et al. 2001, Kinzie et al. 2006).

Robert Zink and A.C. Chubb have given us a new perspective on patterns of evolution and population genetics among the native gobies (Zink 1990, Zink et al. 1996, Chubb et al. 1998). Dan Lindstrom, Robert Nishimoto and Daryl Kuamo'o studied the timing of reproduction and larval drift, and post larval recruitment in Hawaiian amphidromous fishes (Lindstrom 1998, 1999; Nishimoto and Kuamo'o 1997; Chong 1999). Mike Yamamoto and Annette Tagawa (2000) published a popular guidebook for identification of native and alien freshwater species in Hawai'i. Richard Radtke and Robert Kinzie collaborated to clarify the larval life span of amphidromous gobies (Radtke et al.1988, Radtke and Kinzie 1996, Radtke et al. 2001). Basic research studies have also addressed biological organization at the community and ecosystem levels (Larned 2000, McIntosh et al. 2002, and Kinzie et al. 2006). Jim Parham created a GIS-based model to predict the distribution of amphidromous fishes in Hawaiian streams (Parham 2002).

Vis et al. (1994), LaPerriere (1995), Larned and Santos (2000), and Sherwood (2004a and 2004b) shed light on the identity and productivity of Hawaiian stream algae.

Dan Polhemus and Ron Englund of the Bishop Museum focused their attention on the important but understudied communities of aquatic insects (Polhemus 1994, 1995; and numerous publications of the Bishop Museum). These and related studies on insects revealed extensive patterns of speciation that parallel the terrestrial insects and flora of Hawai'i. Both Englund and Polhemus, along with Eric Benbow, have suggested that endemic aquatic insects may be a more sensitive bellwether of stream health than presence/absence of amphidromous species (Benbow et al. 1997). Kido et al. (1993), Polhemus and Asquith (1996), Eldridge and Miller (1997), and Kondratieff et al. (1997) also provided new insight on the ecology of native Hawaiian aquatic insects.

More recent studies include the reproductive ecology of *Eleotris sandwicensis* in urban and forested streams (Sim 2006); assessment of ecological sinks and sources (McRae 2007); aquatic insect taxa as indicators of habitat disturbance (Englund et al. 2003); production and dispersal of larval gobiids (Murphy and Cowan 2007); and tracing nutrient sources in adult and larval gobiids (Hobson et al. 2007). In addition to recent research in Hawai'i, scientists have found striking similarities between the ecology of Hawaiian amphidromous species and those of Oceania, the Indo-West Pacific, Caribbean, and Atlantic high islands (Erdman 1961, Hunte 1978, Bright 1982, Maciolek and Ford 1987, Covich 1988, Resh et al. 1990, Ryan 1991, Resh et al. 1992, Resh et al. 1995, Nelson et al. 1997, Holmquist et al. 1998, Resh et al. 1992, Myers et al. 2000, Buden and Lynch 2001, Fitzsimons et al. 2002, Keith 2003, McDowall 2003, March et al. 2003, Pyron and Covich 2003, McDowall 2007, Fukushima et al. 2007).

As Murphy and Cowan (2007) state, "…what is known about the biology of other species of amphidromous gobies should be transferable to the Hawaiian 'o'opu, with consideration of species-specific differences and the degree of geographical isolation that are unique to the Hawaiian Islands."

1.5 Setting

The Hawaiian Islands are among the youngest major archipelagos, forming over a 'hot spot' for at least the last 70 million years. The archipelago consists of linear chains of islands or seamounts produced as the Pacific Plate moves in a northwesterly direction. The former high islands in the extreme northwestern portion of the archipelago (now seamounts) are perhaps 60 to 90 million years old. Kaua'i is roughly 5.5 million years old, and volcanism is still building the Island of Hawai'i today at Kīlauea (Juvik and Juvik 1998).

The area studied by Gingerich and Wolff (2005) and SWCA encompassed 21 streams along the northeastern slopes of Mt. Haleakala in East Maui (Figure 1). Among the main Hawaiian Islands, East Maui is intermediate in age, and notably has both broad deeply incised valleys (e.g. Ke'anae) as well as much smaller watersheds (e.g. Waiohue and 'Ohia) (Figure 2). Except on the oldest islands or in the broadest valleys, streams in Hawai'i are typically steep with step-like profiles consisting of alternating falls/pools and shallow riffle areas. The substratum ranges from bedrock to boulders, cobbles and gravel in pools and slower runs. Because of the step-like nature of the channels, pools can retain water even when flow is low or nonexistent. These pools serve as important refugia for aquatic animals in times of low flow. Geologically older streams such as those on Kaua'i and O'ahu fall precipitously into deeply incised valleys, then flow into broad terrestrial estuaries. Many smaller streams on geologically younger Maui and Hawai'i flow directly into the sea over terminal waterfalls.

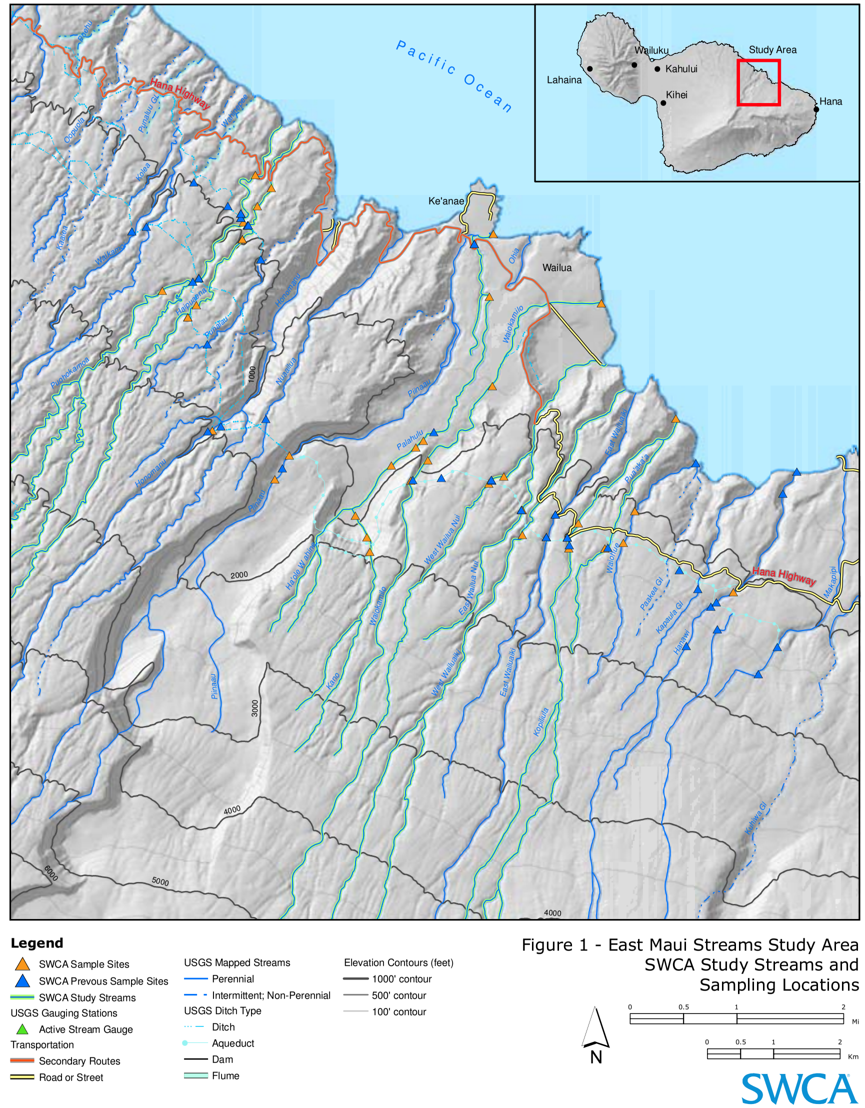


Figure 1 - East Maui Streams Study Area SWCA Study Streams and Sampling Locations

Source:
Elevation contours provided by the School of Ocean and Earth Science and Technology, University of Hawai'i Streams, Ditches, and other watercourses provided by USGS

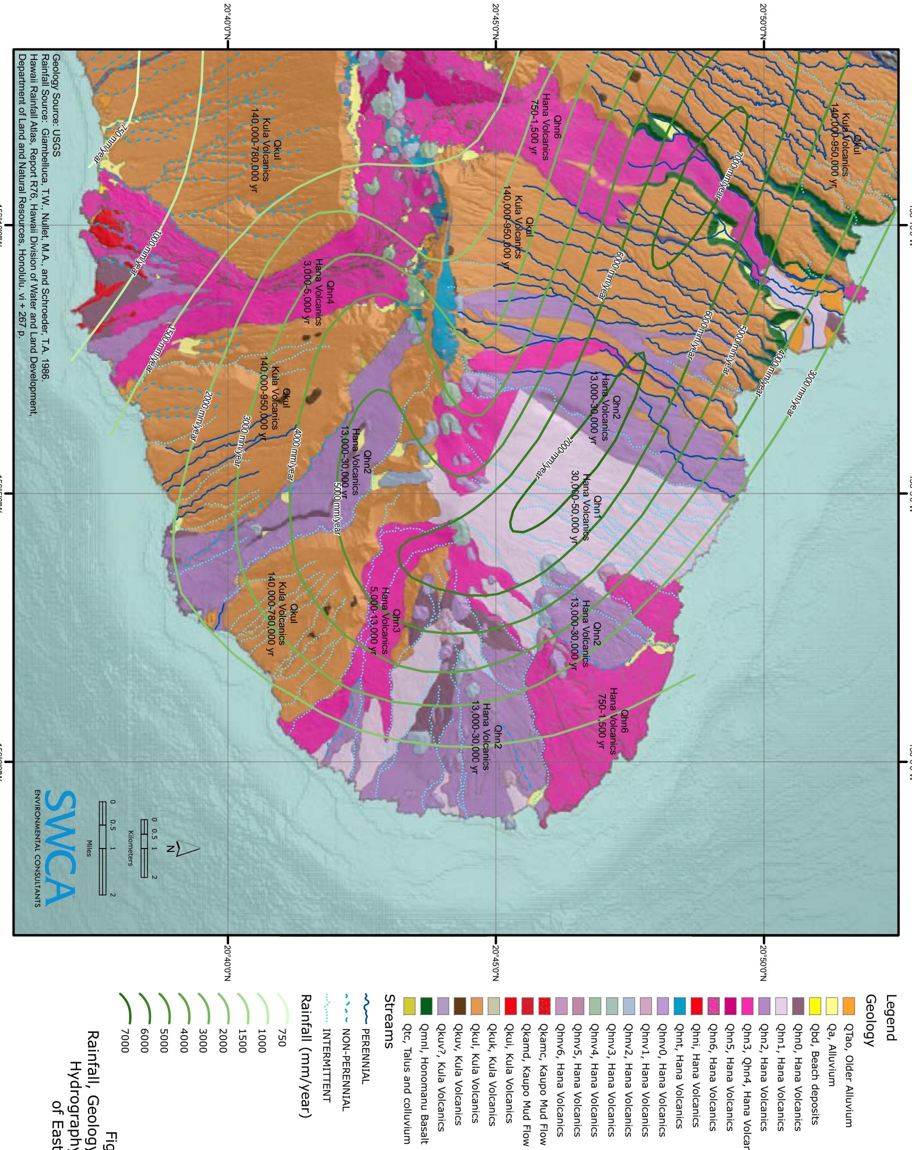


Figure 2
Rainfall, Geology, and
Hydrography Map
of East Maui

Depending on the current state of the channel/valley system and the degree of erosion, Hawaiian streams can be roughly divided into those that enter the sea as high terminal waterfalls (e.g. Waiokamilo and Haipuaʻena) or across a beach, often composed of boulders which can sometimes close off the stream from the sea such as Hanawī and Puohokamoa (Maciolek 1977, McRae 2007).

2.0 INTRODUCTION TO HAWAIIAN STREAM ECOLOGY

2.1 Origins of the Characteristic Macrofauna

Located some 5,000 km (3,000 mi) southwest of the nearest continental landmass, the Hawaiian Islands are among the most isolated and youngest islands in the world. The former high islands in the extreme northwestern portion of the archipelago (now seamounts) are perhaps 60 - 90 million years old; Kauaʻi is roughly 5.5 million years old; and volcanism is still building the Island of Hawaiʻi today.

All of Hawaiʻi's native biota originated from sources outside the archipelago (Ziegler 2002). Representatives of various taxonomic groups arrived infrequently from diverse regions throughout the Pacific Rim. As a result, the biota is considered disharmonic; that is, it lacks many groups of organisms represented on continental landmasses. This is also true of Hawaiʻi's freshwater fauna (Ford and Kinzie 1982, Kinzie 1997, McDowall 2003). Scientists have recognized for years that certain freshwater fishes, crustaceans, and mollusks do not demonstrate the same pattern of speciation and adaptive radiation characterized by many Hawaiian terrestrial plants, insects, and birds. The reason why this is so is linked to the unique amphidromous life cycle of these animals (Myers 1958, Ford and Kinzie 1982, McDowall 1988).

Characteristic macrofauna of Hawaiian streams (Table 1) include five species of goby fishes: *Awaous guamensis* (oʻopu nakea), *Sicyopterus stimpsoni* (oʻopu nopili), *Lentipes concolor* (oʻopu alamoʻo); and the eleotrids *Eleotris sandwicensis* (oʻopu akupa) and *Stenogobius hawaiiensis* (oʻopu naniha). Two gastropods, *Neritina granosa* (hīhīwai) and the estuarine *Neritina vespertina* (hapawai), are common in many East Maui, Hawaiʻi, Molokaʻi and Kauaʻi streams. The shrimp *Atyoida bisulcata* (ʻōpae kalaole) inhabits the middle and upper reaches of pristine mountain streams statewide and is locally abundant in plunge pools and irrigation ditches.

Table 1. *Amphidromous species known to inhabit East Maui streams and their generalized distribution within natural undiverted streams (shaded area).*

Scientific Name / Hawaiian Name	Biogeographic Status	Lower Reach	Middle Reach	Upper Reach
MOLLUSKS				
Neritina vespertina / hapawai	Endemic	shaded		
Neritina granosa / hīhīwai	Endemic	shaded	shaded	
CRUSTACEANS				
Macrobrachium grandimanus / ʻŌpae ʻoehaʻa	Endemic	shaded		
*Macrobrachium lar / Tahitian prawn**	Introduced	shaded	shaded	
Atyoida bisulcata / ʻŌpae kalaʻole	Endemic	shaded	shaded	shaded
FISHES				
Stenogobius hawaiiensis / ʻOʻopu naniha	Endemic	shaded		
Eleotris sandwicensis / ʻOʻopu akupa	Endemic	shaded	shaded	
Awaous guamensis / ʻOʻopu nakea	Indigenous	shaded	shaded	
Sicyopterus stimpsoni / ʻOʻopu nopili	Endemic	shaded	shaded	
Lentipes concolor / ʻOʻopu alamoʻo	Endemic	shaded	shaded	shaded

NOTE: The Tahitian prawn, while a non-native amphidromous species, in included here as it is often an important element of the stream fauna.

The Hawaiian prawn *Macrobrachium grandimanus* ('ōpae 'oeha'a) inhabits estuaries and the terminal reaches of streams. Original descriptions of these species first begin to appear in scientific literature in the 19th century. Between 1900 and 1955, several authors revised these early catalogues of fishes and invertebrates. Early literature specific to the life history aspects of Hawaiian stream fauna appeared in Edmondson (1929), Mainland (1939), and Ego (1956). Lindstrom (1998) presents a cogent review of early scientific evidence on amphidromous fishes.

All of these species share the same life history strategy referred to as *amphidromy*. Larvae of these amphidromous species hatch from demersal eggs and are swept into nearshore marine waters where they develop for periods up to 150 days as zooplankton before re-entering freshwater streams as post-larvae (Radtke et al. 1988, 2001).

Once they re-enter a stream mouth, post-larvae migrate upstream rapidly where they grow and reproduce as adults (Maciolek 1977; Ford and Kinzie 1982; Radtke and Kinzie 1991; Nishimoto and Kuamo'o 1996, 1997; Keith 2003). Lindstrom (1999) developed a method to identify newly hatched larvae of all Hawaiian freshwater gobies and provided a key for their identification, and Tate et al. (1992) developed a key for the identification of post-larval Hawaiian freshwater gobies. Unlike diadromous salmon, amphidromous species in Hawaii show no definitive evidence of returning to their natal stream.

In addition to the amphidromous macrofauna, some other native marine species are important in Hawaiian stream ecology. Fishes commonly found in the terminal and lower reaches of small Hawaiian streams also include the endemic predatory flagtails *Kuhlia xenura* and *K. sandvicensis* (ʻāholehole). ʻĀholehole are not amphidromous but may be considered an itinerant marine species. Adults live and breed in nearshore coastal reefs, but juveniles commonly invade stream mouths in large schools presumably to avoid predation and to utilize post-larval and juvenile gobioids as a food source. Many other itinerant marine species may undergo juvenile development in estuaries of large streams.

ʻĀholehole are known to attack nests of goby eggs (Ha and Kinzie 1996) and may also consume returning post-larval gobies. Many other itinerant marine species may undergo juvenile development in streams; however, since non-amphidromous species do not have the ability to climb terminal waterfalls, these species may only occur in streams with low gradient terminal reaches or estuaries. Additionally, numerous alien stream animals, both amphidromous (e.g. *Macrobrachium lar*) and those restricted to freshwater, are impacting native Hawaiian species including fishes, amphibians and crustaceans (Yamamoto and Tagawa 2000).

Myers (1949) used the term *amphidromous* to describe fishes that undergo regular, obligatory migration between freshwaters and the sea "at some stage in their life cycle other than the breeding period". McDowall (1988) described two different forms of amphidromy. All the Hawaiian amphidromous species exhibit 'freshwater amphidromy' where spawning takes place in freshwater, and the newly hatched larvae are swept into the sea by stream currents. While in the marine environment, the larvae undergo development as zooplankton before returning to freshwater to grow to maturity. The length of time they spend in marine plankton is unknown for most species.

An important ecological characteristic of the amphidromous fauna is the ability (in varying degrees among species) to move upstream, surmounting riffles and small falls, and for some species even very high waterfalls (Ford and Kinzie 1982, Radtke and Kinzie 1996). Amphidromous species occur throughout the world's tropical and subtropical freshwater streams, especially high islands. The native Hawaiian species are descendents from amphidromous species elsewhere and did not develop this life style after their arrival in Hawaiʻi (Myers 1949, Kinzie 1991, McDowall 2003). This means that the life history characteristics and ecological requirements of these species reflect a pattern common to amphidromous species throughout the world, not one specific to the Hawaiian Islands.

The non-amphidromous native stream fauna has, until fairly recently, received less attention than the amphidromous species. However the native insects, snails, and other invertebrates are important for their diversity, endemism, and their contribution to the freshwater ecosystem dynamics. Currently the USFWS has listed six damselfly species in the endemic genus *Megalagrion* as Candidate Endangered Species, two of which have been recently observed by SWCA and DAR biologists in East Maui streams: the Flying earwig Hawaiian damselfly (*Megalagrion nesiotes*) and the Pacific Hawaiian damselfly (*Megalagrion pacificum*) (Polhemus and Asquith 1996). A listed endangered gastropod

mollusk (*Erinna newcombi*) can also be found confined to streams and seeps in central Kauaʻi. Many factors in addition to dewaterment may contribute to the demise of these unique species including predation by both native and non-native insects, birds, and aquatic species. Other native damselflies including *M. nigrohamatum nigrohamatum* are still common today in East Maui streams. Scientists are continually describing new species of endemic aquatic insects as their field studies take them farther into the headwaters of Hawaiian streams (e.g. Englund et al. 2003).

In the recent past, aquatic biologists in Hawaiʻi considered the presence of all the native amphidromous species described above as an indicator of outstanding environmental quality. Conversely, the total absence of these species in streams between sea level and 1,500 ft elevation was considered a possible indicator of environmental degradation (Hawaii Cooperative National Park Studies Unit 1990). However, community structure in a given Hawaiian stream may change frequently due to random processes affecting reproduction, recruitment of post-larvae, migration, predation and competition, and survival (Kinzie and Ford 1982, Kinzie 1988). Therefore, the absence of a given species at any reach and time must not be interpreted as a negative indicator of stream quality (Parham at al. 2008).

Most prior research on Hawaiian freshwater ecology has dealt with individual species and populations of the characteristic macrofauna. Little is known about Hawaiian stream ecosystem response to changes in stream flow (Covich 1988; Chong et al. 2000; Larned 2000; Larned et al. 2003; Kido 1996a, 1996b, 1996c; and Kinzie et al. 2006). Research over the past decade on the genetics of stream fishes suggests that each of the Hawaiian freshwater gobies is a member of a statewide metapopulation (Fitzsimons et al. 1990; Zink et al. 1996; Chubb et al. 1998; Lindstrom, personal communication). A metapopulation consists of a group of spatially separated populations of the same species in which gene flow occurs with sufficient frequency to prevent isolation and subsequent speciation. Simply put, the native Hawaiian amphidromous fishes, shrimp, and mollusks found in East Maui streams are from the same metapopulations as those found in ʻOahu, Molokaʻi, Kauaʻi, and Hawaiʻi Island streams. In the case of native amphidromous species, these spatially separated (by island and stream) populations are able to exchange individuals via their oceanic larval pool and recolonize sites from which the species has recently been extirpated. As the evidence of recent genetic studies has illustrated (Zink et al. 1996, Chubb et al. 1998), there is no evidence of within-archipelago diversification or speciation of the Hawaiian stream fishes, indicating among-island gene flow attributable to amphidromy.

Species with extended ocean larval life spans and those capable of delaying metamorphosis are able to achieve greater dispersal among island streams. Radtke et al. (1988), Radtke and Kinzie (1991), and Radtke et al. (2001) provide excellent data on the length of larval life (LLL) in four species of amphidromous gobies from Hawaiian Island streams. The mean LLL for the endemic *Lentipes concolor* was 84 days (n=236), while the mean LLL for the indigenous *Awaous guamensis* was found to be 161 days (n=8) (Radtke et al. 2001).

One characteristic of freshwater amphidromy is spawning and egg-laying in freshwater (McDowall 1988). When larvae hatch, they are swept into the sea by stream currents and temporarily undergo development as marine zooplankton before returning to freshwater as 10 - 16mm long post-larvae to migrate upstream and continue their growth to maturity. Recruitment of post-larvae from the oceanic pool, characteristic of amphidromy, allows rapid recolonization of streams after catastrophic events such as landslides, floods, hurricanes, and droughts (Ford and Yuen 1986; Fitzsimons and Nishimoto 1995; Kido 1996a, 1996b, 1996c; Kinzie 1988; Chubb et al. 1998; Way et al. 1998; McIntosh et al. 2002; Keith 2003; and McDowall 1993, 1995, 2003), and prevents genetic isolation of populations. Holmquist et al. (1998) noted that ʻoʻopu will recruit to any freshwater source regardless of the suitability of the habitat from which it flows.

2.2 Adaptive Advantages of Amphidromy

McDowall (1997) suggested that amphidromy is an "ancient, widespread, successful, and evolutionarily stable life history strategy that has evolved in many fish groups (at least 10 families and perhaps more than once in some of these)." Zink (1990) concluded that *L. concolor* "does not yet show effects of population reduction and 'genetic peril' (if any), and that the planktonic larval pool may well form a sort of natural insurance that will allow colonization of streams in areas influenced by prevailing ocean currents." Based upon the results of their studies of population genetics of Hawaiian stream fishes, Fitzsimons et al. (1990) suggested that the common marine planktonic pool offers a "natural insurance against extinction." They also speculated that once instream conditions become favorable for native fishes, "restocking from other streams will likely occur automatically." By "other streams", he is referring to larvae contributed to the ocean larval pool from other streams.

It is no wonder that the native amphidromous species of fishes, shrimps, and mollusks in Hawaii represent families that inhabit high-island tropical and subtropical streams. Amphidromous gobies "have evolved reproductive patterns adapted to the extremely variable and unpredictable habitat conditions characteristic of Hawaiian streams" (Way et al. 1998). They are adapted to the naturally ephemeral hydrologic torrential flash floods (Keith 2003). Nishimoto (2005) recognized that "…animals in these streams survive, not in spite of episodic floods, but actually because of them."

Fitzsimons and Nishimoto (1995) evaluated the recovery of Kaua'i streams following their devastation by Hurricane Iniki and concluded that the Hawaiian stream fishes showed "remarkable resilience." They noted that amphidromy "provides the potential for repopulating a stream with a full complement of its formerly predominant vertebrate and invertebrate species". In his written direct testimony in the Waiahole Stream case, Devick noted that, "The flashy nature of Hawaiian windward streams, with their sudden peaks and long troughs in flow rates is an integral component for maintenance of biotic stability in the streams. The peak flows help to flush debris from the streambed and provide triggers for migration and spawning by aquatic organisms. *Periodic drying that naturally occurs in the lower reaches of streams may help maintain genetic variability in amphidromous species that would be advantageous for survival over the long term in response to temporal shifts in weather patterns. Native species, particularly amphidromous species, have evolved to fit these conditions*" (emphasis ours).

Hobson et al. (2007) provide recent biochemical evidence that the larvae of amphidromous species may congregate in nutrient-rich freshwater plumes offshore of stream mouths prior to their recruitment. But it is not yet known whether these larvae spend their entire planktonic existence in freshwater nutrient plumes close to natal streams or 'stage' at river mouths after a period of drifting offshore (Hobson et al. 2007). Murphy and Cowan (2007) note that seasonal post-larval recruitment of 'o'opu to Hawaiian shores corresponds to the return of drift bottles deployed in surface current experiments conducted by Barkley et al. (1964). The lack of genetic isolation among 'o'opu among islands described by Fitzsimons et al. (1990), Zink et al. (1996), and Chubb et al. (1998) could be explained by as few as one recruit per generation per species drifting between streams (Hobson et al. 2007; Kinzie, personal communication). To date there is no evidence of within-archipelago isolation or insipient speciation of this unique group of Hawaiian aquatic animals, indicating among-island and between-stream gene flow attributable to their amphidromous life-cycle.

Aquatic biologists now speculate that some streams may be greater sources of larvae than others. Some streams may in fact be "sinks" where larvae cannot reach the sea and/or where recruits may not survive to reproduce. McRae (2007) speculated that sinks might include larger, longer second- and third-order streams with terminal estuaries that harbor many potential predators, and source streams might include shorter first-order streams with terminal falls where itinerant marine predators are excluded. Sinks might also include irrigation ditches connected to streams where breeding populations of amphidromous species inhabit waters upstream of intake structures. The ditch systems are also known to provide habitat for amphidromous species and may act as a conduit for movement of adults between streams but this has not be studied to date.

To fully appreciate how successful a life strategy amphidromy is, one must consider the nature of disturbance in the stream ecosystems in which these species evolved. Cataclysmic influences discussed above include flood, drought, landslides, and volcanism. Longer-term influences must have included periodic changes in rainfall patterns, stream piracy, gaining and losing reaches, predation, competition for resources, and shifting patterns of ocean currents. Reproduction and recruitment of the native amphidromous species appear to respond to stochastic influences. This flexibility allows rapid recolonization of disturbed areas from the oceanic larval pool. The fact that this group of aquatic animals has not demonstrated the adaptive radiation seen in Hawaiian terrestrial fauna and flora suggests that oceanic mixing and transport of larvae sufficiently prevent genetic isolation (McDowall 2003).

3.0 ENVIRONMENTAL INFLUENCES ON HAWAIIAN STREAMS

3.1 Influence of Stream Geomorphology, Discharge, and Periodicity on Species Distribution

Biologists have learned that the geomorphologic profile of tropical insular streams strongly influences the distribution of amphidromous species within a given stream due to the differences in climbing ability, territorial behavior, dietary preferences, and interspecific interactions among the amphidromous species. Overlaps in species distribution and other exceptions to the pattern of distribution (Table 1) are common. Based upon oral histories and written records (e.g., Titcomb 1972; Pukui 1983; and Maly 2001a,) it is likely that this was also understood to some extent by pre-contact native Hawaiians.

Maciolek (1977) coined the phrase "*Lentipes* streams" to describe those streams in which 'o'opu alamo'o was the dominant or only native amphidromous fish present. Usually, these were small to mid-size streams having a terminal waterfall or cascade that prevented colonization by other amphidromous fishes. Kinzie and Ford (1975, 1982, and 1986) also described trends in longitudinal distribution of amphidromous species that could be attributed to stream morphology. Parham (2002) on Guam, Buden et al. (2003) on Pohnpei, and Cook (2004) on Ta'u described similar patterns. Recently, Parham (2002) used this observed pattern as the basis for a computer model based on geographic information systems (GIS) technology, which he hopes will predict the distribution of amphidromous species within island streams. Geomorphology too has influenced patterns of distribution and local endemism in several families of aquatic insects (Polhemus 2005). This issue is significant to the establishment of IIFS insofar as it helps to pinpoint reaches where we would expect to find significant populations of amphidromous species and where others might be naturally excluded.

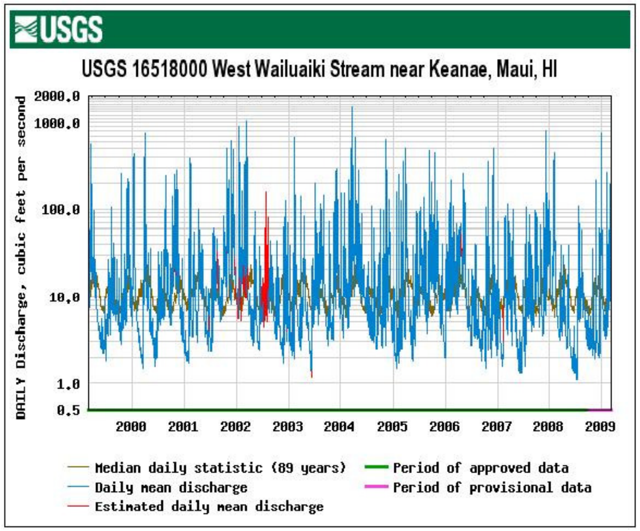
The relationship between the morphology of the stream channel and hydrology is direct and well understood (Macdonald et al. 1983, Morisawa 1968); there is also a strong influence of the channel conditions on the distribution and abundance of the stream biota. The importance of the longitudinal profile of streams to the location of aquatic species in tropical insular streams was known to Hawaiians of the past (Titcomb 1972) as well as today (Maly and Maly 2001a, 2001b).

The climate of the archipelago is dominated by northeasterly trade winds, especially in the summer months (Juvik and Juvik 1998). Storms with accompanying high rainfall are most common in the winter but can occur in any month. High flows occurring at irregular and unpredictable intervals are an integral part of Hawaiian surface water hydrology. Local weather conditions are strongly influenced by the interactions of prevailing winds and landforms producing patterns of orographic rainfall, typically heaviest on the windward (northeast) sides of the high islands. Precipitation at higher elevations leads to erosion of stream channels especially along windward slopes. Headward valley erosion produces the typical amphitheater-headed valleys, and stream piracy results in the older islands having a few very large valleys (Stearns 1966).

Precipitation, ground cover, soils, geology, and the structure of underlying lavas influence stream flows. Heavy rainfall between 2,000 and 3,000 ft elevations (Figure 2) and fog drip form the most significant contributions to streamflow and groundwater in East Maui (Scholl et al. 2002). Rainfall in the region averages more than 350 inches per year at the 2,500-ft elevation on the slopes of Haleakala to about 120 to 160 in/yr on the coast (Giambelluca et al. 1986). While the effects of terrain on storm rainfall are not as pervasive as on trade wind showers, large differences in rainfall do occur over small distances because of topography and location of the rain clouds. The heaviest rains come with winter storms between October and April, though storms and freshets can and do occur at any time of year. The nature of the rainfall patterns and underlying rock of the windward slopes of Haleakala dictate that discharge in East Maui stream channels fluctuates over several orders of magnitude from base flow to peak flood flow in a day (see Miike 2004), and sometimes hourly, from stream-to-stream throughout the year.

Flow regimes in Hawaiian streams are affected by both weather and geology. Perhaps the most characteristic feature of Hawaiian streams is their 'flashy' pattern of flood and base flow that reflects a direct relationship to patterns of rainfall. Figure 3 illustrates the natural daily streamflow data and statistics for West Wailuaiki Stream (above the diversion) over a recent nine-year period. Throughout each year there are several periods of high and low flows.

Figure 3. *USGS daily stream flow data and statistics for West Wailuaiki Stream, East Maui, over nine years (1999-2008) illustrating the frequency of flash floods or freshets typical of Hawaiian streams. All flows over 20mgd (31 cfs) pass below the diversion dam, so it is clear to see just how often these 'freshet' flows are available, even on a diverted stream, to serve as passage for amphidromous species' downstream larval drift and upstream migration of post-larvae. Source: USGS.*



While many larger perennial streams possess naturally continuous surface waters (Polhemus et al. 1992) from the headwaters to the sea, smaller streams and tributaries of large streams can be naturally intermittent with losing reaches going dry in periods of low rainfall and reduced base flow (Stearns and Macdonald 1942, Macdonald et al. 1983). On East Maui, perennial continuous streams are concentrated on older lava flows within the USGS study area and Kipahulu Valley (Figure 2). Many streams in Hawai'i are naturally interrupted due to their geological structure, and sometimes run dry as water is 'lost' through the streambed. Examples of naturally interrupted streams in East Maui include Waiokamilo, Pi'ina'au, and the Palikea tributary of Ohe'o Gulch in Kipahulu Valley. Streams east of Makapipi from Kuhiwa Gulch eastward past Hana toward Kipahulu cross younger lava flows and are naturally intermittent. Timbol and Maciolek (1978) recognized 96 perennial streams on Maui. Fifty-eight percent (58%) of these were continuous, the rest naturally interrupted, and the remainder are naturally interrupted streams or intermittent.

Use of surface water in Hawai'i, whether by the native stream fauna and flora, or by humans, cannot avoid these features of the natural system, and whether by evolution or engineering, the systems in place today reflect these hydrological realities.

Hawaiian streams are also subjected to a number of natural cataclysmic events including torrential flooding, drought, and landslides. All three processes can locally exterminate stream fauna in affected reaches. Ford and Yuen (1986) observed dramatic evidence of this immediately following a cataclysmic landslide in Pelekunu Valley, Moloka'i. These events can occur at any time. Yet despite wide fluctuations in stream flow under natural conditions, both interrupted and intermittent streams

can provide habitat for amphidromous species, as a decade of extensive stream surveys by State of Hawaii Division of Aquatic Resources staff have demonstrated.

Unlike streams in temperate continental ecosystems where seasonal cues (e.g. day length, deciduous shade, wide temperature changes, and spring snow melt) strongly influence the biology and behavior of animals, stochastic, or chance, processes are more important to the biology of tropical insular streams (Kinzie and Ford 1982, Lake 2000). A review of the literature demonstrates that most amphidromous species have broad periods of reproductive activity and relatively weak seasonal trends. Lindstrom (1999) found this to be the case during his study of larval gobioid drift in the Wainiha River on Kauai. In their study of fish populations in small Hawaiian streams, Kinzie and Ford (1982) found that reproduction, recruitment, and hence community structure at any given time were the result of stochastic phenomena. They found that reproductive periodicity in native stream fishes was so broadly spread over time that it appeared unlikely that a strong correlation with seasonal cues had evolved. They also found that the timing of recruitment was also widely variable and prolonged. Other detailed life history studies (Couret 1976, Ford 1979b, Ha and Kinzie 1996, Kinzie 1988, Way et al. 1998, and Lindstrom 1998) discovered similar evidence with regard to the timing of reproduction and recruitment.

Recent studies of larval drift by Lindstrom (1999) in the Wainiha River on Kaua'i suggest that 'o'opu reproduction occurs year-round and appears to be strongly influenced by freshets. Nishimoto and Kuamo'o (1997) also found that post-larval recruitment of gobies into streams occurs year-round, and appears to be most common immediately after freshets and periods of heavy rain. Hence, populations of the same species in different streams appeared to be acting independently with regard to breeding and recruitment (Kinzie and Ford 1982), and may be strongly influenced by instream and offshore conditions. Equally important is the invasion of stream mouths by post-larval amphidromous species. Research by several authors suggests that this may occur at different times for different species. Given the stochastic processes influencing current patterns, streamflow, and planktonic larval survival one would expect that these patterns might be subject to considerable temporal and geographic variation. Common in all areas is the necessity for terminal discharge of sufficient duration and volume to attract and accommodate upstream migration of post-larval fishes, mollusks, and crustaceans.

McRae (2007) suggested that during wet periods, small streams might be more significant as contributors of larvae to the oceanic larval pool. In dry periods, large streams may provide more eggs. Hence, they argue that representative streams of all types must be protected in order to ensure the continued survival of amphidromous species in Hawai'i.

4.0 HUMAN IMPACTS

Since the arrival of humans in the archipelago some 1600 years ago there have been alterations to the islands' landscapes, streams, and watersheds (Kirch 1982, 2000; Burney et al. 2001; Athens et al. 2002). Understanding and formulating management plans today requires understanding of these events in the past.

4.1 Pre-Captain Cook Human Influences on Hawaiian Streams

While restoration to a pre-Captain Cook state (Miike 2004) might be an idealistic goal for stream restoration, so much post-contact modification has occurred that the combined impacts of cumulative perturbations to Hawaiian streams prevent us from knowing what a stream with pre-Captain Cook characteristics looked like or how it might have functioned (Kinzie 1993). Zimmerman (1963), Kirsch (1982), Wagner et al. (1985), Stone (1985), Cuddihy and Stone (1990), Athens et al. (2002), and Ziegler (2002) summarize the impacts to forested watersheds in Hawai'i caused by activities of prehistoric Polynesians beginning about 1,600 years ago. Activities most likely to adversely impact stream ecosystems included the extensive lower watershed deforestation by clearing and burning, agriculture (especially the modification of stream flow for wetland crops), introduction of alien species, and fishing.

Following and after the arrival of the first and second waves of Polynesian immigrants, the Hawaiians refined the ahupua'a concept of resource allocation and engineered diversions ('auwai) to irrigate taro fields (lo'i) (Kirch 1982, Gingerich et al. 2007). Sometimes quite extensive in nature, these 'auwai carried water to irrigate taro lo'i throughout the middle and lower reaches of many valleys on the five major Hawaiian Islands (Handy and Handy 1972). Widespread impacts of these pre-historic activities and deforestation caused by the introduced Polynesian rat included decrease in watershed soil moisture, permeability, and surface water retention; rapid run-off; sedimentation of streams and nearshore waters; lowered water tables; altered-microclimates; and drought (Newman 1969, Spriggs 1985). Hawaiians directly influenced the stream fauna by fishing and collecting returning post-larvae (hinana) (Titcomb 1972); however, this impact may have been small compared to the alterations in the landscapes (Athens et al. 2002).

4.2 Post-Captain Cook Human Influences on Hawaiian Stream Ecosystems

By the time comprehensive descriptions of the Hawaiian landscape began appearing in western literature in the late 1700s, feral ungulates and non-native plants had already begun to dramatically change the nature of Hawaiian watershed structure and function. The restriction (kapu) placed upon killing introduced cattle permitted the unchecked growth of large herds, which along with introduced sheep beginning in 1793, decimated native lowland forests. This was accompanied by the introduction of non-native plants that forever changed the nature of Hawaiian watersheds. These cumulative effects of human activities led to the permanent and irreversible modification of Hawaiian watersheds and their streams. The effects include but are not limited to the following, in rough chronological order:

• Changes to watershed vegetation, soils, and water budgets by introduced species
• Destruction of watershed vegetation and soil erosion caused by feral ungulates
• Surface water diversions, groundwater, and well development
• Soil erosion from sugar cane and pineapple cultivation
• Discharge of bagasse at stream mouths (late 1800s to 1972)
• Aquatic alien plant and animal introductions
• Introduced diseases and parasites of aquatic animals
• Urbanization and industrialization with subsequent impacts upon water budgets and quality
• Widespread stream channel modifications for flood control
• Modern consumptive practices (e.g., fishing with illegal electroshocking and traps)

4.3 Water Development

The history of surface water development in Hawai'i was summarized by Wilcox (1996). She documented the tremendous engineering feats involved in bringing water, often from long distances over rough terrain, to centers of large-scale agriculture. The plantation system this water development supported laid the groundwork for the economic development of the Hawaiian Islands beginning in the late 1800s. While we know the history and current state of the movement of water through these systems, we know much less about how diversion impacts Hawaiian stream ecosystems. Kido (1997b) noted that the "rapidly changing terrestrial landscape in Hawaiian watersheds coupled with the escalating rates of alien species introductions are altering natural functioning of these [stream] ecosystems."

In one of the few published studies that directly examined the effects of stream dewaterment in Hawai'i, Kinzie et al. (2006) found that stream diversion reduced available habitat for benthic (bottom-dwelling) invertebrates in reaches below a hydropower dam on the Wainiha River, Kaua'i. Benthic primary and secondary production were lowest at sampling sites below the diversion dam with the lowest flows. Complex and sometimes subtle biotic and abiotic effects associated with diversions were also discovered that are yet difficult to explain. Invertebrate drift was strongly influenced by the dam suggesting entrainment of drift into the diversion ditch (Kinzie et al. 2006).

Maciolek (1978) stated that *Neritina granosa* (hīhīwai) can occupy continuous streams up to 400 meters in elevation; however, it is uncommon to find hīhīwai at that elevation. Ford (1979b) and Brasher (1997a) found that hīhīwai were limited to about 185 meters and 223 meters in the lower reaches of Waiohue and Waikolu Streams, respectively. Both investigators suggested that this was due to the effects of dewaterment on habitat availability. Way et al. (1998) noted altered patterns in reproductive out put among *Lentipes concolor* ('o'opu alamo'o) from continuous Makamaka'ole Stream on Maui and diverted Waikolu Stream on Molokai.

Benbow (1997) concluded that a Maui diversion dramatically reduced habitat for benthic invertebrates. A major unanswered question is whether these impacts threaten populations of native amphidromous species. This question is central to the crafting of instream flow standards, but has yet to be properly answered.

Native Hawaiian amphidromous species are able to surmount many low dams and weirs as we have discovered in our field studies of East Maui, Nā Wai 'Ehā (SWCA 2008), and other West Maui streams (SWCA 2004, 2007). This was reported by both USGS (Gingerich and Wolff 2005) and DAR (Parham et al. 2008). Under existing diverted conditions, flow volume and frequency is sufficient to allow upstream migration by 'o'opu nākea, 'o'opu alamo'o, 'opae kala'ole and by the non-native amphidromous Tahitian prawn to inhabit elevations where they would normally be found. Fukushima et al. (2007) discovered that upstream migration by gobies was unaffected by dams in Hokkaido streams. Holmquist et al. (1998) noted that the native Antillean goby *Sicydium plumieri* was able to negotiate high dams with spillway releases, albeit in reduced numbers, in Puerto Rican rivers.

Diversion structures in many East Maui streams are located at or above the uppermost elevations that 'o'opu alamo'o and 'ōpae kala'ole normally inhabit under natural undiverted conditions. In such cases the structures would not represent 'bottlenecks' to upstream migration. However, as Gingerich and Wolff (2005) noted, dry stream reaches (e.g. below diversion structures) can function as 'bottlenecks' for the migration of any species. In Hawaiian streams, dry reaches in diverted, naturally intermittent, and interrupted perennial streams are temporary and are periodically wetted by freshets. The presence of amphidromous species above dry reaches throughout the State (Parham et al. 2008) demonstrates that ecological connectivity is restored during these events allowing migration to occur. Large waterfalls may prevent upstream migration of all amphidromous species except 'o'opu alamo'o and 'ōpae kala'ole (Gingerich and Wolff 2005). This is true under both natural and diverted conditions. This is significant in the evaluation of IIFS for native stream life. Changes in aquatic habitat caused by diversions in upstream reaches are not relevant to those species that do not normally inhabit reaches above natural bottlenecks or cannot migrate upstream to inhabit these reaches (Gingerich and Wolff 2005).

4.4 Summary of Human Impacts on Hawaiian Streams

SWCA believes that there are no 'pre-Captain Cook' streams (sensu Miike 2004) in Hawai'i today, and there can never be such streams again due to the complex synergistic effects of watershed alteration by a millennium of human alteration of the environment throughout the archipelago. There are, however, streams with minimal levels of alteration that continue to harbor healthy populations of native amphidromous species. These streams are commonly referred to today as being 'pristine', 'unaltered', or 'natural' (Hawai'i Cooperative National Park Studies Unit 1990).

Despite the history of disturbances in island watersheds that began with the Polynesian immigrants the amphidromous fauna of Hawai'i persists, although not in the numbers once described in literature and lore. The characteristic species may still be found in many streams on all five major islands, and often in abundance. East Maui streams continue to be recognized among the most important habitats for native Hawaiian stream animals in the State (Hawai'i Cooperative National Park Studies Unit 1990, Gingerich and Wolff 2005). No specific evidence is available to suggest that any of the amphidromous species is presently at risk of extinction. However, the synergistic effects of human alterations have led to a decline in the populations of native freshwater species statewide. Surprisingly, no studies have been conducted on the long-term population trends for Hawaiian amphidromous species, and there is nothing in the scientific literature on this topic.

A pattern that is not yet widely acknowledged is that the amphidromous native macrofauna are extraordinarily resilient to changing conditions within streams, and they continue to persist within the Hawaiian Islands in apparently stable metapopulations. Evidence of this has been cited by others, including Dr. Lawrence Miike of the CWRM (see his quotation in the Executive Summary on page 3 of this report), yet its significance is perhaps not recognized:

> *While continuous stream flow from the source in the mountains to the mouth at the ocean ("connectivity from mauka to makai") is perhaps a necessary condition for most of Hawaii's perennial streams to sustain reproducing amphidromous populations at pre-diversion levels, …there are streams that are naturally interrupted with healthy populations; i.e., with*

ecological instead of physical connectivity, or stream flows of sufficient volume and frequency to allow the normal distribution of native amphidromous species within a given watershed, F0F 557… (Hearing Officer's Proposed Finding of Fact, Conclusions of Law, and Decision and Order, Case Number CCH-MA06-01, April 2009).

These [Statewide Monitoring and Survey Program] surveys have already yielded valuable and unexpected results. For example healthy 'o'opu populations have been discovered in intermittent leeward streams, previously thought to be incapable of supporting native fishes. (Dr. Robert Nishimoto, Aquatic Biologist, as quoted in "Hawaiian Waters - the Mauka Makai Lifeline" video published by the Education Program, Department of Aquatic Resources, DLNR.)

5.0 THE EAST MAUI IRRIGATION COMPANY (EMI) DITCH SYSTEM

Built between 1876 and 1923, the East Maui ditch system is operated by the East Maui Irrigation Company (EMI), a subsidiary of Alexander and Baldwin. It is an engineering marvel consisting of at least 388 intakes, 24 miles of ditches, 50 miles of tunnels, 12 inverted siphons, and hundreds of small secondary intakes with a total capacity of about 445 mgd (Wilcox 1996). She estimated the replacement cost to be $200 million, and states that it is the "largest privately owned water company in the United States, perhaps in the world."

Today the ditch system conveys 62 billion gallons of water per year (over 20.2 million acre feet) to Central Maui to irrigate 30,000 acres of sugar; and up to one billion gallons per year (over 326,000 acre feet) for domestic use by the County of Maui. The American Society of Civil Engineering designated the EMI ditch system as a National Historic Civil Engineering Landmark in February 2003. Within the USGS East Maui study area, six ditch/tunnel systems intercept stream flows from 21 streams at elevations as high as 1,950 ft. The County of Maui collects water from some East Maui streams at even higher elevations. EMI records document 58 major structural intakes and 119 minor diversions within the study area (Table 2).

Major structures generally consist of concrete and/or stone diversion dams or fixed-crest weirs built across the stream channel. Water is diverted into ditches and flumes through debris gratings or drainage galleries adjacent to and immediately upstream of the dams. The volume of water entering the ditch systems can be adjusted at each stream by manually operated head gates. None of the diversion structures currently have bypass systems (e.g. fish ladders or fish-ways) built specifically to enhance upstream or downstream fish passage. Many of the dams have some seepage through the face or toe of the structure and through head gates.

Table 2. *Registered diversion structures within the East Maui study area (Source: East Maui Irrigation Company, Ltd.)*

Ditch Name	Major Diversions	Minor Diversions
Koʻolau	33	83
Wailoa	4	3
Spreckels	10	22
New Hamakua	3	0
Manuel Luis	5	10
Center	3	1
Total diversions	**58**	**119**

Secondary diversions structures consist of small water development tunnels, weirs, check dams, and PVC pipes fitted to capture seepage below dam faces and runoff from small gullies and swales. Several streams in the western portion of the study area are diverted at several elevations by different ditch systems.

During periods of prolonged drought in East Maui, flow in the ditch system is reduced to 10 mgd. This is the volume of water that is available to provide the County of Maui to supply domestic water needs for upcountry towns including Pukalani, Kula, and Makawao.

The ditch system itself supports both native and non-native aquatic life, yet we are unaware of any scientific study of its biological function. Local residents know well that portions of the ditch system are the best places to collect mountain ʻōpae for subsistence. The ditch serves as a means of lateral dispersal across watersheds for *both* native and non-native aquatic species. It may also serve as a sink for newly hatched larvae of amphidromous species inhabiting the upper reaches of East Maui streams.

6.0 AMPHIDROMOUS SPECIES IN EAST MAUI STREAMS

6.1 Recent Studies

Gingerich (1999) studied the relationship between and availability of groundwater and surface water in East Maui as potential future sources for domestic water supply. Following the submittal of a petition to set Instream Flow Standards (IFS) in 27 East Maui streams in 2002 by concerned citizens, the geographic extent of the East Maui study area was limited to the region between Kolea Stream and Makapipi Stream (Gingerich 2004). In his study of median- and low-flow characteristics under natural and diverted conditions, Gingerich (2004) developed a system to estimate flow characteristics (base flow and total flow) for ungaged East Maui streams. Building on this, he further identified the location of gaining and losing reaches and significant springs in stream valleys in the East Maui study area. Gingerich and Wolff (2005) attempted to estimate habitat for native stream macrofauna and to model how the amount of this habitat might respond to changes in flow.

SWCA biologists conducted biological surveys and collected flow measurements above and below diversions throughout the study area. Kinzie et al. (2006) had found that reaches affected most by water removal are those located between ditch intakes and influent tributaries, springs, or seeps that contribute to flow at lower elevations. This pattern was also apparent within the East Maui study area as well as in Honokohau Stream on West Maui (SWCA 2004, 2005). The location and type of diversion structures and stream crossings strongly influence the ability of amphidromous species to surmount the structure to inhabit upstream reaches (March et al. 2003a, Resh 2004, SWCA 2004, 2005).

Seven of the 21 East Maui study streams within the project area have terminal waterfalls or cascades. The East Maui streams with high terminal falls are: Kolea, Waikamoi, Wahinepeʻe, Haipuaʻena, Waiokamilo, and Paʻakea. Paʻakea has a freshwater plunge pool just above the mouth of the stream; however, the falls above it restricts other amphidromous fishes from inhabiting the stream above the terminal pool. *Lentipes* and *Atyoida* were observed together in most of the streams studied by USGS, SWCA, and DAR. A summary of amphidromous species presence within the study area streams in found in Table 3.

The atyid ʻōpae kalaʻole was the most conspicuous species found above the diversions during our study. Dragonfly and damselfly naiads, Japanese wrinkled frog tadpoles, and lymnaeid snails were common. ʻŌpae were also observed above every intake with the exception of Punalau Stream. Insufficient data are available to assess amphidromous species populations in Wahinepeʻe, ʻOhia, Waiaʻaka and Makapipi streams. Direct visual surveys of upper Uluini tributary and Nuaʻailua streams were not possible due to excessive turbidity. The source of suspended sediments in these areas appeared to be from disturbance of watershed soils by feral pigs (Hew, personal communication; Voorhees, personal communication).

In 2008, at the request of the CWRM, DAR biologists conducted comprehensive longitudinal sampling in five East Maui stream systems, including Honopou, Hanehoi, Piʻinaʻau, Waiokamilo, and Wailuanui. Their results, which were published online in the Hawaii Watershed Atlas (www.hawaiiwatershedatlas.com), included data for amphidromous species listed in Table 3. DAR biologists also surveyed native freshwater insects in each of the five stream systems and found a greater diversity of native insects in the upper reaches of streams above the highest diversion structure. Insect diversity in the lower reaches of streams affected by diversions was reduced.

At least one species of endemic damselfly, *Megalagrion pacificum*, a candidate endangered species, was found in the upper reaches of Honopou, Hanehoi, and Piʻinaʻau Streams. DAR concluded that diversion of surface waters converted the normally perennial mid-reaches of these five systems into the equivalent of intermittent streams. The few remnant pools were colonized by alien invasive species. They also concluded that upstream dispersal of invasive species was inhibited by numerous

Table 3. Known distribution of amphidromous species in streams of the East Maui study area (data summarized from SWCA, USGS, and DAR sources). X = present; ND = no data. Streams have not been surveyed equally throughout all reaches and over time, so the lack of an observation of a given species from a given stream must not be interpreted as absolute evidence of that species' absence from that watershed. East Maui streams with the greatest number of amphidromous species reported have been the most intensively studied and surveyed repeatedly over a period of may years (e.g. Hanawī, Waiohue, and Palauhulu/Pi'ina'au).

East Maui Streams (T) = terminal falls	*Kuhlia spp.*	*Eleotris* sandwicensis	*Stenogobius hawaiiensis*	*Awaous guamensis*	*Sicyopterus stimpsoni*	*Lentipes concolor*	*Neritina granosa*	*Neritina vespertinus*	*Macrobrachium lar (Alien amphidromous)*	*Macrobrachium grandimanus*	*Atyoida bisulcata*
Honopou		X		X	X	X			X	X	X
Hanehoi											X
Kolea (T)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Waikamoi (T)									X		X
Wahinepe'e (T)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Haipua'ena (T)						X			X		X
Puohokamoa				X		X			X		X
Punalau				X	X	X			X		
Honomanū											X
Nua'ailua				X	X	X	X	X	X		X
Palauhulu/Pi'ina'au	X	X	X	X	X	X	X	X	X	X	X
'Ohia							X				
Waiokamilo (T)				X					X		X
Wailua Nui	X	X		X		X			X		X
W. Wailua Iki	X			X		X	X		X		X
E. Wailua Iki	X	X		X		X	X		X		X
Kopiliula	X	X		X	X	X	X		X		X
Waiohue	X	X	X	X	X	X	X	X	X	X	X
Pa'akea (T)				X		X	X		X		X
Kapaula											X
Hanawī	X	X	X	X	X	X	X		X		X
Makapipi	X	X		X	X	X			X		X

waterfalls in each stream. They further suggested that the EMI ditch systems serve as lateral conduits for spread of invasive species, but failed to acknowledge the presence of native amphidromous species throughout the ditch and the significance of the ditch in the cross-watershed dispersal of native species.

DAR also suggested that the potential exists for recolonization by native species in all five streams, and they predicted that native fishes would recolonize from the terminal reaches up, and insects would recolonize from the headwater reaches down. Given the potentially deleterious impacts to the successful recolonization by the presence of non-native species, they recommended that flow restoration be released from stream flows, not ditch flows, to mitigate the spread of aquatic invasive species.

It is interesting to note that streams close to areas of habitation in East Maui have the largest number of non-native species. The State of Hawai'i Department of Health may have introduced non-native Poeciliid fishes (guppies and mosquitofish) to several East Maui streams during the 2002 outbreak of Dengue fever (Brock, pers. comm.). Local residents of Keanae and Wailua peninsulas have also introduced numerous species of potentially harmful non-native species which may represent a significant threat to native amphidromous species, if they are allowed to disperse throughout the stream systems. Potentially harmful species reported from East Maui streams include guppies, mosquitofish, swordtails, carp, oriental weatherfish (dojo), goldfish, Louisiana crayfish, apple snails, and Asian clam. The potentially detrimental effects of the non-native Tahitian prawn, also an amphidromous species introduced by the State of Hawai'i in the late 1960s, have never been determined.

6.2 Status of Amphidromous Species Distribution in East Maui Streams

Table 4 shows the number of amphidromous species known to occur in the 21 streams within the USGS East Maui Study Area (Gingerich and Wolff 2005, Parham et al. 2008, and this study). The information in Table 4 is graphically depicted in Figure 4. Of the 21 streams, data on amphidromous species are available for 18, and all of these streams have diversion structures. The interruption of flow by diversion ditches can create an sporadic impediment to downstream larval drift and upstream migration of post-larvae, but should not be interpreted as the sole cause of low numbers of native amphidromous species (Timbol and Maciolek 1978, Kirch 1982, Chan 1986, Cuddihy and Stone 1990, Devick 1991, Kido 1997, Englund 1999, Brasher and Wolff 2001, Richardson and Jowett 2002, Englund 2002, Brasher 2003, Resh 2005).

Table 4 also reflects the distribution of amphidromous species along longitudinal gradients within the streams, and includes species occurrence data from the newly available Hawaiian Watershed Atlas (Parham et al 2008). Although many of the records within the atlas are older (circa 1961-63), all reported observations are post-diversion (e.g. after 1900). In the table, each stream has been partitioned into lower, middle, and upper reaches. These are relative terms that are widely and loosely used in scientific literature. The lower reach generally refers to that length of stream channel from its mouth upstream to the head of its terminal estuary or to the base of the first significant high waterfall, or it may roughly encompass the lower third of the stream's total length. The middle reach encompasses the stream above the lower reach but below an elevation of about 1,000 to 1,500 ft. The upper reach generally refers to elevations above 1,500 ft, or the upper third of the total stream length, and represents the highest elevations inhabited by amphidromous species under natural, undiverted conditions. Of course the highest elevations inhabited by these species vary with local geomorphologic and hydrologic conditions.

Figure 5 summarizes the number of streams within the USGS East Maui study area (Gingerich and Wolff 2005) that harbor amphidromous species in their lower, middle, and upper reaches. It is significant to note that of the 18 East Maui streams for which we have data, 17 were found to have amphidromous species in their upper reaches. These individuals had to have migrated upstream past diversion structures to inhabit these reaches, confirming that ecological connectivity occurs under existing conditions. It is also possible that the EMI ditch system may also be a means of access to stream reaches above diversions.

The data also confirm that there is a substantial amount of suitable habitat in East Maui streams for all nine native amphidromous species (as well as the non-native amphidromous Tahitian prawn) under existing diverted conditions. Based upon Gingerich and Wolff (2005), SWCA calculated that there are roughly 106 linear kilometers (66 linear miles) of stream channels within the study area below an elevation of 2,000 ft (which is presumed to be the uppermost elevation inhabited by amphidromous species under natural, undiverted conditions). Figure 6 (Plate 1 of Gingerich and Wolff 2005) illustrates the amount of aquatic habitat availability in relation to undiverted conditions estimated by Gingerich and Wolff (2005). Figure 7 illustrates stream channel lengths, in linear meters, throughout the East Maui study area in which the aquatic habitat values were estimated by Gingerich and Wolff (2005) as a certain percentage of natural conditions at base flow.

Table 4. *Distribution of amphidromous species in lower, middle, and upper reaches of East Maui Streams within the USGS study area (summarized from SWCA, USGS, and DAR sources).*

STREAM	Number of Amphidromous Species Reported			Terminal Waterfall	Number of Non-Native Species Reported
	Lower	Middle*	Upper**		
Kolea	ND	ND	ND	√	ND
Waikamoi		1	2	√	5
Waikamoi – Alo***			1		
Wahinepe'e	ND	ND	ND	√	ND
Puohokamoa	4	3	2		1
Haipua'ena	1	3	1	√	4
Punalau	2	1	1		2
Honomanu	1		1		
Nua'ailua	6	5	2		2
Pi'ina'au / Palauhulu	10	6	4		9
'Ōhi'a	1				
Waiokamilo		2	2	√	8
Wailuanui	10	6	5		5
West Wailuaiki	4	4	1		7
East Wailuaiki	5	2	1		1
Kopiliula / Puaka'a	4	7	6		3
Waiohue	10	5	4		2
Pa'akea	5	2	1	√	1
Waia'aka	ND	ND	ND		
Kapā'ula			1		
Hanawi	7	7	2		2
Makapipi	4	5	2		6

Key to Table:

ND = no data

* Above diversion structures in some reaches

** Above diversion structures

*** Waikamoi and its tributary Alo are counted as one stream.

Of the total 106 linear kilometers of stream channels within the study area, 57 percent of the total stream length retained 75 - 100 percent of aquatic habitat at base flow relative to the estimated undiverted conditions (Gingerich and Wolff 2005). An additional 27 percent of the total stream length retains between 25 - 75 percent of aquatic habitat at base flow relative to the estimated undiverted conditions, and 16 percent of the total stream length within the study area was dry at base flow.

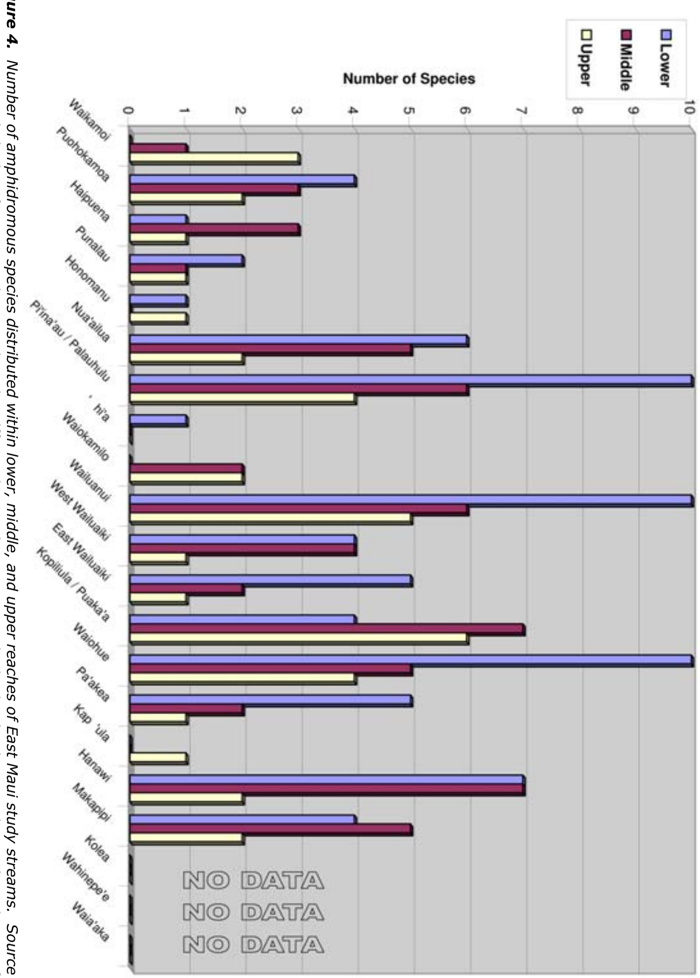


Figure 4. *Number of amphidromous species distributed within lower, middle, and upper reaches of East Maui study streams. Source data for this assessment include data from USGS (Gingerich and Wolff 2005), DAR (Hawaii Watershed Atlas (Parham et al. 2008), and SWCA field studies since 2003, and data obtained in numerous other surveys conducted by authors Kinzie and Ford since 1974.*

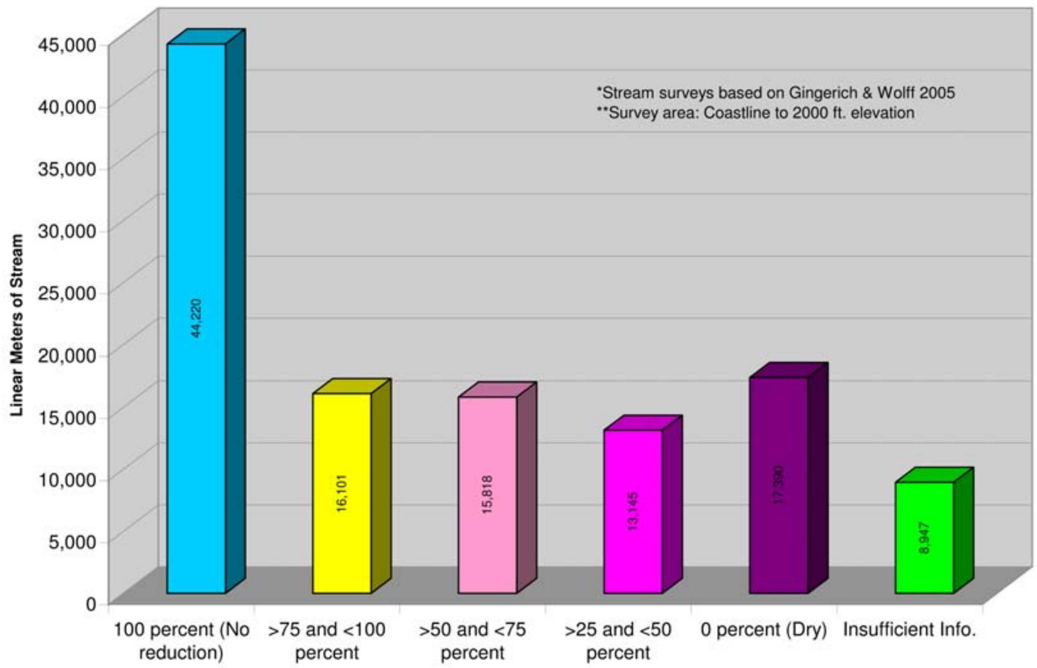


Figure 6. *Summary of estimated aquatic habitat at diverted base flow conditions relative to natural conditions for the USGS study area streams in East Maui, calculated with GIS technology by SWCA from stream lengths illustrated in Plate 1 of Gingerich and Wolff (2005).*

12.0-27

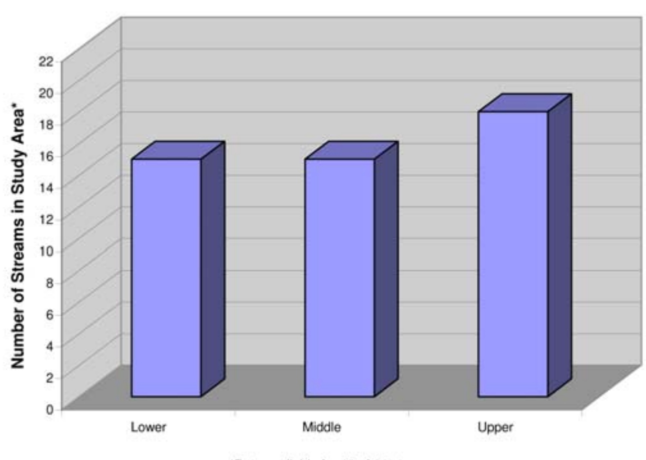


***Figure 5**. Seventeen of 18 East Maui streams for which data are available were found to have amphidromous species within their upper reaches, demonstrating that ecological connectivity occurs under present diverted conditions. Source data for this assessment include data from USGS (Gingerich and Wolff 2005), DAR (Hawaii Watershed Atlas (Parham et al. 2008), and SWCA field studies since 2003, and data obtained in numerous other surveys conducted by authors Kinzie and Ford since 1974.*

12.0-26

Our observations and review of scientific literature published over the past decade helped us realize that the native Hawaiian amphidromous species appear to be far more resilient than once imagined. Natural patterns of frequent drought, flood, and landslides can have devastating impacts on stream biota in individual streams; however, those impacts tend to be temporary. Following natural disturbance, recolonization by algal, invertebrate, and amphidromous species has proven to be relatively rapid (Ford and Yuen 1986; Fitzsimons and Nishimoto 1995; Kido 1996a, 1996b; Sherwood 2002, 2004a).

A potential risk associated with flow restoration in streams that are known to harbor alien species, particularly predatory poeciliid fishes, is the inadvertent dispersal of aliens throughout the stream by enhanced flow. For example, mosquitofish (*Gambusia affinis*) were observed immediately above the diversion structure in Kopiliula Stream during this study. Their origin in the stream is unknown, but they may have been introduced by State or County health department officials or unknowing persons as a hopeful check against disease-bearing mosquitoes. Mosquitofish are members of the live-bearing family Poeciliidae, native to South and Central America, which includes guppies and swordtails. Englund (1999, 2002) suggested that poeciliid fishes may be accountable for the demise of endemic insect taxa including damselflies of the genus *Megalagrion*. The potential for both upstream and downstream dispersal of poeciliids during flood events and the failure of flood flows to eliminate these species from streams is well documented (Chapman and Kramer 1991, Englund and Filbert 1999).

7.0 SUMMARY POINTS

- Contrary to what was once believed, there are no data available to suggest that any of the nine native Hawaiian amphidromous species is at risk of either endangerment and/or extinction in East Maui streams or elsewhere within the State. Native amphidromous species persist in East Maui streams and other streams throughout the State despite 1,600 years of human modifications to the landscape and a century of modern water development.

- Amphidromous species have life histories that are adapted to the extremely variable and unpredictable habitat conditions characteristic of Hawaiian streams.

- Amphidromous species are part of statewide metapopulations and are buffered from isolation by having a continuous source of genetic renewal through interisland oceanic larval transport. As such, they are resilient to changing conditions within individual streams and continue to persist within the Hawaiian Islands as apparently stable metapopulations.

- In Hawaiian streams, dry reaches in both diverted and naturally intermittent and interrupted perennial streams are ephemeral and are periodically wetted by freshets. The presence of amphidromous species above dry reaches throughout the State demonstrates that ecological connectivity is restored during these events allowing migration to occur (Nishimoto, undated video; Parham et al 2008).

- Of the 21 East Maui streams under study, data exist for 18 streams. Of those, 17 streams have amphidromous species reported from their upper reaches, once again confirming that ecological connectivity occurs under existing conditions.

- The system of water diversions in East Maui, while clearly extending the dry end of the wet-dry daily cycle of stream ecology, has not been demonstrated to preclude suitable habitat conditions for sustaining populations of the amphidromous species.

- Under diverted conditions, of the total 106 linear kilometers of stream channels within the study area, 57 percent of the total stream length retained 75 - 100 percent of aquatic habitat at base flow relative to the estimated undiverted conditions. An additional twenty-seven percent of the total stream length retained between 25 - 75 percent of aquatic habitat at base flow relative to the estimated undiverted conditions.

- The extent of larval exchange among breeding populations of amphidromous species in Hawaii is sufficient to result in genetic homogeneity among the main islands.

- No one has yet documented a direct quantitative relationship between the abundance or density of native Hawaiian amphidromous species and weighted usable habitat area (WUA) as estimated through the Physical Habitat Simulation Model (Bovee et al 1998).

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APPENDIX A
LIFE HISTORIES OF SELECTED NATIVE HAWAIIAN AMPHIDROMOUS SPECIES

Eleotris sandwicensis (Vaillant and Sauvage 1875) ʻOʻopu akupa

Oʻopu akupa is endemic to the Hawaiian Islands. Although it is generically referred to as a goby in the Hawaiian language (e.g. ʻoʻopu), it is not a true goby but is a member of the family Eleotridae (Gosline and Brock 1960). Eleotrids do not have fused pelvic fins, or ʻsucking disk' characteristic of the true gobies. As a consequence, ʻoʻopu akupa are confined to the lower reaches of streams and estuaries (Kinzie 1990) due to their inability to cling to rocks. ʻOʻopu akupa are found in the terminal and lower reaches of streams on all the main Hawaiian Islands and are abundant on Oahu in both altered and unaltered streams (Yamamoto and Tagawa 2000).

Culturally, ʻoʻopu akupa were prized as a food item and are also used as bait for papio by near-shore fishermen (Titcomb 1972). This is one of the largest ʻoʻopu in Hawaiian streams and there are more specific names for this species in the Hawaiian language than for any other ʻoʻopu, including akupa, akupakupa, okuhe, okuhe melemele, okuhekuhe, apoha, oau, and owau (Titcomb 1972). ʻOʻopu akupa are carnivorous and predaceous. Food items most often taken consist of thiarid snails and Asiatic clams, though fishes (including smaller ʻoʻopu akupa) and crustaceans are also consumed (Fitzsimons et al. 2002).

Reproductive biology of ʻoʻopu akupa on Oahu was studied by Sim (2006). She found females and males with mature gonads year-round, suggesting year-round reproduction with a peak spawning season possibly between July to March. This peak spawning period encompasses the rainy season (November to March), which is the spawning season of most Hawaiian gobiids, but is prolonged and extends into the dry season (April through October). It is possible that each female may spawn more than once a year. Batch fecundity in females ranged form 4950 eggs to 54670 eggs and was positively correlated with standard length and wet weight of the individual. The minimum size at maturity has not been documented but the smallest female collected with mature gonads was 54mm SL; the smallest male was also 54 mm SL (Sim 2006).

Both water quality and island location have significant effects on the size and weight of ʻoʻopu akupa (Sim 2006). Specimens were collected from pristine and degraded streams on Oʻahu, Hawaiʻi and Kauaʻi. Mature males and females from pristine streams were significantly larger and heavier than individuals collected from degraded streams. ʻOʻopu akupa that Sim (2006) collected increased in size and wet weight from Oahu to Hawaiʻi to Kauaʻi. She speculated that higher predation pressure on ʻoʻopu akupa and lower food quality in degraded streams may be factors that result in smaller sizes and earlier onset of maturity in these streams.

A young ʻoʻopu akupa (right) photographed in an aquarium, illustrating its distinct dark brown mottled coloration. Photo by John Ford.

Awaous guamensis (Valenciennes 1837) ʻOʻopu nakea

As the largest true goby (280 - 340mm SL) inhabiting Hawaiian streams and historically the most popular freshwater food fish, ʻoʻopu nakea was among the first Hawaiian freshwater goby species whose life history patterns were investigated in detail (Ego 1956). Originally described as the endemic *A. stamineus* until Watson (1992) reclassified it, the species is now believed to be indigenous throughout the tropical Pacific. In Hawaiʻi it is found in streams on all major islands having perennial streams (Ha and Kinzie 1996); however, populations of the species are reduced on Oʻahu. ʻOʻopu nakea characteristically inhabits the lower and middle reaches of streams in areas with deeper, slower waters (Kinzie 1988), and is most abundant in larger rivers on Kauaʻi. Kido and Heacock (1991) and Ha and Kinzie (1996) studied the reproductive biology of the species, and found that larger adults migrate downstream with freshets to spawn in large aggregations in riffles just above the terminal, estuarine reaches of streams. Male and female fish had the potential to spawn between August and December (Ha and Kinzie 1996). Size at first reproduction is 73 mm SL for both male and female fish.

Ha and Kinzie (1996) estimated fecundity, based to 21 nests measured in the field, to be between 117,600 eggs (for a 144 mm SL female) to 689,500 eggs (for a 217 mm SL female). Ego (1956) estimated well over one million eggs for a 280 mm SL female. Although *A. guamensis* is among the largest gobies, it has very small demersal, spheroid eggs. Eggs are laid on the underside of rocks and tended by male fish for two to four days until hatching (Ego 1956, Miller 1984, Nishimoto and Fitzsimons 1986, Timbol et al. 1990, Lindstrom and Brown 1996). Newly hatched yolk sac larvae are swept downstream and into the sea.

Downstream larval drift occurs throughout the year, and is most prevalent during the first hours after sunset (Lindstrom 1998). The highest concentration of larvae measured from any single hour-long sample was 413 larvae/m^3. Based on these data, Lindstrom (1998) calculated mean daily watershed larval output for all sample dates (n=36) at 0.45 – $1.4x10^6$, yielding an annual larval output of $1.6\text{-}5.1x10^8$ larvae per year from the entire watershed for only the first three hours after sunset. He believed that this was an underestimation of the complete watershed output value. Lindstrom (1998) noted that samples with higher concentrations of drifting larvae were dominated by *A. guamensis* suggesting that this species concentrates its reproductive effort in specific seasons. He calculated that only 2500 breeding *A. guamensis* would be needed to produce the number of larvae calculated, given $2x10^5$ as the single spawn fecundity of an average-sized breeding adult (Tamaru 1991).

Adult ʻoʻopu nakea, Awaous guamensis, in Hanawi Stream (left). Buff colored spots on rocks are hīhīwai (Neritina granosa) egg capsules. Photo by John Ford.

Once they reach the sea, larvae develop as part of the marine planktonic community for up to 169 days (Radtke et al. 1988, Radtke and Kinzie 1991). Tate (1997) and Nishimoto and Kuamoʻo (1997) reported that *A. guamensis* post-larvae were transported to river mouths by waves and that they entered streams at any time of the day, though in greatest numbers in the evening, at about 16 mm SL in size. They may spend several weeks in the estuarine or lower reaches before migrating upstream, and are generally limited to the lower 1,000 ft in elevation. They are not strong climbers and are restricted from reaches above waterfalls. Kido et al. (1997a, 1997b) characterized oʻpu nakea as an omnivorous benthic feeder, utilizing primarily algae, and opportunistically feeding upon introduced aquatic insects and terrestrial invertebrates in drift. Their work supported the conclusions of Ego (1956) with regard to algae; however, endemic atyid shrimp or damselflies were absent from oʻopu nakea gut samples collected by Kido et al. (1997a, 1997b) from ʻoʻopu nakea collected in the Wainiha River, Kauaʻi.

Sicyopterus stimpsoni (Gill 1860) ʻOʻopu nopili

Tomihama (1972) provided the first description of *S. stimpsoni* (ʻoʻopu nopili) life history from a sample of 400 fishes taken from 17 locations on Oʻahu and Maui. He recorded 162,000 eggs from an 89-mm SL female, and hypothesized that maturation might occur in the second year of life. Although he did not witness spawning, he surmised from ovary examination that o'opu nopili between August and March. Fitzsimons et al. (1993) reported that eggs of less than 0.5mm in diameter are laid in single rows forming a narrow mass under boulders. Eggs presumably hatch within 24 hours. Courtship and territorial behavior are well documented in this species by Yuen (1987) and Fitzsimons et al. (1993); however, details of the species' reproductive biology in Hawaiian streams are lacking.

Post-larvae returning to streams from the oceanic larval pool are the largest of the post-larval freshwater gobies in Hawaiʻi (Tate 1997) and were measured at an average length of 23 mm SL (Tomihama 1972, Nishimoto and Kuamo'o 1997). Recruitment into streams occurs mainly during February to May (Tate 1997), and usually occurs in schools. Returning post-larvae undergo dramatic morphological changes due primarily to their changing diet (Tomihama 1972, Schoenfuss et al. 1997). Tate (1997) described two morphological varieties of *S. stimpsoni* post-larvae and juveniles that apparently represented two distinct behavioral types he found in streams on Hawaiʻi and Kauaʻi Islands.

At left is a male ʻoʻopu nopili, Sicyopterus stimpsoni (photo by Mike Yamamoto, DAR); and at right is a ventral view of S. stimpsoni illustrating the sucking disk created by fused pelvic fin that helps enable all freshwater gobiid fishes to navigate torrential streams (photo by John Ford)

Their oceanic larval development is estimated to be between three to six months (Kinzie 1990). Postlarvae returning to streams from the sea undergo a rapid growth phase characterized by a cranial metamorphosis that is correlated with their changing diet and intraspecific behavior (Schoenfuss et al. 1997, Keith 2003). Postlarvae are rheotactic and quickly move upstream (Smith and Smith 1998). This allows them to clear obstacles in intermittent streams. The returning postlarval 'hinana' of this species constituted the bulk of the goby fry fishery in Hawaiʻi (Titcomb 1972, Bell 1999). Titcomb (1972) also indicates that adult ʻoʻopu nopili were also greatly relished as food by prehistoric Hawaiian communities.

ʻOʻopu nopili characteristically inhabit the lower and middle reaches of streams. Adults are generally herbivorous, and their diets change as they mature (Julius et al. 2005). Kido (1996, 1997a, 1997b) reported that their principal food source consisted of a variety of diatoms. Fitzsimons et al. (2003) reported that adult fish tend to 'farm' large feeding rocks through continual feeding over a period of days. Julius et al (2005) reinforced this concept and hypothesized that both farming activity and repeated freshets act to constantly renew patterns of algal succession. Hence, these natural disturbance events are believed to be crucial to maintenance of ecological integrity in Hawaiian streams.

***Lentipes concolor* (Gill 1860) ʻOʻopu alamoʻo, ʻOʻopu hiʻukole**

So striking is the sexual dimorphism in ʻoʻopu alamoʻo (Lau 1973), that it was originally described as two distinct species (*L. concolor* Gill 1860; *L. seminudus* Günther 1880). It characteristically inhabits the middle and upper reaches of streams commonly to an elevation of 1,500 feet, but sometimes as high as 3,000 feet, except in streams with terminal waterfalls where it may be the dominant fish throughout the stream course (Maciolek 1977, Kinzie and Ford 1982). It is believed to be omnivorous, ingesting equal quantities of algae, diatoms, insects, oligochaetes, and atyid shrimp (Lau 1973). Reproductive biology of ʻoʻopu alamoʻo has been studied in Hawaiʻi, Maui, and Molokaʻi Island streams (Maciolek 1977, Kinzie 1993, Way et al. 1998). Maciolek (1977) suggested that female *L. concolor* matured at about 50 mm SL. He found ripe females between August to May and suggested that spawning might occur year round. He observed between 7,000 and 14,000 eggs in two females examined. Kinzie (1993) found 23 nests between October and May, having between 1,300 to 24,700 eggs each. He also observed nine clutches laid by a single o'opu alamo'o in an aquarium during the same months that nests were found in the field. Based on his observations, he suggested that a single female *L. concolor* 73 mm SL in length was capable of producing 55,200 - 69,000 eggs a year. Adult male ʻoʻopu alamoʻo are territorial.

Female ʻoʻopu alamoʻo, Lentipes concolor, (left) in Palikea Stream, East Maui; and male ʻoʻopu alamoʻo (right) in aquarium. Photos by John Ford.

Territories may vary in size depending in part upon stream discharge (Fitzsimons and Nishimoto 1990). Way et al. (1998) compared the reproductive biology of ʻoʻopu alamoʻo in an undiverted small stream on West Maui (Makamakaʻole) with that of a diverted stream on Molokaʻi (Waikolu), and found a wide variability in the timing and degree of reproduction in their two-year study. In the undiverted Makamakaʻole Stream on Maui, ʻoʻopu alamoʻo were reproductively active all year, with reproduction significantly correlated with elevated stream discharge. In the diverted Waikolu Stream on Molokaʻi, ʻoʻopu nopili reproduction appeared to occur on a 'boom or bust' cycle and varied widely in relation to streamflow. Way et al. (1998) concluded that *L. concolor* is capable of adjusting its fecundity in response to environmental changes.

Once hatched, free embryos of ʻoʻopu alamoʻo swim upward in the water column (Kinzie 1993). This behavior facilitates their transport to the ocean. Their oceanic larval life was measured between 63 to 106 days (Radtke et al. 2001), with significant differences between islands and between warm and cool seasons. Size at recruitment into streams ranged between 13.5 mm TL and 17.9 mm TL, with no differences between islands. However, *L. concolor* recruited at smaller sizes during seasons with warmer sea surface temperatures. Post-larvae entered streams in the hours just after sunrise in waves on incoming tides (Nishimoto and Kuamo'o 1997), and immediately begin their migration upstream at a measured rate of 90 meters/hour (Tate 1997). According to Lindstrom and Brown (1994), exposure to seawater within hours of hatching is critical to the survival of larval ʻoʻopu alamoʻo. They reasoned that larvae in streams that lack connection to the marine environment due to dewaterment, geographic, or geological factors could be doomed. They suggested that base flows in such streams are critical to maintain larval transport to the sea. Lower stream flows might also negatively affect habitat space and hatching success.

***Atyoida bisulcata* (Randall 1939) ʻŌpae kalaʻole**

Edmondson (1929) described the endemic ʻōpae kalaʻole or ʻōpae kuahiwi as being ubiquitous in mountain streams among the Hawaiian Islands. He studied aspects of opae physiology; however, he did not realize that the species was amphidromous and therefore could not explain its distribution among Hawaiian island streams. Originally considered one of two morphologically similar species (*Atya bisulcata* and *Ortmannia henshawi*) from Hawaiian streams, the name *Atyoida bisulcata* is now accepted as the correct name. It was a favorite food of aboriginal Hawaiians, and is still favored for luaus and meals for special occasions. In 1976 it could be found infrequently in fish markets selling for $9/lb.

Couret (1976) found the male to female ratio in ʻōpae kalaʻole M/F ratio to be 1.4. He observed molting both day and night at intervals between 31 and 61 days. Following molting it may take up to two days for the exoskeleton to harden sufficiently to permit the shrimp to move naturally. Unpublished records of the Hawaii Cooperative Fishery Research Unit at the University of Hawaii indicate that opae kalaole have been found in a majority of perennial streams throughout the state. It is rheophilic and moves rapidly upstream following recruitment to inhabit the upper reaches of streams between roughly 300 m and 1,100 m elevation as adults.

At left, is a photo of adult ʻōpae kalaʻole, Atyoida bisulcata, taken in an aquarium by Carl Couret.

ʻŌpae kalaʻole is well adapted to torrential flows and is common in shooting waters, such as cascades and waterfalls, as well as in plunge pools. It is capable of both filter feeding from the water column and grazing from the surface of rocks. Its food consists primarily of detritus and filamentous algae (Couret 1976).

ʻŌpae kalaʻole mature between 15.8 mm and 20.5 mm in length (Couret 1976). Mating occurs when females molt, and egg deposition begins 12 hours after mating. Couret (1976) estimated fecundity between 73 and 3,557 eggs from a study of 23 female ʻōpae. Berried female ʻōpae are found throughout the year suggesting a multivoltine reproductive cycle, a trait common in many other tropical species. Given the frequency of molting and an average time of 66 days between molts, annual fecundity of large female ʻōpae kalaʻole may be 16,000 -17,000 larvae per year (Couret 1976). Reproductive effort of ʻōpae kalaʻole from two East Maui streams was found to be slightly elevated in populations from higher elevations (Ford 1979a).

Hatching of larvae occurs within 19 -21 days of oviposition (Couret 1976). Length of larval life is not well documented. Couret (1976) suggested that opae kalaole recruit into stream mouths from the ocean at 6.2mm SL. Based upon his studies of zoeae (i.e. shrimp larvae) growth and survival, this body length would be reached in approximately 40 days. Juveniles were found1.6 km upstream within a period of 230 days in Waiohue Stream by Couret (1976). Life span is estimated to be in excess of three years (Couret 1976). Burky et al. (2003) recorded both drift and migration of ʻōpae kalaʻole throughout the summer with peaks in late April and early July. They believed drift and migration were influenced by lunar phase; a distinct diurnal drift pattern was found for shrimp zoea with a peak near midnight. They noted that lunar and diurnal movement provides increased probability of oceanic development and reduced mortality in both drift and upstream migration.

Couret (1976) noted that diversion structures and dry streambeds in East Maui tended to serve as temporary barriers to migration. However, he also noted that adults could also invade the upper reaches of streams through the irrigation ditches. Couret (1976) concluded that this species' success in inhabiting highly ephemeral Hawaiian streams is due in part to its amphidromous multivoltine reproductive cycle, high capacity for interisland dispersal, anatomical adaptation against desiccation, well-developed climbing ability, and its ability to utilize multiple food sources.

Neritina granosa (Sowerby) Hīhīwai or Wī

Hīhīwai (or wī as it is sometimes known on Hawaiʻi Island) is an amphidromous, rheophilic gastropod found clinging to rocks and boulders exposed to swift currents in the lower reaches of clear, steep gradient streams (Ford 1979b). Two other endemic, amphidromous neritid gastropods, *Neritina vespertina* (hapawai) and *Theodoxus cariosus* (pipiwai) may sometimes be found in estuarine reaches of streams. The endemic hīhīwai was traditionally gathered as food by native Hawaiians, and was at one time collected for commercial sale. Today, it is still collected for food on a recreational level.

The species is uncommon in larger, gentle gradient rivers and is usually confined to the terminal riffles above estuaries in such streams (Maciolek 1978). Although 5,000 hīhīwai were transplanted to Oʻahu from Kauaʻi in 1938, hīhīwai is only occasionally found in small numbers in two or three windward Oʻahu streams. Ford (1979b) found that hīhīwai are limited to reaches with continuous flow in velocities greater than 13 cm/s. He found the greatest densities of adult hīhīwai in the terminal and lower reaches of shallow, well-oxygenated streams, and usually within the central portion of the stream channel.

At left, is a ventral view a large adult hīhīwai, Neritina granosa, illustrating its muscular foot and orange septum (photo by Dr. Richard Valdez). At right is a dorsal view of a large hīhīwai taken in situ (photo by John Ford).

They remain hidden against predation by native Black-crowned night herons and Wandering tattlers during the day, and emerge from under boulders at night to graze on diatoms and microalgae on the surface of silt-free boulders, rocks, and cobbles. Post-larval and juvenile hīhīwai have a strong rheotactic response and orient into currents during their recruitment from the oceanic larval pool. Like the amphidromous ʻoʻopu and ʻōpae, juvenile hīhīwai migrate upstream across all substrata at rates measured at 3.5cm/sec (Ford 1979b).

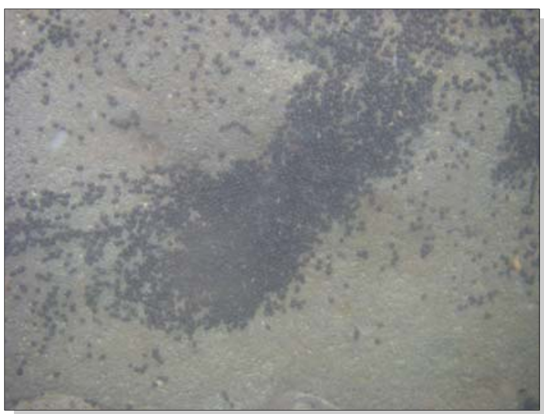
Small individuals may be commonly found on the vertical faces of waterfalls and cascades in the lower reaches of streams they inhabit. Ford (1979b) reported seeing 'chains' of up to 80 juveniles in physical contact with one another migrating upstream. Their upstream migration may be driven in part by a search for suitable diatom and microalgal food sources that are also utilized by other native species. He also followed cohorts of post-larvae (spat) and juveniles as they moved upstream from the mouth of the stream.

Like other amphidromous species, the distribution of hīhīwai is influenced by the geomorphologic profile of individual streams. Hīhīwai densities tended to increase upstream reaching a maximum density in plunge pools at the base of waterfalls. The largest individuals were found in the lower reaches of study streams. Ford (1979b) did not find hīhīwai in waters deeper than 2 meters or in still water pools. Maciolek (1978) stated that hīhīwai occupy streams up to 400 meters in elevation; however, finding hīhīwai at this elevation is uncommon. In East Maui streams, hīhīwai may be expected to reach only 185 meters in elevation due primarily to the reduction of stream flows by irrigation ditches. Brasher (1997a) found similar results for hīhīwai in Waikolu Stream, Moloka'i, which is also affected by a surface diversion. Except perhaps in freshets, hīhīwai are poorly represented in downstream drift (Barnes and Shiozawa 1985).

Studies of hīhīwai reproductive biology are limited. Eggs are fertilized internally and encapsulated, and egg capsules are deposited on rock surfaces as well as on the crenulated shells of hīhīwai themselves (Ford 1979b). Ford (1979b) found a mean number of 248 larvae in egg capsules he examined from two East Maui streams. While fresh eggs capsules were discovered year round, peak production in East Maui occurred between June and August and tapered off by late fall. On Molokai, Brasher (1997) observed peak breeding in the late fall, late spring, and summer. Veliger larvae may hatch within 30 days but apparently have the ability to delay hatching. Based upon cage experiments, Ford (1979b) hypothesized that females may possess annual fecundities between 4,740 and 10,140 larvae. Females do not die after spawning and appear to be iteroparous.

Veliger larvae are carried into the sea when they are between 150 – 175 micrometers (µm) in length and begin development as free-swimming zooplankton (Ford 1979b). Individual hīhīwai held experimentally in freshwater after hatching showed little or no movement until seawater was added (Ford 1979b). Mature protoconch lengths in hīhīwai were measured between 540 µm and 640 µm, and spat (recruits) visible to the naked eye were measured at 2 mm in shell length (Ford 1979b). Both Ford (1979b) and Brasher (1997a) observed significant recruitment events in May and November. Circumstantial data found a one to two month lag between the appearance of fresh egg capsules and recruits in study streams (Ford 1979b); however, this is insufficient evidence upon which the length of larval life (LLL) can be determined.

Kinzie and Ford (1982) examined four polymorphic loci in hīhīwai from East Maui streams and found that none deviated significantly from the Hardy-Weinberg equilibrium model, suggesting that populations from different locations may represent a single gene pool. Hodges (1992) studied population genetics of hīhīwai and determined that a significant portion of recruits in study streams originated as larvae from the same streams (e.g. they returned to the stream of their birth). However, sufficient larvae transport occurs within and among the islands to prevent genetic isolation of populations (Kinzie, personal communication).



Hundreds of juvenile hīhīwai were observed on cobbles and boulders in the terminal reach of Waikolu Stream, Moloka'i, by SWCA biologists Robert Kinzie and John Ford in on September 30, 2008 (photo by John Ford).

WATER USE BY CATTLE OPERATIONS ON MAUI AND WATER USE/NEEDS

Estimated acreage for cattle operations:

Ranch	Acres	Water Source East Maui	Other
Ranch #1	27,000	27,000	
Ranch #3	6,000	6,000	
Ranch #4	20,000	20,000	
Ranch #5	6,000	3,600	2,400
Ranch #6	3,000	3,000	
Ranch #7	18,000		18,000
Ranch #8	3,200		3,800
Ranch #9	13,000	9,100	3,900
Totals	96,200	68,700	28,100

Other livestock needs based on water originating from east Maui west of Makapipi

Ranch	Goats	Horses	Sheep	Elk	Feral goats/ deer/pigs	Total
Ranch #1	400	40	400		5,500	6,340
Ranch #3	150	30	150		1,500	1,830
Ranch #4	80	50	15	100	4,000	4,245
Ranch #5		12			1,000	1,012
Ranch #6		3			1,100	1,103
Ranch #7						0
Ranch #8						0
Ranch #9	1,000	800	200		4,000	6,000
Totals	1,630	935	765	100	17,100	20,530

Cattle counts

Ranch	Cattle	Water Source East Maui	Other
Ranch #1	4,000	4,000	
Ranch #3	2,500	2,500	
Ranch #4	4,000	4,000	
Ranch #5	1,000	600	400
Ranch #6	1,000	1,000	
Ranch #7	2,500		2,500
Ranch #8	2,200		2,200
Ranch #9	2,500	1,750	750
Totals	19,700	13,850	5,850

Resulting water needs, other livestock

Ranch	Goats (3 gpd/hd)	Horses (20 gpd/hd)	Sheep (3 gpd/hd)	Elk (10 gpd/hd)	Feral goats/ deer/pigs (5 gpd/hd)	Total
Ranch #1	1,200	800	1,200	0	27,500	30,700
Ranch #3	450	600	450	0	7,500	9,000
Ranch #4	240	1,000	45	1,000	20,000	22,285
Ranch #5	0	240	0	0	5,000	5,240
Ranch #6	0	60	0	0	5,500	5,560
Ranch #7	0	0	0	0	0	0
Ranch #8	0	0	0	0	0	0
Ranch #9	3,000	16,000	600	0	20,000	39,600
Totals	4,890	18,700	2,295	1,000	85,500	112,385

Water consumption - cattle

Ranch	Cattle	Water Source East Maui	Other
Ranch #1	80,000	80,000	0
Ranch #3	50,000	50,000	0
Ranch #4	80,000	80,000	0
Ranch #5	20,000	12,000	8,000
Ranch #6	20,000	20,000	0
Ranch #7	50,000	0	50,000
Ranch #8	44,000	0	44,000
Ranch #9	50,000	35,000	15,000
Totals	394,000	277,000	117,000

Water consumption - all requirements (cattle, goats, sheep, feral, horses)

Ranch	All Types	Water Source East Maui	Other
Ranch #1	110,700	110,700	0
Ranch #3	59,000	59,000	0
Ranch #4	102,285	102,285	0
Ranch #5	25,240	17,240	8,000
Ranch #6	25,560	25,560	0
Ranch #7	50,000	0	50,000
Ranch #8	44,000	0	44,000
Ranch #9	89,600	74,600	15,000
Totals	506,385	389,385	117,000

Last Updated 11/5/200912:50 PM

13.0 Maui County Farm Bureau, Revised Tables on Cattle Operations and Water Use/Needs

14.0 Maui Department of Water Supply, Memorandum of Understanding Concerning Settlement of Water and Related Issues

MEMORANDUM OF UNDERSTANDING CONCERNING SETTLEMENT OF WATER AND RELATED ISSUES

Pursuant to this Memorandum of Understanding, the Board of Water Supply, County of Maui ("BWS") and Alexander & Baldwin, Inc. ("A&B") hereby agree to cooperate on certain matters being discussed by the parties relating to the following subjects:

1. Wailoa Ditch
2. Iao-Waikapu Ditch
3. H'poko Wells
4. Power
5. Central Maui Source Joint Venture ("JV")
6. East Maui Water Development Plan

The implementation of this Memorandum will be pursuant to one or more agreements to be negotiated and agreed upon as a package. The parties agree as follows:

1. <u>Wailoa Ditch</u>

The 1973 Memorandum of Understanding ("MOU") will be amended (the "Amendment") to accomplish the following:

(a) Increase the BWS's allotment to 12 mgd with option for additional 4 mgd (per original agreement).

(b) During periods of low flow, BWS to have minimum allotment of 8.2 mgd.

(c) During periods of low flow, HC&S will have a minimum flow of 8.2 mgd (9.4 mgd should fire flow be required).

(d) When the ditch flow drops below the combined minimum needs of BWS and HC&S (i.e., 16.4 mgd, or 17.6 mgd with fire flow), then BWS and HC&S each shall be entitled to receive: (a) its respective direct contribution to the ditch flow (i.e., BWS would be entitled to the portion of ditch flow attributable to ground water it pumps into the ditch, and HC&S would be entitled to the portion of the ditch flow attributable to its East Maui lands (30%); and (b) 50% of the amount of ditch flow remaining after deducting the parties' direct contributions from the total.

(e) During periods of low flow, HC&S will not divert water to lower elevation ditch systems.

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(f) When the three-day average flow in the ditch falls below 55 mgd, BWS shall fully utilize all available ground water sources to supplement the Upcountry system and encourage conservation practices by domestic water users.

(g) Extend the term of the MOU for 25 years.

(h) The fee charged to BWS will remain unchanged (six cents per thousand gallons).

(I) BWS to initiate and implement a long-term plan for permanent improvements to the Waikamoi flume system.

(j) A&B to cooperate in the development of a dual system to serve Upcountry diversified agriculture.

(k) BWS will develop and implement a stream flow monitoring program to provide current baseline data.

(l) As long-term agricultural water needs are reduced, a stream restoration program will be studied, developed, and initiated by BWS.

(m) In return for increasing the allocation of ditch water to BWS, A&B may receive an appropriate allocation of domestic water (subject to normal system-wide limitations and conformity with general and community plans), to be mutually agreed upon in the Amendment.

(n) BWS shall utilize its best efforts to maintain storage levels at 80% of maximum capacity of both Piiholo and Kahakapao reservoirs.

(o) BWS shall pursue the implementation of additional raw water storage in the Lower Kula system.

(p) BWS shall cooperate with A&B regarding appropriate permits or leases (short and long-term) for East Maui waters from the State of Hawaii.

(q) BWS to pursue ground water development for Upcountry Maui to mitigate drought effects. For example, BWS shall pursue exploratory wells (i.e., Lower Kula and Pulehu) to supplement the domestic water sources for Upcountry. A&B may participate in such well development in exchange for an appropriate water allocation (subject to normal system-wide limitations and conformity with general and community plans).

(r) BWS to pursue, with HC&S's cooperation, establishing supplemental water sources to maintain the viability of the Kula Ag Park.

2. Iao Waikapu Ditch

Subject to Wailuku Agribusiness's agreement, a new Agreement Concerning Temporary Withdrawal from the Iao Waikapu Ditch will be entered into and include the following terms:

(a) BWS shall be entitled to withdraw up to 300,000 gallons per day from the Iao Waikapu Ditch, except when the flow in the Iao Stream falls below 11.5 mgd.

(b) BWS shall pay a monthly charge of $2,000 for this allocation.

(c) BWS shall be entitled to take additional water (for a total withdrawal of up to 2 million gallons per day) whenever the flow in Iao Stream exceeds 55 mgd. For this additional water, BWS shall pay $0.12 per thousand gallons (not including water used for back-washing filters).

(d) The term of the agreement shall be two years and may be extended upon mutual agreement of the parties.

3. H'poko Wells

BWS and HC&S to pursue the following:

(a) BWS to expedite completion of necessary engineering reports and will pursue approvals to utilize the wells for domestic purposes.

(b) A&B will convey all necessary land and easements to BWS.

(c) Subject to the completion and acceptance of the East Maui Development Plan EIS, A&B will consider participating in the construction of the transmission line from the well site to the BWS's Paia system in exchange for an appropriate allocation of water for its participation.

(d) In consideration of providing such necessary land and easements, A&B may receive an appropriate allocation of domestic water (subject to normal system-wide limitations and conformity with general and community plans) to be mutually agreed to.

4. Power

BWS and HC&S intend to pursue the following:

(a) HC&S will provide appropriate information on its transmission and distribution system to BWS or its consultants.

(b) HC&S shall provide available power to BWS at mutually agreed upon locations, at a price not to exceed that paid by Maui Electric. BWS understands that the power being provided is not "firm", and that it shall be responsible for any necessary stand-by generators.

(c) BWS shall, with HC&S's cooperation, explore the long-term feasibility of developing hydroelectric and other alternative energy sources.

5. Central Maui Source Joint Venture

(a) BWS acknowledges that there is an unmet obligation to the Central Maui Source Joint Venture arising out of the JV's prior development of three wells having an installed pumping capacity of 13.4 mgd.

(b) Subject to the approval of the other parties to the JV, BWS and the JV shall enter into a mutually acceptable settlement agreement resolving all outstanding issues regarding the Central Maui Source Joint Venture.

(c) Any entitlement arising out of this resolution shall be for properties the JV members own or subsequently acquire for development within the area served by the Central Maui system; rights may be transferred to a subsequent purchaser or developer, but may not otherwise be transferred.

(d) Within 30 days of the Memorandum, the Chairman of BWS (and/or his designees) shall enter into negotiations with representatives of the JV on a settlement agreement to establish:

(1) Existing usage by members of the JV;

(2) Future usage standards to be applied;

(3) The remaining entitlement of the JV;

(4) The terms and conditions of providing and utilizing the entitlement.

6. East Maui Water Development Plan

BWS and HC&S intend to pursue the following:

(a) BWS to proceed expeditiously with the supplemental EIS for the project as originally planned.

(b) BWS will assure that stream flow monitoring is an integral part of the scope of work.

(c) A&B may participate in the project in exchange for an appropriate water allocation (subject to normal system-wide limitations and conformity with general and community plans).

IN WITNESS WHEREOF, the parties hereto have caused their duly authorized representatives to execute this Memorandum of Understanding as of this 13th day of ~~March~~ April, 2000.

ALEXANDER & BALDWIN, INC.

Its Vice President

Its Vice President

APPROVED AS TO FORM AND LEGALITY:

Deputy Corporation Counsel

Date: April 13, 2000

MAUI COUNTY BOARD OF WATER SUPPLY

Elmer F. Cravalho, Chairperson

Orlando A. Tagorda, Vice Chairperson

Clark S. Hashimoto, Board Member

Adolph M. Helm, Board Member

Michael A. Nobriga, Board Member

Robert K. Takitani, Board Member and Past Chairperson

Howard Nakamura, Board Member

Peter Rice, Board Member

Jonathan A. Starr, Board Member

15.0 Maui Department of Water Supply, Second Amendment to Memorandum of Understanding Concerning Nahiku

SECOND AMENDMENT TO
MEMORANDUM OF UNDERSTANDING

THIS AMENDMENT, made and entered into this 25th day of April, 1994, by and amongst EAST MAUI IRRIGATION COMPANY, LIMITED, a Hawaii corporation, whose mailing address is P. O. Box 266, Puunene, Hawaii 96784, referred to as "EMI", A & B HAWAII, INC., through its division, HAWAIIAN COMMERCIAL AND SUGAR COMPANY, a Hawaii corporation, whose mailing address is P. O. Box 266, Puunene, Hawaii 96784, referred to as "HC & S", and the BOARD OF WATER SUPPLY of the County of Maui, whose principal place of business and mailing address is 200 S. High Street, Wailuku, Hawaii 96793, referred to as "BWS",

W I T N E S S E T H:

WHEREAS, on December 31, 1973, EMI, HC&S and BWS entered into that certain Memorandum of Understanding, referred to as the "Memorandum", relating, in part, to the collection and delivery of water by EMI to, the maintenance of certain water collection facilities of, and the furnishing of water to BWS; and

WHEREAS, on May 1, 1992, EMI, HC&S and BWS entered into that certain Amendment to Memorandum of Understanding relating to the extension of the Memorandum from December 31, 1993 until December 31, 1995; and

WHEREAS, the Memorandum permits BWS to withdraw up to 6,000 gallons of water per twenty-four hour day to serve the Nahiku community; and

WHEREAS, the maximum daily usage of the Nahiku community is

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currently 12,600 gallons per day; and

WHEREAS, BWS desires to increase the withdrawal rate for the Nahiku community; now, therefore,

IN CONSIDERATION of the mutual promises and agreements hereinafter set forth, the parties hereto agree as follows:

1. Item 1 of the Memorandum is deleted in its entirety and substituted with the following:

"1. Nahiku. EMI will continue to collect and deliver to BWS at the rates provided herein up to 20,000 gallons of water per twenty-four hour day to serve the Nahiku community. The delivery point shall be the same point as presently used by EMI and BWS."

2. Save and except as amended herein, the Memorandum, as amended on May 1, 1992, remains in force and effect.

IN WITNESS WHEREOF, the parties hereto have caused this instrument to be duly executed on the date first above written.

EMI:

EAST MAUI IRRIGATION COMPANY, LIMITED

Richard F. Cameron
(Please type or print name above)
Its Executive Vice President

Beverly J. Green
(Please type or print name above)
Its Secretary

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A & B HAWAII, INC.
through its division
HAWAIIAN COMMERCIAL AND SUGAR COMPANY

Richard F. Cameron
(Please type or print name above)
Its Senior Vice President

Beverly J. Green
(Please type or print name above)
Its Secretary

BWS:

BOARD OF WATER SUPPLY
COUNTY OF MAUI

~~Larry Jefts~~ Byron Watters
Its Chairperson

APPROVED AS TO FORM AND LEGALITY:

John S. Rapacz
Deputy Corporation Counsel
County of Maui

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STATE OF HAWAII) SS.
CITY & COUNTY OF HONOLULU)

On this 25th day of April, 1994, before me appeared Richard F. Cameron and Beverly J. Green, to me personally known, who, being by me duly sworn, did say that they are the Executive Vice President and Secretary, respectively, of EAST MAUI IRRIGATION COMPANY, LIMITED, a Hawaii corporation; that the seal affixed to the foregoing instrument is the corporate seal of said corporation; and that said instrument was signed and sealed on behalf of said corporation by authority of its Board of Directors, and the said officers acknowledged said instrument to be the free act and deed of said corporation.

IN WITNESS WHEREOF, I have hereunto set my hand and official seal.

L.S.

Notary Public, State of Hawaii

My commission expires: 7/15/94

STATE OF HAWAII) SS.
CITY & COUNTY OF HONOLULU)

On this 25th day of April, 1994, before me appeared Richard F. Cameron and Beverly J. Green, to me personally known, who, being by me duly sworn, did say that they are the Senior Vice President and Secretary, respectively, of A&B-HAWAII, INC., through its division HAWAIIAN COMMERCIAL & SUGAR COMPANY, a Hawaii corporation; that the seal affixed to the foregoing instrument is the corporate seal of said corporation; and that said instrument was signed and sealed on behalf of said corporation by authority of its Board of Directors, and the said officers acknowledged said instrument to be the free act and deed of said corporation.

IN WITNESS WHEREOF, I have hereunto set my hand and official seal.

L.S.

Notary Public, State of Hawaii

My commission expires: 7/15/94

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STATE OF HAWAII) SS.
COUNTY OF MAUI)

On this 26th day of April, 1994, before me appeared Byron Walters, to me personally known, who, being by me duly sworn, did say that he is the Chairperson of the BOARD OF WATER SUPPLY of the County of Maui, and that the seal affixed to the foregoing instrument is the lawful seal of the said BOARD OF WATER SUPPLY, and that the said instrument was signed and sealed on behalf of the said BOARD OF WATER SUPPLY, and the said Byron Walters acknowledged the said instrument to be the free act and deed of said BOARD OF WATER SUPPLY.

IN WITNESS WHEREOF, I have hereunto set my hand and official seal.

Notary Public, State of Hawaii

My commission expires: 4/19/98

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EAST MAUI IRRIGATION P.01

16.0 Hawaiian Commercial & Sugar, Co., Updated Economic Impact Information, Additional Information on EMI System, Information on Trasnportation Agreement with MLP, and IAL Designation

MAUI HC&S HAWAIIAN COMMERCIAL & SUGAR COMPANY

September 24, 2009

Mr. Ken Kawahara, Deputy Director
Commission on Water Resource Management
P. O. Box 621
Honolulu, Hawaii 96809

Dear Mr. Kawahara:

By letter dated June 2, 2009, HC&S provided you with information for inclusion in the Instream Flow Standard Assessment Reports ("IFSAR") that we understand your staff is in the process of preparing for several East Maui streams. Although we have not received any response on our prior submission nor a request for further information, we understand that you remain open to receiving input and we have since gathered additional and updated information which we believe is relevant and hope you will find useful and appropriate for inclusion in the IFSARs.

As in our previous transmittal, we offer the following information for inclusion in **Section 13.0 Noninstream Uses,** on the assumption that you will be structuring these additional East Maui stream reports in the same fashion as the first five IFSARs. The offered information would be relevant for all of the subject IFSAR's. (For convenience, we include some page number references, which refer to the Honopou IFSAR.).

(1) **Updated Economic Impact Information:** We would like to update and augment the text we had provided previously entitled "Economic Impact of Restricting HC&S's Uses of Water." The complete narrative is provided below and should replace the version we submitted on June 2, 2009.

Economic Impact of Restricting HC&S's Uses of Water

The availability of surface water for diversion is essential to HC&S' ability to grow sugarcane at yields that will enable it to remain financially viable. The last two years of drought conditions have demonstrated how severe irrigation deficits diminish yields and lead to sizable financial losses. A&B's 2006 Annual Report states that A&B's four agribusiness related companies (one of which is HC&S) generated an operating profit in 2006 of $6.9 million against revenues of $127.4 million (5.4%). HC&S itself has a very slim profit margin. In 2006, HC&S earned operating profit of approximately $2.6 million. Since then, however, HC&S suffered substantial losses due in large measure to the impacts of the severe drought conditions of 2007 and

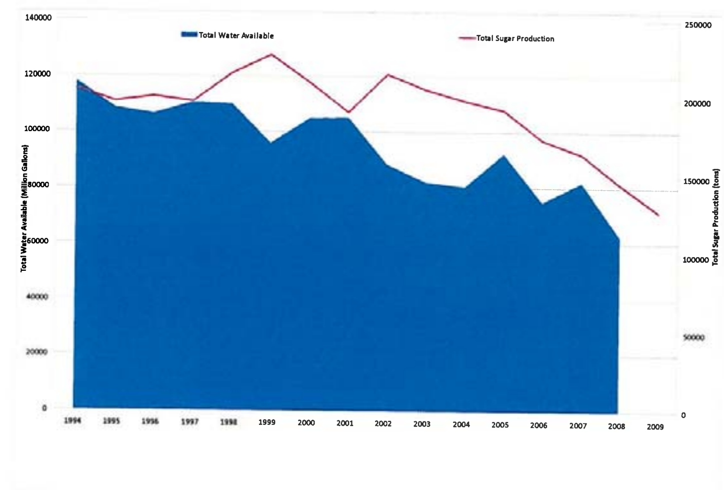
2008. In 2008, A&B's agribusiness operations reported a $13 million loss, caused entirely by losses at HC&S. See Alexander & Baldwin Inc. Form 10-K filed 2/27/09.[1] The full negative impact of two years of drought is being felt in 2009. For the first six months of 2009, A&B's agribusiness operations disclosed a loss of $13.2 million, caused, again, entirely by losses at HC&S, with losses for the last six months of the year expected to be even greater.

Because of the magnitude of these losses, HC&S is at a critical juncture, and a decision on whether HC&S will continue in business is currently scheduled to be made by year-end 2009. Critical to that decision is HC&S's ability to significantly reduce its losses and stabilize its financial performance, which it can do only by restoring yields (as explained below). Each one of HC&S' revenue streams (raw sugar, specialty sugar and energy) is tied to the amount of sugar produced on the farm.

Importance of Water to Yields: Studies show that there is a 95% correlation between crop yield, i.e., tons sugar per acre produced (TSA), and applied water. Underirrigated cane produces less sugar and renders it more susceptible to diseases, which also reduces sugar yield. Severe droughts cause delays in planting new crops, reducing the age on the cane and ultimately sugar production. As an example, HC&S' crops that were cultivated in 2001-2002, which were considered average years in terms of water availability (193,000 million gallons of water available during the two-year period), had average TSA of 13.14 in harvest year 2003. In contrast, for cane cultivated in 2007-2008, during two years of record drought (127,500 million gallons of water available for the two-year period), the TSA for the 2009 crop (of which 78% of the crop has already been harvested) is currently projected to be 8.59. In simple terms, 145.6 million pounds less sugar will be produced this year due to the lower amount of available water.

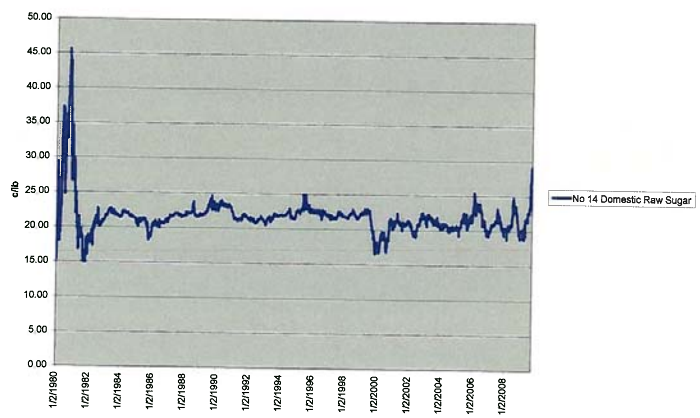
The following graph depicts the correlation between available water and actual sugar yields from 1994 to the present.

[1] The Form 10-K can be accessed at http://ccbn.tenkwizard.com/xml/download.php?format=PDF&ipage=6171597.



Although there are a number of interrelated factors that determine the viability of any business, for HC&S (as for most agricultural endeavors), water is a critical factor. Water translates directly into increased sugar yields, and thus increased revenues for HC&S. Given that sugar is a high fixed-cost business, maintaining economies of scale and high sugar production is key to HC&S' continued viability (see Laney Report). Sugar prices cannot be relied upon to improve HC&S performance on a sustained basis. As the chart below shows, although there are short term spikes and dips, over the long-term sugar prices have remained relatively flat. Thus, while the current upward spike in sugar price will dampen the losses this year, and perhaps next year somewhat, history has shown that these sugar spikes occur occasionally (the last was in 1981) but are never sustained.

No 14 1980-2009



Nor can HC&S look to further cost-cutting to reduce its losses—over the past few years HC&S has aggressively tried to improve efficiencies and cut operational costs as much as practicable and has even cut into personnel costs. With the cooperation of the union, HC&S has frozen salaries, reduced some employee benefits, and all employees are now on mandatory furloughs of 10 days per year, thus effectively taking pay cuts.

Thus, to sustain viability at HC&S, it is essential that it regain/maintain high TSA. The diminishing availability and/or increasing cost of water exponentially affects the company's viability, i.e., the impacts of reducing water availability by 5 mgd, 10 mgd, or 15 mgd is not a linear progression. It is not possible to simply linearly scale back the size of the plantation in response to lesser water availability—and still remain viable. Viability for HC&S comes down to maintaining high yields, which is highly dependant on the sufficient availability of affordable water.

Economic Impacts: If, as a result of insufficient water at reasonable cost, HC&S is no longer viable as an on-going business, the economic consequences to Maui, and to the state will be severe. HC&S employs 800 people and spends approximately $100 million annually in the

local economy, primarily on Maui.[2] This figure includes $47 million annually in wages and benefits to employees and retirees. Indirectly, however, the 'trickle-down effect' will result in a significant number of additional jobs and economic activity also being negatively impacted. Maui's landscape will be significantly changed, with Central Maui returning to the dry natural conditions which existed prior to the cultivation of sugar cane.

Also compromised would be the state's renewable energy production. In addition to producing sugar, the HC&S Puunene Sugar Mill provides a renewable energy alternative in the form of sugar cane bagasse, a fibrous byproduct of the sugar extraction process. Bagasse is the primary fuel used in boilers to generate steam, a requirement for sugar processing and for driving steam turbine generators to produce electricity. HC&S also produces hydroelectric power. The electricity that is not used internally is sold to MECO for distribution to the community, which currently amounts to approximately seven percent of MECO's power sales coming from renewable sources. The approximate oil savings to MECO amount to approximately 140,000 barrels per year. HC&S is under contract with MECO to supply power each and every day, at specified rates, 12 megawatts of power from 7:00 a.m. to 9:00 p.m. daily except Sunday and 8 megawatts at all other times. The contract provides for monetary penalties if these requirements are not met by HC&S. The loss of hydroelectric and biomass fueled electric generation would significantly set-back the achievement of the goals of the Hawaii Clean Energy Initiative.

(2) **Additional Information on EMI System:** Below is additional information about the EMI system that would be relevant to add to the discussion found on page 125 of the Honopou IFSAR.

The EMI system includes 74 miles of ditch and tunnel spanning from Nahiku to Maliko Gulch, of which nearly two-thirds is concrete and rock lined. The EMI ditches deliver water either directly to the HC&S fields for irrigation or to 35 reservoirs located throughout the plantation. Most of the reservoirs are relatively small earthen-works, ranging in size from 4 to 80 MG, most of them unlined. The reservoirs are primarily holding ponds where water is collected and distributed for irrigation or other uses on a daily basis. Only when ditch flows are high does HC&S have the ability to store additional water in these reservoirs. The combined storage capacity of these reservoirs, at full capacity—which would only occur during times of high rainfall - is 862 MG which is only a five to ten

[2] HC&S has explored, and continues to explore, agricultural options other than sugar cane, but has not yet found a more viable model. Regardless, any alternative crop will require an assured source of water. HC&S's goal is to be able to keep the sugar plantation viable and its workers employed at least until a more viable agricultural alternative is discovered.

day supply of water for the fields that are serviced by these reservoirs (about 12,800 acres). Greater storage capability was contemplated in the 1960s, but not pursued after a study indicated that a billion-gallon reservoir would provide only a 10-day supply of water for the plantation. Although the cost of any reservoir would depend on a number of factors such as terrain, acquisition of land, permitting, etc., it is estimated that a billion-gallon reservoir, if built today on Maui, would cost well in excess of $150 million.

(3) **Information on Transportation Agreement with MLP:** We note that pages 134-135 of the Honopou IFSAR includes a discussion of Maui Land and Pineapple Company, Inc.'s (MLP) use of water delivered through the EMI ditches. The following provides additional information about the source of this water and EMI's relationship with MLP.

EMI and MLP have a water transportation agreement under which MLP pumps groundwater from its Kuhiwa well and diverts water from Hanawi Stream, piping this water to the EMI ditch system for transportation to MLP's fields in central Maui. Under the agreement, MLP puts into the ditch system only the amount that it intends to use (MLP is allowed to "bank" a very small amount of water for use when its inputs cannot meet its needs) and use is limited to agricultural purposes only. As an accommodation to a fellow agricultural company, the agreement allows MLP to exercise an option to use additional water ("option water") from the EMI system (i.e., more water than MLP puts into the ditch system) when rainfall is plentiful and ditch flows exceed 100 million gallons per day. Over the years MLP has consistently withdrawn more water from the EMI system than it puts in. In relation to total ditch flows, MLP's inputs and withdrawals constitute a very small amount, less than a quarter of one percent.

(4) **IAL Designation:** Our June 2 submission included information for inclusion in Section 13.0 Non-instream Uses in the form of a narrative entitled: "HC&S Water Usage". The HC&S Water Usage section included information about the size of the plantation, the number of acres under cultivation, and the number of acres irrigated with EMI water. Since our submittal, a significant number of HC&S acres have been designated "Important Agricultural Lands" by the State Land Use Commission as a result of a voluntary petition by landowner, Alexander & Baldwin, Inc. Please add to that text the fact that of the 29,000 acres irrigated with EMI water, 22,254 acres have been recently designated as Important Agricultural Lands (IAL) pursuant to HRS Chapter 205, Part III. This IAL designation is a commitment to keep these lands in productive agriculture over the long term.

Conclusion

We appreciate the opportunity to provide you with this additional and updated information and hope that you find it useful. Please feel free to contact us if you have any questions, comments, or if there is other information you would like us to provide.

Sincerely,

Christopher J. Benjamin
Plantation General Manager