Technical Memorandum

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Prepared for: County of Maui, Department of Water Supply, Water Resources & Planning Division

Project Title: Feasibility Study for East Maui Source Development

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Subject: Phase 3: Cost-Benefit Study for Central, Upcountry, and East Maui

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List of Abbreviations

A&B	Alexander & Baldwin
AACE	Association for the Advancement of Cost Engineering International
ADD	average day demand
ASR	aquifer storage and recovery
BC	Brown and Caldwell
BCE	business case evaluation
BLNR	Board of Land and Natural Resources
BWS	Honolulu Board of Water Supply
CBA	cost-benefit alternative
County	County of Maui
CWRM	Commission on Water Resource Management
D&O	Decision and Order
DBCP	1,2-Dibromo-3-chloroporopane
DHHL	Department of Hawaiian Homelands
D&O	Decision and Order
DLNR	Department of Land and Natural Resources
DOFAW	Division of Forestry and Wildlife
DOH	State of Hawai'i Department of Health
DOT	Department of Transportation
DWS	Department of Water Supply
EAP	Emergency Action Plan
EDB	Ethylene dibromide
EMFS	East Maui Feasibility Study
EMI	East Maui Irrigation
EPA	Environmental Protection Agency
GAC	granulated activated carbon
GDE	groundwater dependent ecosystem
gpd	gallons per day
gpm	gallons per minute
GWMA	Groundwater Management Area
HAR	Hawaii Administrative Rules
HC&S	Hawaiian Commercial & Sugar Company
HEER	Hazard Evaluation and Emergency Response
HFRA	Healthy Forests Restoration Act
HRS	Hawaii Revised Statutes
IFS	Instream Flow Standards
IFSAR	Instream Flow Standard Assessment Report
IIFS	Interim Instream Flow Standards
LUST	leaking underground storage tank
MCDA	multiple criteria decision analysis
MCL	maximum contaminant level
MDWS	Maui County Department of Water Supply
mg/L	milligrams per liter
mgal	million gallons
mgd	million gallons per day
MMD	maximum month demand
MSL	mean sea level
NPV	net present value
O&M	operations and maintenance
OSDS	onsite sewage disposal system
PEP	Plasch Econ Pacific
PFAS	per- and polyfluoroalkyl substances
ppm	parts per million
PV	present value
$Q_{50/70/90}$	median/moderate/low flow
R&R	rehabilitation and replacement
SCAP	Stream Channel Alteration Permit
SDWB	Safe Drinking Water Branch
SDWP	Stream Diversion Works Permit
SPAM	Stream Protection and Management
SWMA	Surface Water Management Area
SWPP	State Water Projects Plan
SWUP	surface water use permit
SY	sustainable yield
T&C	traditional and customary
TCP	1,2,3-Trichloropropane
TM	technical memorandum
USBR	United States Bureau of Reclamation
USGS	United States Geological Survey
WRPP	Water Resources Protection Plan
WTF	Water Treatment Facility
WUDP	Maui Island Water Use & Development Plan
WUP	water use permit

Executive Summary

The Maui County Department of Water Supply (MDWS) is evaluating potential water sources to meet projected public water system demands of 12 million gallons per day (mgd) annual average and 18 mgd peak month for Central and Upcountry water systems. Brown and Caldwell (BC) conducted a cost-benefit analysis of groundwater and surface water sources in the Central Maui, Upcountry, and East Maui regions. This technical memorandum (TM) summarizes Phase 3 of the East Maui Feasibility Study (EMFS). Report sections are as follows:

- **Section 1: Potential Water Sources.** A review of potential groundwater and surface water sources, environmental and hydrological constraints, and legal and permitting considerations.
- **Section 2: Non-Economic Analysis.** A multiple criteria decision analysis (MCDA) used to evaluate a broad list of potential water sources and identify the top 15 options with highest relative benefits for further analysis.
- **Section 3: Supply and Development Strategies.** Conceptual strategies with general locations and associated infrastructure needs for potential well fields, surface water diversions, access roads, raw water transmission, storage, and treatment.
- **Section 4: Engineering Economic Analyses.** Life cycle cost estimates for each potential supply and development strategy based on capital, operations and maintenance (O&M) costs. Combination of individual strategies into cost-benefit alternatives (CBAs) that could meet projected demand and identification of the top nine CBAs based on life-cycle costs and non-economic benefits.
- **Section 5: Cost Benefit Analysis.** Economic cost-benefit analysis of potential water source CBAs relative to the baseline alternative and a no-action alternative.
- **Section 6: Ka Paʻakai Analysis.** Identification of traditional and customary practices related to water source options in the study area, potential impacts of water source development strategies, and recommendations for continued application of the Ka Paʻakai analysis.
- **Section 7: Conclusions and Recommendations.** Summary of findings from the cost-benefit analysis of surface and groundwater resources in the Central, Upcountry, and East Maui regions.

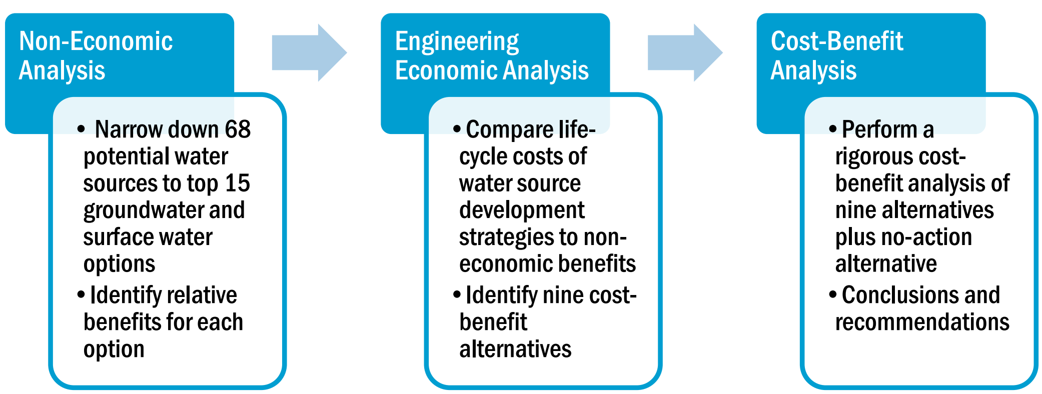

Figure 1. Cost-Benefit Study Process Overview

The following is a brief overview of each report section.

Potential Water Sources

Potential groundwater and surface water sources from Central, Upcountry, and East Maui were identified within the study area. Groundwater resources within the Koʻolau, Central, and Wailuku aquifer sectors were evaluated for remaining sustainable yield (SY) based on current pumpage and Department of Hawaiian Homelands (DHHL) reservations. Surface water resources including stream and ditch flows were evaluated according to available flow data, Interim Instream Flow Standards (IIFS), and usage data. Information about current and long-term resource availability is summarized.

Figure 2 shows aquifers within the EMFS Phase 3 study area boundary.

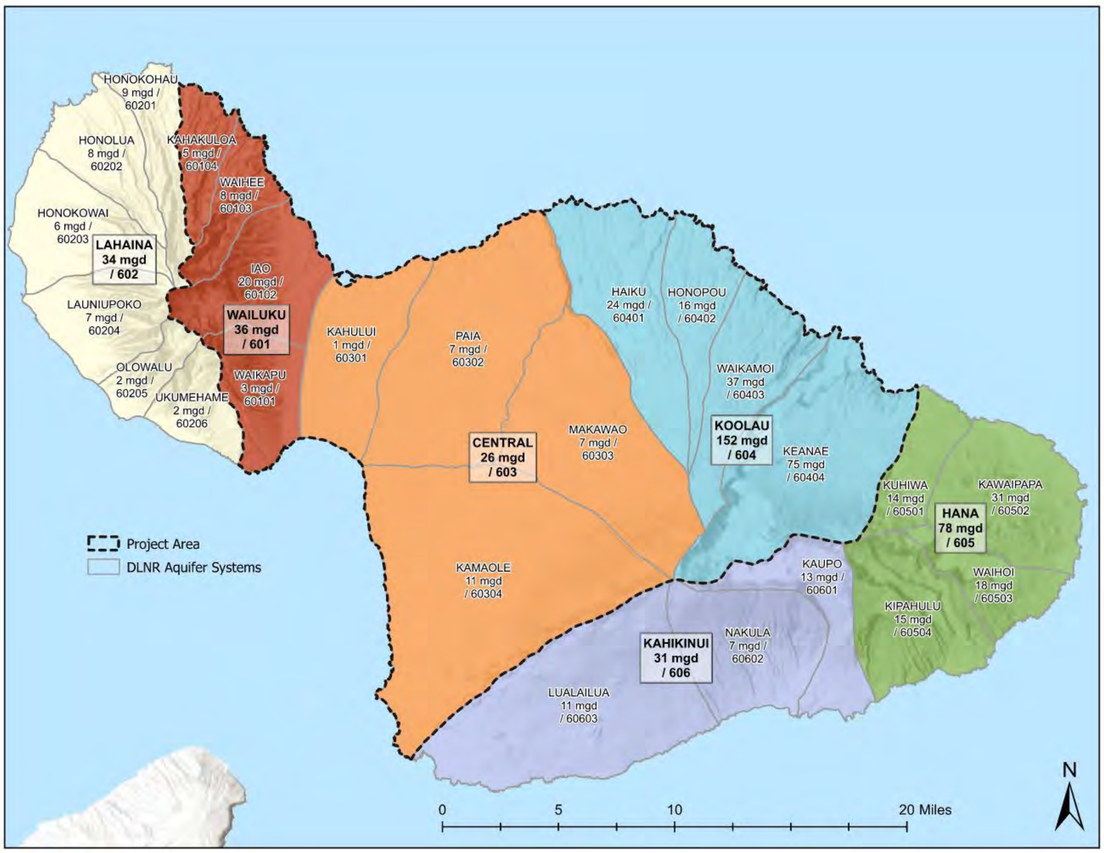

Figure 2. Map of Aquifers within EMFS Phase 3 Study Area Boundary

Long-term availability of groundwater is affected by land cover, rainfall, runoff, evapotranspiration, climate change, recharge, and extraction rates. This report discusses the projected effects of climate change on groundwater availability and impacts to source resilience.

Leeward and Central Maui are projected to get drier, while much of East Maui is projected to get wetter. By mid-century, groundwater recharge for Maui overall is estimated to decrease by nearly 10 percent. Decreases in aquifer system recharge are estimated for all but three of Maui's aquifer systems. The greatest decreases in aquifer-system recharge are estimated for the Kamaʻole and

Makawao aquifer systems. Changes in groundwater recharge could affect water availability, groundwater levels, and salinity, impacting drinking water and ecosystems (Kāne et al 2023).

Groundwater is a relatively reliable source of water, since it is less vulnerable to short-term fluctuations in rainfall than surface water. The MDWS's ability to utilize surface water is constrained by lack of raw water storage capacity. Any new water source development may be subject to lengthy and uncertain permitting timeframes.

Non-Economic Analysis of Potential Water Sources

Groundwater and surface water sources were evaluated using a non-economic MCDA, to narrow a list of 68 potential sources down to the top 15 sources for supply and development strategies and economic analysis. Water source considerations include water availability, sustainability, proximity to demand, and potential impacts to ecosystems and traditional and customary (T&C) uses. Regulatory considerations include designated water management areas, permitting complexity and IIFS. Criteria used in the non-economic analysis are shown in Figure 3.

Category	Groundwater Criteria	Surface Water Criteria
Water Source	Quantity Groundwater sustainability Saltwater intrusion risk Groundwater quality	Quantity Surface water reliability Surface water quality
Diversity and Supply-Demand Area	Source Location and Type Diversity Supply-Demand Area	Source Location and Type Diversity Supply-Demand Area
Environmental	Groundwater Dependent Ecosystems (GDEs) Climate impacts Drought resilience Wildfire risk	Surface Water Ecosystems Climate impacts Drought resilience Wildfire risk
Permitting	Groundwater permitting complexity Transmission permitting complexity	Surafce water permitting complexity Transmission permitting complexity
Infrastructure	Well elevation Topography Proximity to water system Treatment complexity	Raw surface water storage availability Proximity to water system Treatment complexity
Energy	Energy grid accessibility Energy grid capacity Energy grid risk	Energy grid accessibility Energy grid risk

Figure 3. Non-Economic Evaluation Criteria

A total of 46 groundwater sources within the study area were identified as alternatives. Each aquifer within the study area was divided into applicable elevation ranges: (1) below 500 feet, (2) 501 – 1,500 feet, and (3) 1,501 – 4,000 feet. Initial alternatives for each aquifer elevation range included existing wells, legacy wells, or potential new well sites.

A total of 22 surface water source options were identified as alternatives, grouped by: (1) available base flow in the stream or ditch, (2) reallocate permitted uses, (3) improve ditches, (4) high stream or ditch flows, and (5) stormwater. Potential surface water sources in the Waikapū, ʻĪao, and Waiheʻe hydrologic units analyzed in EMFS Phase 2 were carried forward into Phase 3 for evaluation with other potential water sources in Central, East, and Upcountry Maui.

Criteria definitions and criteria weighting were used to determine an initial ranking of potential water sources based on non-economic benefit scores. Table 1 shows the top 15 potential source options carried forward into the engineering economic analysis.

Table 1. Water Source Options for Further Analysis

ID	Groundwater Elevation Range/ Stream Locations	Comments
A	Haʻikū aquifer groundwater at elevation <500 feet	• Relatively large amount of groundwater potentially available in the aquifer. • Potential contamination sources (historic pineapple cultivation, onsite sewage disposal systems) in some areas. • Potential to impact GDEs (coastal wetlands and estuaries). • Area may have slightly less groundwater recharge in a future climate scenario. • Infrastructure requirements may include construction of an access road from the nearest public road to the well site, well drilling, storage tank, transmission infrastructure, and treatment as required.
	Haʻikū aquifer groundwater at elevation 501-1,500 feet	
	Haʻikū aquifer groundwater at elevation 1,501-4,000 feet	
B	Makawao aquifer groundwater at elevation 501-1,500 feet	• Medium amount of groundwater potentially available in the aquifer. • Few potential contamination sources (historic pineapple cultivation, onsite sewage disposal systems). • Minimal impact to GDEs. • Area may have less groundwater recharge in a future climate scenario. • Infrastructure requirements may include construction of an access road from the nearest public road to the well site, well drilling, storage tank, transmission infrastructure, and treatment as required.
	Makawao aquifer groundwater at elevation 1,501-4,000 feet	
C	Kamaʻole aquifer groundwater at elevation <500 feet	• Medium amount of groundwater potentially available in the aquifer. • Potential contamination sources in some areas (historic pineapple cultivation, onsite sewage disposal systems) and risk of saltwater intrusion at low elevations. • Potential impacts to GDEs. • Area may have less groundwater recharge in a future climate scenario. • Infrastructure requirements may include construction of an access road from the nearest public road to the well site, well drilling, storage tank, transmission infrastructure, and treatment as required.
	Kamaʻole aquifer groundwater at elevation 1,501-4,000 feet	
D	Waikamoi aquifer groundwater at elevation <500 feet	• Relatively high amount of groundwater potentially available in the aquifer. • Few potential contamination sources. • Potential impacts to GDEs. • Area may have more groundwater recharge in a future climate scenario. • Infrastructure requirements may include construction of an access road from the nearest public road to the well site, well drilling, storage tank, transmission infrastructure, and treatment as required.
	Waikamoi aquifer groundwater at elevation 501-1,500 feet	

Table 1. Water Source Options for Further Analysis

ID	Groundwater Elevation Range/ Stream Locations	Comments
E	Pāʻia aquifer groundwater at elevation <500 feet	• Medium amount of groundwater potentially available in the aquifer. • Multiple potential contamination sources (historic pineapple cultivation, onsite sewage disposal systems). • Potential impacts to GDEs. • Area may have less groundwater recharge in a future climate scenario. • Infrastructure requirements may include construction of an access road from the nearest public road to the well site, well drilling, storage tank, transmission infrastructure, and treatment as required.
F	Waikapū aquifer groundwater at elevation <500 feet	• Relatively small amount of groundwater potentially available in the aquifer. • Potential contamination sources in some areas (historic pineapple cultivation, onsite sewage disposal systems) and risk of saltwater intrusion. • Minimal impact to GDEs. • Area may have less groundwater recharge in a future climate scenario. • Infrastructure requirements may include construction of an access road from the nearest public road to the well site, well drilling, storage tank, transmission infrastructure, and treatment as required.
G	Keʻanae aquifer groundwater at elevation <500 feet	• Relatively large amount of groundwater potentially available in the aquifer. • Few potential contamination sources. • Potential impacts to GDEs. • Area may have more groundwater recharge in a future climate scenario. • Infrastructure requirements may include construction of an access road from the nearest public road to the well site, well drilling, storage tank, transmission infrastructure, and treatment as required.
H	Honopou aquifer groundwater at elevation 501-1,500 feet	• Medium amount of groundwater potentially available in the aquifer. • Few potential contamination sources. • Potential impacts to GDEs. • Area may have more groundwater recharge in a future climate scenario. • Infrastructure requirements may include construction of an access road from the nearest public road to the well site, well drilling, storage tank, transmission infrastructure, and treatment as required.
I	Waiheʻe aquifer groundwater at elevation 501-1,500 feet	• Relatively low amount of groundwater potentially available in the aquifer. • Few potential contamination sources. • Potential impacts to GDEs. • Area may have less groundwater recharge from rain in the future. • Close to roads and existing water system. • Infrastructure requirements may include construction of an access road from the nearest public road to the well site, well drilling, storage tank, transmission infrastructure, and treatment as required.

J	Wailoa Ditch reallocate agricultural water (permitted off-stream reasonable and beneficial uses)	• Relatively large amount of surface water potentially available.
		• Moderate reliability of surface water throughout the year.
		• Infrastructure requirements may include:
		  – No new stream diversions. Utilize existing stream diversions and ditch to convey raw water.
		  – Construct new reservoirs near Kamole Water Treatment Facility (WTF).
		  – Construct a new water treatment facility or expand Kamole WTF.

Table 1. Water Source Options for Further Analysis		
ID	Groundwater Elevation Range/ Stream Locations	Comments
K	Wailuku area reallocate agricultural water (permitted off-stream reasonable and beneficial uses)	• Medium amount of surface water potentially available. • Moderate reliability of surface water throughout the year. • Infrastructure requirements may include: – Utilize existing reservoirs and raw water transmission systems. – Construct a new WTF.
L	Lower Kula System increase the capacity of raw water transmission infrastructure	• Medium amount of surface water potentially available. • Moderate availability of surface water throughout the year. • Potential impacts to downstream ecosystems and users. • Infrastructure requirements may include: – No new stream diversions. Replace existing pipes with larger ones. – Construct an additional reservoir with raw water transmission pipes and connection to the Pi‘iholo WTF.
M	Wailoa Ditch high flows Q_{50} and above	• Relatively large amount of surface water available. • Limited availability of high flows throughout the year. • Infrastructure requirements may include: – No new stream diversions. Utilize existing stream diversions and ditch to convey raw water. – Construct new reservoirs near Kamole WTF. – Construct a new water treatment facility or expand Kamole WTF.
N	Waihe‘e River high flows Q_{50} and above	• Medium amount of surface water available. • Limited availability of high flows throughout the year. • Infrastructure requirements may include: – Construct a new diversion to capture high flows only on Waihe‘e River near the Spreckels Ditch diversion. – Construct a new reservoir and a new WTF.
O	Wailuku River high flows Q_{50} and above	• Medium amount of surface water available. • Limited availability of high flows throughout the year. • Infrastructure requirements may include: – Construct a new diversion to capture high flows only on Wailuku River near the Spreckels Ditch diversion. – Improve existing Wai‘ale Reservoir, construct a new reservoir, and construct a new WTF.

Engineering Economic Analysis

Supply and development strategies were defined for each of the top 15 water source options from the non-economic analysis. An engineering economic evaluation was prepared to assess the potential life-cycle costs associated with each strategy. The strategies with the lowest life-cycle costs represent the overall best value from an engineering economic basis. The life-cycle economic evaluation consists of a net present value (NPV) comparison of cash flow patterns for each strategy. The NPV analysis includes capital, O&M, and replacement and rehabilitation (R&R) costs. An appropriate inflationary factor and discount rate are applied to obtain the NPV over a 30-year planning period. Figure 4 shows a summary of the potential water yield and life-cycle cost estimate for each of the strategies.

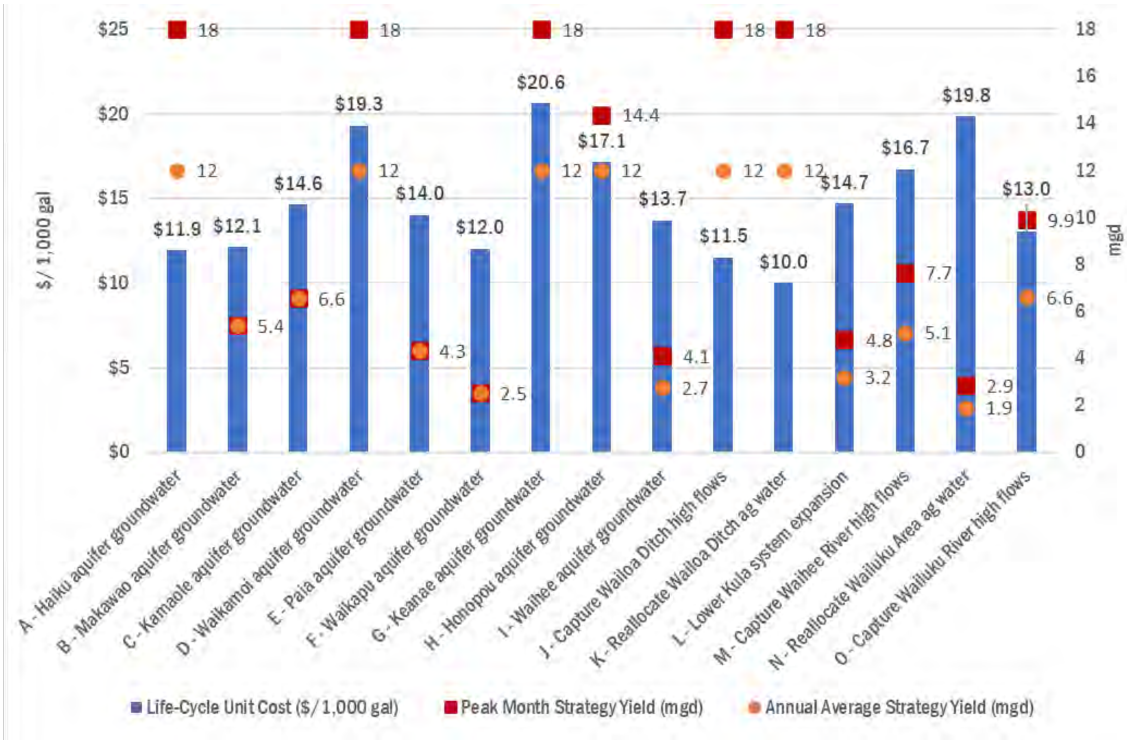

Figure 4. Life-Cycle Unit Cost Comparison

The results of the life-cycle cost evaluation and the non-economic evaluation were combined to identify the most attractive strategies with lower life-cycle costs and higher non-economic scores. Figure 5 shows the combined non-economic and engineering economic analysis.

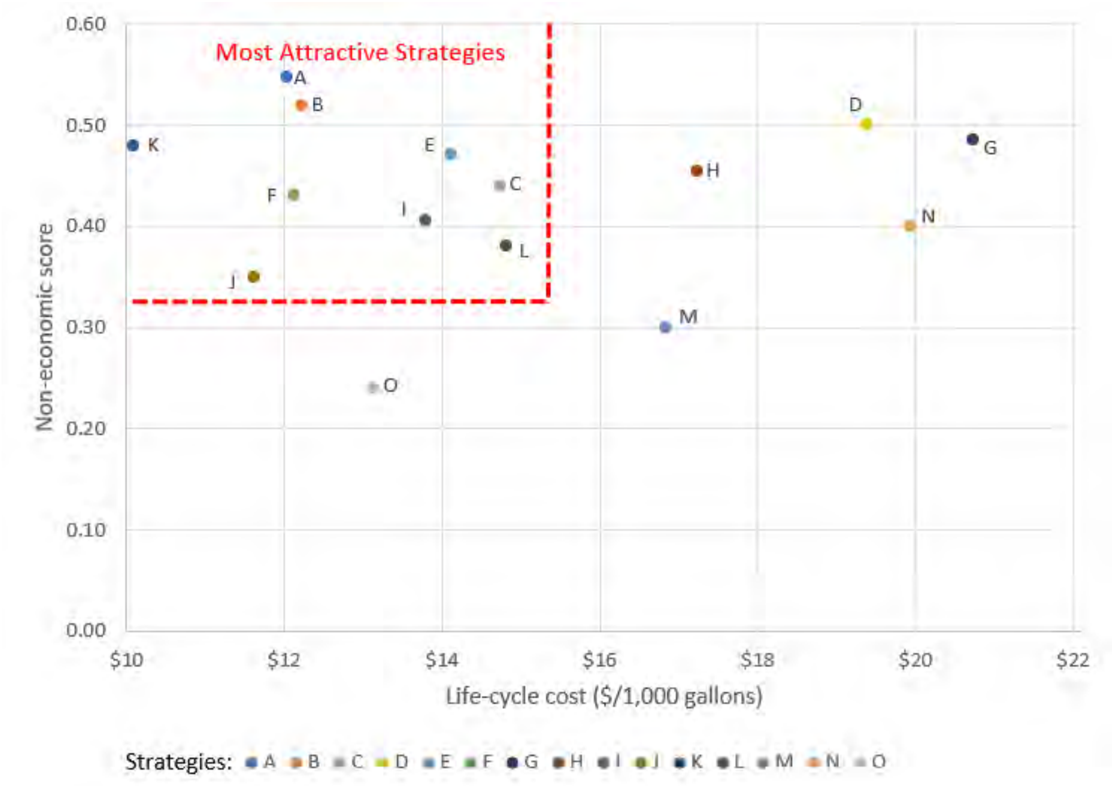

Figure 5. Combined Economic and Non-Economic Evaluation Results

Table 2 lists the most attractive strategies, along with their respective maximum yields, life-cycle unit costs, and non-economic scores.

Table 2. Summary of Most Attractive Strategies

Strategy	Maximum Yield (mgd)	Life-Cycle Unit Cost ($/1,000 gallons)	Non-Economic Score
A. Ha'ikū aquifer groundwater	12	$11.9	0.55 [a]
B. Makawao aquifer groundwater	5.4	$12.1	0.52 [a]
C. Kama'ole aquifer groundwater	6.6	$14.6	0.44 [a]
E. Pā'ia aquifer groundwater	4.3	$14.0	0.47 [a]
F. Waikapū aquifer groundwater	2.5	$12.0	0.43 [a]
I. Waihe'e aquifer groundwater	2.7	$13.7	0.41 [a]
J. Capture Wailoa Ditch high flows	12	$11.5	0.35
K. Reallocate Wailoa Ditch agricultural water	12	$10.0	0.48
L. Lower Kula system expansion	3.2	$14.7	0.38

Note:

a. *Average of elevation band scores within the aquifer.*

The highest benefit and lowest cost strategies are groundwater from Haʻikū , Makawao, Kamaʻole, Pāʻia, Waikapū, and Waiheʻe aquifers, and East Maui surface water from the Wailoa Ditch and the Lower Kula water system. From these strategies, 10 promising CBAs were identified that could meet the projected demand, including one CBA identified by MDWS (CBA-11).

The CBAs plus the "no-action" alternative are shown in Table 3.

Table 3. Alternatives for Cost Benefit Analysis

Identifier	Source Strategy 1		Source Strategy 2		Source Strategy 3		Total Flow (mgd)
	ID	Flow (mgd)	ID	Flow (mgd)	ID	Flow (mgd)	
CBA-1	A – Haʻikū aquifer groundwater	12	--	0	--	0	12
CBA-2	B – Makawao aquifer groundwater	5	I – Waiheʻe aquifer groundwater	2.7	A – Haʻikū aquifer groundwater	4.3	12
CBA-3	J – Capture Wailoa Ditch high flows	12	--	0	--	0	12
CBA-4	K – Reallocate Wailoa Ditch agricultural water	12	--	0	--	0	12
CBA-5	B – Makawao aquifer groundwater	3	L – Lower Kula System Expansion	2.4	C – Kamaʻole aquifer groundwater	6.6	12
CBA-6	F -Waikapū aquifer groundwater	2.5	I – Waiheʻe aquifer groundwater	2.7	K – Reallocate Wailoa Ditch agricultural water	6.8	12
CBA-7	F -Waikapū aquifer groundwater	2.5	K – Reallocate Wailoa Ditch agricultural water	5	B – Makawao aquifer groundwater	4.5	12
CBA-8	B – Makawao aquifer groundwater	4	K – Reallocate Wailoa Ditch agricultural water	4	E – Pāʻia aquifer groundwater	4	12
CBA-9	B – Makawao aquifer groundwater	5	I – Waiheʻe aquifer groundwater	2.7	J – Capture Wailoa Ditch high flows	4.3	12
CBA-10	No Action						0
CBA-11 [a]	MDWS Identified Action						12

Note:

a. *MDWS Identified Action contains a diversified 5 source strategy to generate 12 mgd of total flow with an additional 3 mgd backup flow. CBA-11 includes 1.5 mi of Iao Ditch improvements to generate approximately 0.5 mgd of additional surface flow as well as the following source strategies and their associated flows:*

A – Haʻikū aquifer groundwater (8 mgd)

B – Makawao aquifer groundwater (3 mgd backup)

I – Waiheʻe aquifer groundwater (0.5 mgd)

K – Reallocate Wailoa Ditch agricultural water (3 mgd)

Cost-Benefit Analysis

A rigorous cost-benefit analysis was prepared in accordance with federal guidelines. The cost benefit analysis considered impacts to the community at large (i.e., including areas outside of MDWS service area) in the form of lost economic benefits by assessing a “no-action” alternative. The results of the cost-benefit analysis are expressed as the present value (PV) of the cash flow required to construct, operate, and maintain the alternatives over a 50-year period, and includes monetized economic benefits and costs to the community at large relative to the baseline alternative.

Table 4 presents the results of the cost-benefit analysis. Alternatives with lower PV costs are considered favorable over alternatives with higher PV costs.

Table 4. Results of Cost-Benefit Analysis

Alternative	Present Value at 2% Discount Rate ($ millions) [a]	Comparison to Baseline Alternative
CBA-1: Haiku groundwater (baseline)	$1,410	0%
CBA-2: Makawao, Waihee, and Haiku groundwater	$1,621	+15%
CBA-3: Wailoa ditch, high flows	$1,588	+13%
CBA-4: Wailoa ditch, reallocate ag water	$1,428	+1%
CBA-5: Makawao and Kamaʻole groundwater, lower Kula system expansion	$1,712	+21%
CBA-6: Waikapu and Waihee groundwater, reallocate ag water from Wailoa ditch	$1,538	+9%
CBA-7: Waikapu and Paia groundwater, reallocate ag water from Wailoa ditch	$1,555	+10%
CBA-8: Makawao and Paia groundwater, reallocate ag water from Wailoa ditch	$1,654	+17%
CBA-9: Makawao and Waihee groundwater, high flows from Wailoa ditch	$1,672	+19%
CBA-10: No-action (lost economic benefits, partial)	$30,995	+2,098%
CBA-11 MDWS Identified Action	$1,612	+14%

Note:

a. *2% represents the real discount rate for long-term County of Maui projects funded with tax-exempt municipal bonds.*

Development of the County water system to accommodate planned population and economic growth would provide substantial economic benefits to the community at large. These economic benefits would be lost under the No-Action Alternative. The alternative with the lowest PV cost is Haʻikū Groundwater (CBA-1, the Baseline Alternative) with Alternative CBA-4 (Wailoa Ditch, Reallocate Ag Water) as a close second. These two alternatives remain the lowest cost even with reasonable changes in the discount rate.

Based only on expenditures by MDWS, the alternative that would provide the lowest PV cost to the MDWS and the lowest water rates is CBA-4. Alternative CBA-4 represents a centralized approach to meeting future water needs within the service area by expanding an existing water treatment facility (WTF), incorporating economies of scale that diversified and decentralized approaches do not realize. This finding ignores the future loss of farm-related economic benefits due to reallocating ditch water from future farming in Central Maui to the County water system.

Without a replacement, the loss of water to agriculture could result in a change in the farm plan for Central Maui—to decrease irrigated crop farming by about 2,280 acres and increase unirrigated pastureland by the same amount. An estimated 114 future farm jobs could be lost. Increasing the amount of unirrigated pastureland in windy Central Maui is likely to increase wind-blown dust, increase the risk of wildfires, require an increase in fire control services, and negatively impact watershed health.

With Alternative CBA-4, there is risk of not supplying projected water demand for two reasons. First, the planned use of ditch water may be subject to public opposition and legal challenges that, in turn, may delay development and/or reduce the planned flow of water to be reallocated. Second, once developed, the available flow of ditch water will be low during prolonged droughts, possibly resulting in the supply of water being insufficient to meet demand.

Ka Paʻakai Analysis

A Ka Paʻakai analysis was conducted in August 2024 for Phase 3 of the Feasibility Study for East Maui Water Source Development. Three virtual and two in-person meetings were convened to discuss Ka Paʻakai, attended by 10 and 12 individuals, respectively. However, two people participated in both a virtual and an in-person meeting. Two individuals submitted their comments via email correspondence. In all, 22 people participated in the Ka Paʻakai analysis for this project.

Native Hawaiians consulted through the Ka Paʻakai analysis for this study indicated that any development or extraction of groundwater needs to consider potential adverse impacts to stream flows and nearshore ecosystems so that cultural significance and gathering rights are not affected. Participants also expressed a desire to keep water resources within their region of origin, and to prioritize the needs of Maui residents.

The establishment of the Ka Paʻakai analysis framework was intended to address a specific geographic area, and more recently, was expanded to include such analysis in government actions, including rulemaking. Phase 3 encompasses 7 out of the 12 Maui moku, which covers more than half the island. Hence, the Ka Paʻakai analysis for this project encompasses both the larger context of a large geographic reference, values and legal framework, as well as site-specific resources. The Ka Paʻakai analysis discusses larger context of values and legal framework and summarizes information shared about specific locales.

Given the “big picture” nature of the current Ka Paʻakai analysis, it is too early to identify or specify feasible actions to protect Hawaiian rights. There are no specific geographical locations, and no specific projects or actions have been determined or selected at this time. Further, there are ongoing discussions on how to provide restitution for unjust enrichment. It is possible that by the time a project and locations are selected, the legal climate for water and Native Hawaiian rights will have evolved. In any event, continued application of the Ka Paʻakai analysis is highly recommended.

Conclusions and Recommendations

The cost-benefit analysis shows that groundwater from the Haʻikū aquifer (CBA-1) and reallocation of agricultural water from Wailoa Ditch (CBA-4) have the lowest PV costs. Comparison of 10 alternatives that would develop additional source water to support the growth of the community (CBA-1 through CBA-9, and CBA-11) shows that the PV costs of all the alternatives are within 21 percent of the baseline alternative (CBA-1). The analysis shows that although relying on a single aquifer (Haʻikū), or a single surface water source (Wailoa Ditch), to meet future source needs has the lowest PV cost, diversification of source (e.g., multiple aquifers, or combination of groundwater and surface water) does not appear to incur unacceptably higher PV costs.

The high PV cost of the no-action alternative (CBA-10) in comparison to the rest of the alternatives shows that development of additional source water supplies will likely support substantial economic growth within the community.

Based on this study, the most attractive groundwater source options are the Waiheʻe, Makawao, Waikapū, Haʻikū, Pāʻia, and Kamaʻole aquifers. Of these, only the Haʻikū aquifer has remaining SY sufficient to supply the full 12 mgd demand shortage projected for 2040. The most attractive surface water source option is via the Wailoa Ditch. Because of uncertainty associated with the use of East Maui surface water resources, if increased supply from Wailoa Ditch water is pursued BC recommends MDWS pursue a diversified water supply system that also incorporates groundwater from multiple aquifers to meet future needs. Interconnection of the Upcountry and Central Maui water systems would also allow greater flexibility in meeting demands for public water, providing more drought resilience for Upcountry.

Native Hawaiians consulted through the Ka Paʻakai analysis for this study indicated that any development or extraction of groundwater should consider potential adverse impacts to stream flows and nearshore ecosystems to mitigate effects on areas of cultural significance and gathering rights. Participants also expressed a desire to keep water resources within their region of origin, and to prioritize the needs of Maui residents.

Building on public engagement from the Maui Island Water Use & Development Plan (WUDP), MDWS can continue conversations with Maui communities to review the potential water source strategy alternatives presented in this study. Further public outreach and Ka Paʻakai analyses for individual projects will help ensure successful implementation that is sensitive to the goals and needs of each community.

Section 1: Potential Water Resources

1.1 Defining the Regions

The East Maui Feasibility Study (EMFS) Phase 3 study area includes the Central Maui, Upcountry, and East Maui regions pursuant to a 2003 Consent Decree between the Coalition to Protect East Maui Water Resources and the County of Maui (County). The boundaries of each region are not specified in the Consent Decree. For the purposes of this report, the study area is defined as follows:

- **Central Maui** region includes aquifer systems and watersheds located entirely or partially within the Wailuku and Central aquifer sectors, from Kahakuloa to Waikapū, and from Pāʻia to Kamaʻole.
- **Upcountry** region includes aquifer systems and watersheds located entirely or partially within the Koʻolau and Central aquifer sectors, from Makawao to Kamaʻole.
- **East Maui** region includes aquifer systems and watersheds located entirely or partially within the Koʻolau aquifer sector, from Haʻikū to Ke'anae.

Figure 6 shows the hydrological, cultural, and administrative geographic data that were considered in the process to define the study area regions. These data were selected for relevance to water supply and demand in the Central Maui, Upcountry, and East Maui regions.

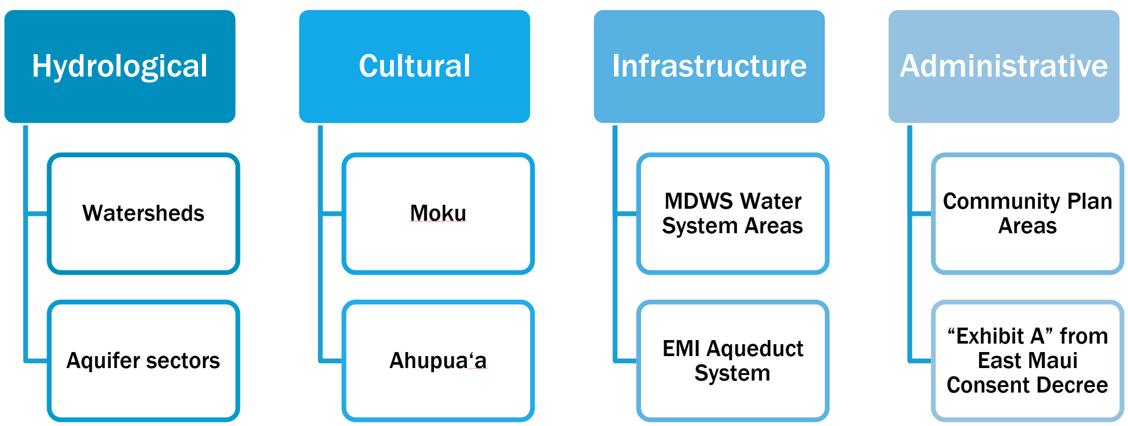

Figure 6. Geographic data considered for study area definition

A set of maps were generated to visualize the overlay of potential study area boundaries with each set of geographic data noted in Figure 6. Groundwater aquifer systems within the three study area aquifer sectors are shown in Figure 7.

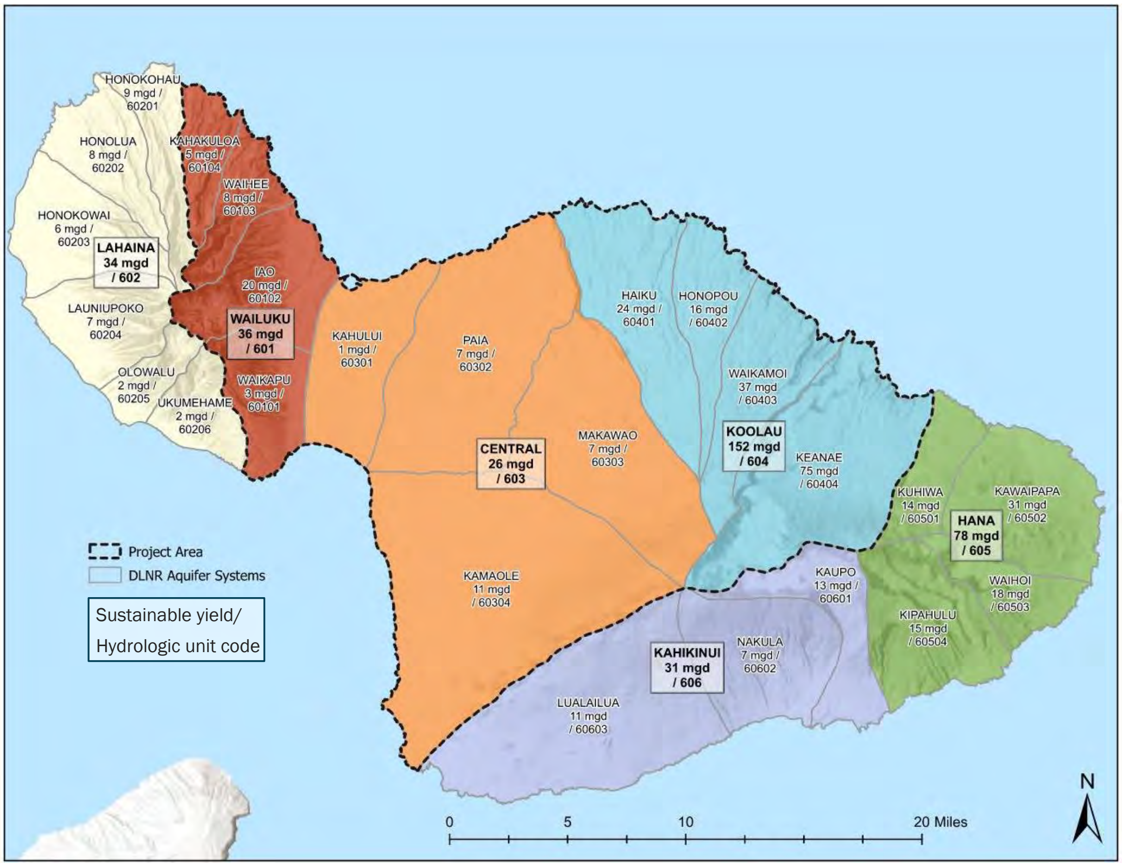

Figure 7. Map of Aquifers within Study Area

The study area includes twelve aquifer systems in three sectors:

- **Wailuku aquifer sector**: Kahakuloa, Waiheʻe, Īʻao, and Waikapū
- **Central aquifer sector**: Kahului, Pāʻia, Makawao, and Kamaʻole
- **Koʻolau aquifer sector**: Haʻikū , Honopou, Waikamoi, and Ke'anae

The moku of Koʻolau, Hamakualoa, Hamakuapoko, Kula, Honuaʻula, Puali Komohana, and Lahaina are included entirely or partially within the study area. Community Plan areas for East Maui, North Shore, Upcountry, Central Maui, and South Maui are included wholly or partially within the study area. Figure 8 shows moku within the study area.

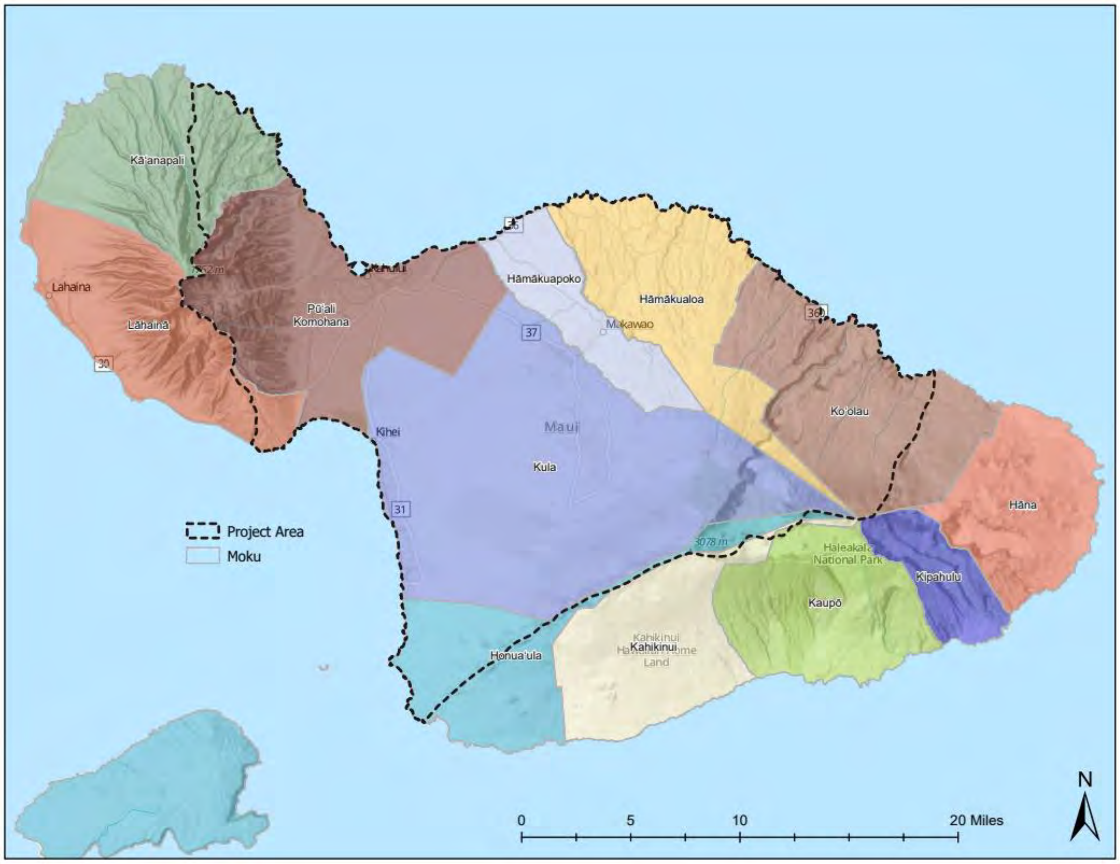

Figure 8. Map of Moku within Study Area

The area currently served by Maui County Department of Water Supply (MDWS) water systems was another factor considered in the selection of the study area. Figure 9 shows general boundaries of MDWS water systems relative to the study area.

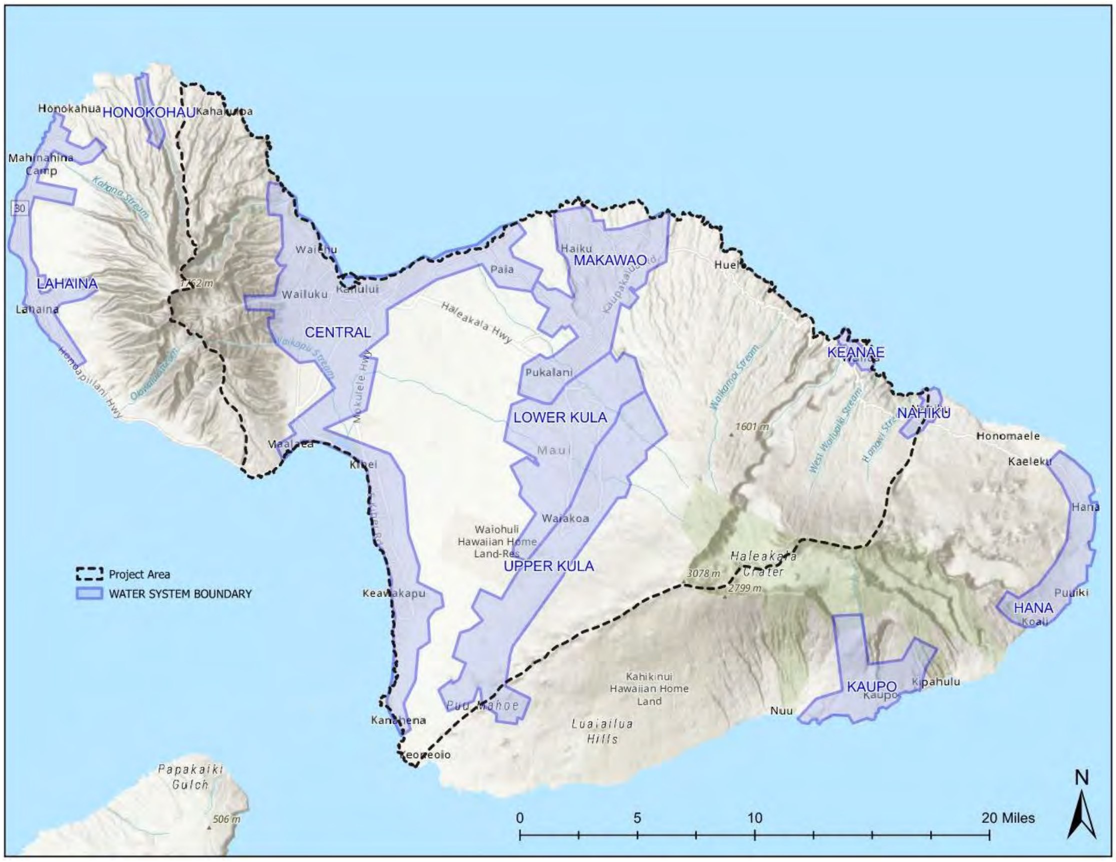

Figure 9. Map of MDWS Water Systems within Study Area

The study area was selected to be inclusive of surface and groundwater sources that serve the MDWS water systems that are commonly considered part of Central, Upcountry, and East Maui. The study area includes portions of the MDWS Central, Makawao, Lower Kula and Upper Kula systems. Although Ke‘anae and Nahikū systems are also within the study area, they are not connected to the other systems and not considered within this analysis. The Hāna and Kaupo water systems are excluded from the study area since their sources are independent of the other water systems and they are anticipated to continue operating separately.

1.2 Demand for Water Resources

The EMFS Phase 1 analyzed MDWS average annual billed consumption and production data between calendar years 2015 and 2020. Production, consumption, and system losses are all increasing over time for both the MDWS Central and Upcountry systems. In 2020, average day demand (ADD) was 24 million gallons per day (mgd) for the Central system and 7.6 mgd for the Upcountry system.

To refine and extend the production demand projections from now through 2040, three separate projection methodologies were evaluated. Ultimately, the recommended projection approach incorporates all three methodologies to establish a range of “most likely” projection values, as well as a conservative upper limit for each time interval considered.

The three methods include:

1. A baseline linear trend was established by projecting forward using the most recent five years of production data.
2. The Maui Island Water Use and Development Plan (WUDP) method was updated and extended to 2040, using population data from Census 2020 and the most recent Socio-Economic Forecast projections.
3. As a high-end (upper threshold) conservative limit estimate production demand associated with planned future development was added to the baseline trend using consumption guidelines from the 2002 Water Systems Standards.

For the Upcountry District, existing and outstanding production demand associated with processing the Upcountry Meter Priority List and subsequently addressing potential Upcountry pent-up demand were also incorporated into the projections.

Based on the projections, the most likely 2040 ADD ranges for the Central system and Upcountry district are 33 to 35 mgd and 11 to 14 mgd, respectively. Within those ranges and for the purpose of this analysis, an additional 3 mgd of water source for the Upcountry water system and 9 mgd for the Central Maui system is assumed needed by 2040—to meet a 12 mgd total of annual average daily needs for public water supply in these regions. The most likely 2040 average maximum month demand (MMD) ranges for the Central system and Upcountry district are 36 to 38 mgd and 13 to 17 mgd, respectively. Within those ranges and for the purpose of this analysis, an additional 6 mgd of water source for the Upcountry water system and 12 mgd for the Central Maui system is assumed needed by 2040—to meet a 18 mgd total of max monthly needs for public water supply in these regions (Brown and Caldwell [BC], 2023).

1.3 Potential Groundwater Resources

This section describes the hydrological and environmental constraints, legal and permitting considerations, and current and long-term availability of groundwater in the EMFS Phase 3 study area.

1.3.1 Hydrological and Environmental Constraints

Groundwater availability is affected by a variety of factors, including land cover, rainfall, runoff, evapotranspiration, geology, and climate change. Maui's rainfall patterns are dominated by northeasterly trade winds which bring moisture to the windward side of the island. Most rain falls during winter storms from October through April, while the summer months June through September are drier. Mean annual rainfall varies from 10 inches on the southwest coast and parts of Central Maui, to 386 inches on the northeast slope (Giambelluca, 2013).

The peaks of the Mauna Kahalawai range are below the trade-wind inversion, so high recharge is centered at or near the summits, consistent with orographic rainfall distribution. In contrast, highest recharge on Haleakalā is centered on the mountain's windward-facing slopes and recharge is low on the summit. In some areas, irrigation has substantially enhanced recharge over that derived from natural rainfall (Izuka et al, 2023).

Volcanic geology affects groundwater flow in Maui. ʻAʻā and pāhoehoe lava flows are typically highly permeable and form good aquifers. Thick or ponded lava flows are less permeable and impede groundwater flow. Dikes and faults occur in the subsurface and surface and are mainly concentrated in the upland areas of Maui and along rift zones.

Hawaiian hydrogeology is categorized into four principal settings (Izuka et al, 2018):

- Freshwater lens (basal aquifer) in highly permeable lava flows such as the Honomanu and Wailuku Basalts.
- Dike-impounded groundwater associated with rift zones and calderas. These are often intruded into shield stage volcanic units at high elevations.
- Perched groundwater. These are not a particularly significant source of groundwater within the study area.
- Caprock groundwater. Caprock groundwater is found in marine and subaerial sediments along the coast.

The capacity of Maui's aquifers to store groundwater is limited because the island is surrounded by seawater, and salt water underlies much of the fresh groundwater. The amount of fresh groundwater available for human use from aquifers is constrained by the consequences of groundwater withdrawal. Limits are placed on groundwater withdrawals to protect stream or coastal ecosystems that rely on groundwater discharge. Limits are also set on the water-level decline and rise of the freshwater-saltwater interface to protect the productivity of existing wells (Izuka et al 2023).

Properly constructed basal wells—in areas where streams are fed primarily by rainfall, surface runoff, and shallow perched—would not be anticipated to impact streamflow. The effects of pumping from the basal freshwater lens will be immeasurable—at streams that are separated from the freshwater lens by more than 100 ft of the unsaturated basalt—because of the very low hydraulic conductivity expected. However, additional data are needed to improve and confirm the understanding of the groundwater flow systems (Gingerich, 1999).

Figure 10 shows a block diagram of the occurrence and flow of fresh groundwater in a basaltic oceanic island and its relation to precipitation, evapotranspiration, runoff, and salt water.

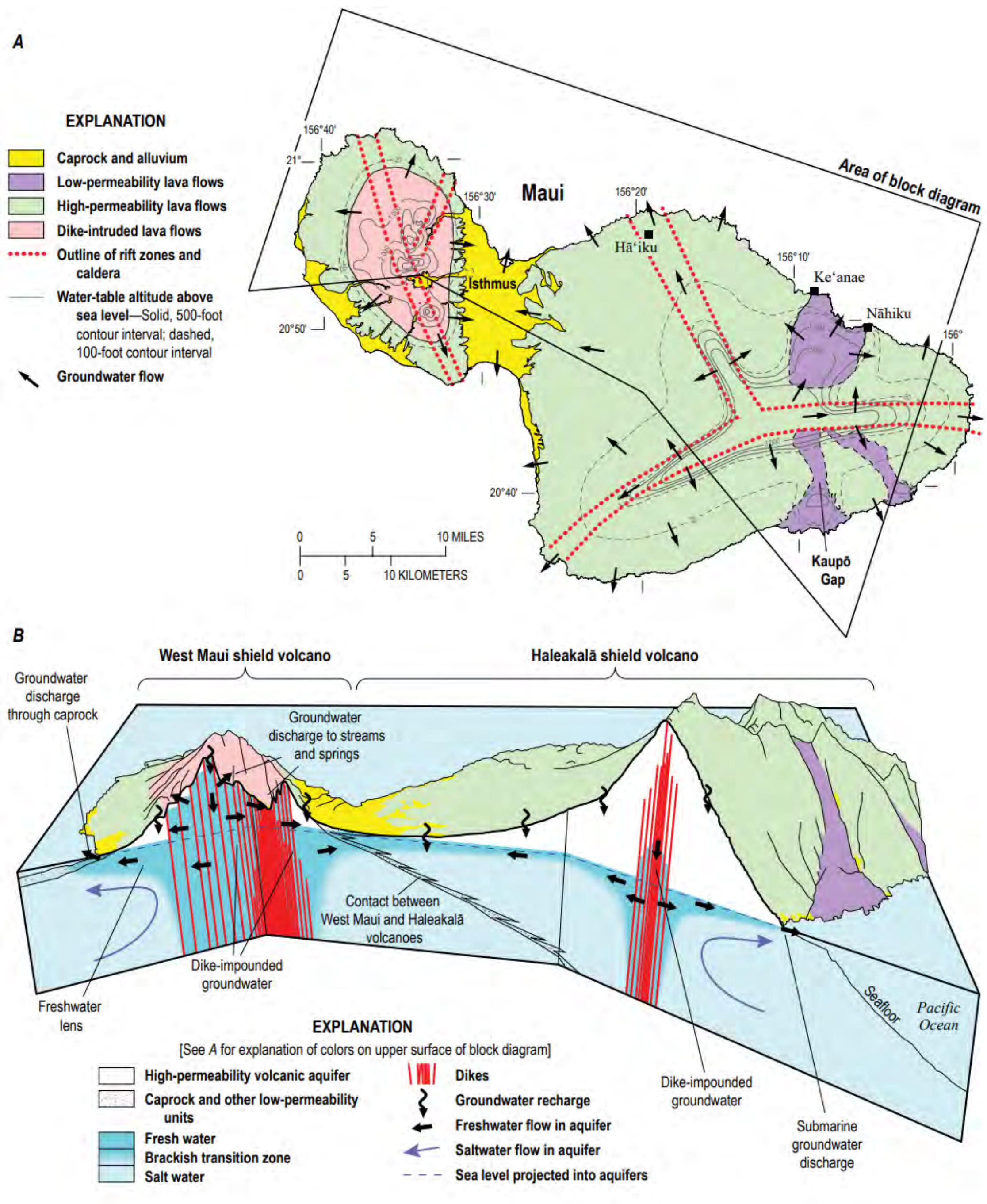

Figure 10. Block diagram of fresh groundwater occurrence and flow on Maui

Source: Izuka et al, 2023

Mean annual groundwater recharge is estimated based on numerical models that consider land cover, rainfall patterns, geology, and runoff. Areas with high amounts of rainfall, porous volcanic rock and vegetation that encourages percolation have the highest recharge rates—i.e., Windward Haleakalā and the summits of Mauna Kahalawai (Izuka et al, 2023).

Figure 11 shows a map of estimated groundwater recharge rates for the island of Maui.

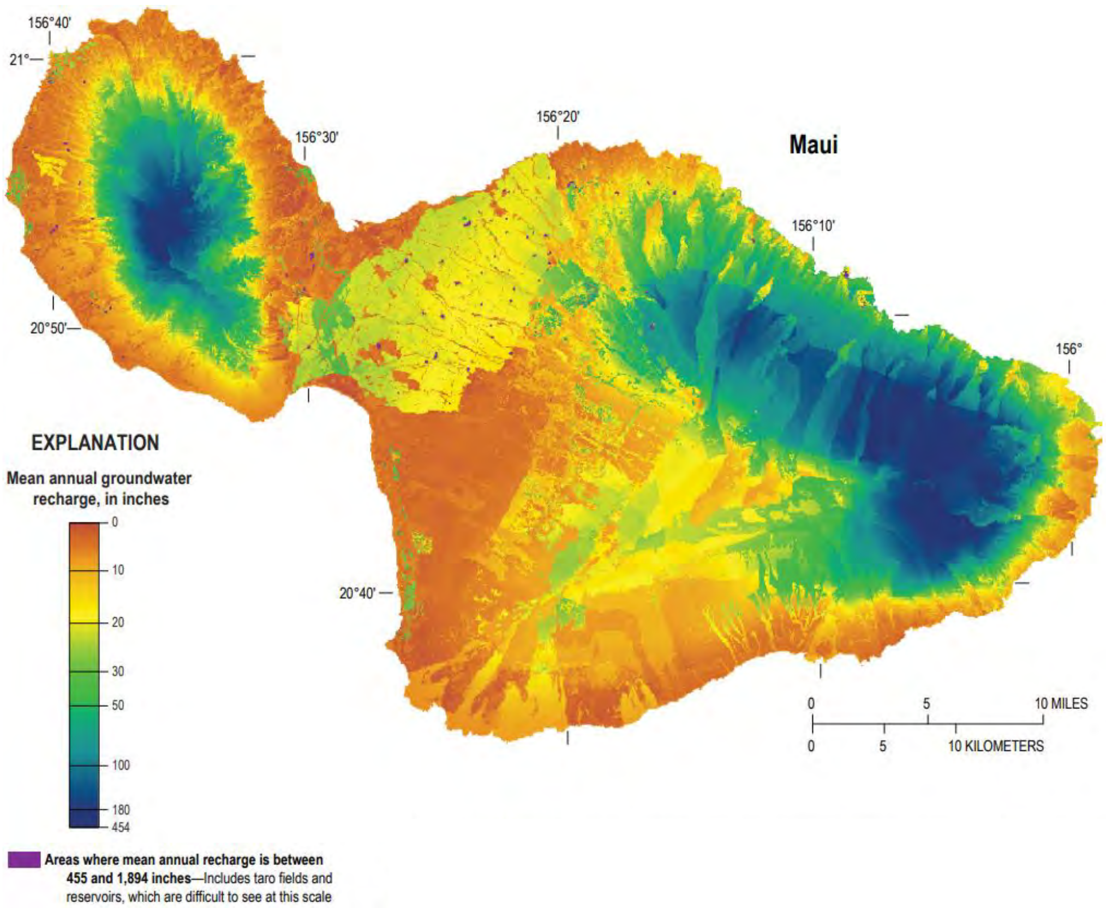

Figure 11. Map of estimated mean annual groundwater recharge

Source: Izuka et al, 2023

Climate change and urbanization are affecting groundwater recharge rates. Impacts of longer dry periods and decreased infiltration are discussed further in Section 1.3.4.1.

Setting limits to the consequences of groundwater withdrawal is a critical part of assessing groundwater availability. Numerical models are used to quantify the amount of water that can be withdrawn within those limits and inform management decisions that seek to balance the impacts of groundwater withdrawals with the need to develop water for domestic use (Izuka et al, 2023).

1.3.1.1 Groundwater Contamination

Known contamination sites or wells are tracked by the Department of Health (DOH) Safe Drinking Water Branch (SDWB) and the DOH Hazard Evaluation and Emergency Response (HEER) Office. Known contamination sites, for this report's purpose, are sampling events that have determined contaminant concentrations that pose a risk to human health or the environment. Known groundwater contamination is a factor when siting water supply wells. SDWB requires water sampling of drinking water wells and publishes the data found. DOH lists four contaminants that have been detected in wells within the study area since the record began in 1993 (DOH, 2024):

- 1,2-Dibromo-3-chloroporopane (DBCP)
- 1,2,3-Trichloropropane (TCP)
- Ethylene dibromide (EDB)
- Atrazine

In addition to the contaminants listed above, per- and polyfluoroalkyl substances (PFAS) have been recently detected in water samples collected in the Maui Business Park System. The detected compounds include perfluorooctanoic acid at a concentration below the maximum contaminant level (MCL) recently established by the US Environmental Protection Agency (EPA). Other compounds detected in the water system, but for which no MCLs have been established, include perfluoroheptanoic acid, perfluorhexanoic acid, perfluoropentanoic acid, and perfluorobutanoic acid (State of Hawa'i DOH, April 17, 2024).

Additional contaminants, if discovered in the future, could affect water source viability and treatment requirements.

Potential for groundwater contamination is assessed by considering the presence of active leaking underground storage tank (LUST) sites, onsite sewage disposal systems (OSDSs) (DOH 2015), commercial and industrial-zoned land (Maui County, 2023), airports (Department of Transportation [DOT], 2011), and historic sugarcane and pineapple lands (Department of Land and Natural Resources [DLNR], 2007).

1.3.2 Legal and Permitting Considerations

The Commission on Water Resource Management (CWRM) derives authority from the State Water Code, Chapter 174C, Hawaii Revised Statutes (HRS), and is implemented under Hawaii Administrative Rules (HAR) §13-167 to 13-171 to protect the overall integrity of Hawai'i's water resources for the benefit of the citizens of the State. The CWRM implements its policies, Hawaii Water Plan provisions, and regulatory requirements for water use, well development, groundwater and surface water withdrawals, and protection of traditional and customary Hawaiian rights. Regulations are also used to protect groundwater quantity and quality, optimize groundwater availability, and obtain maximum reasonable-beneficial uses (CWRM, 2024).

1.3.2.1 Groundwater Management Areas

Groundwater Management Areas (GWMAs) are areas designated by the CWRM. No person shall make any withdrawal or consumptive use of water in any designated groundwater management area without first obtaining a permit from the CWRM. Except for domestic consumption of water, individuals (e.g., well owners) must obtain water use permits (WUPs) from the CWRM to withdraw groundwater for proposed uses within GWMAs. The designation of a water management area may be initiated by the CWRM or by written petition to the CWRM. The designation process includes investigation, fact finding, public hearings, and consultation with the appropriate county council, mayor, and county water board. The process may take several years before the CWRM renders a decision. The CWRM designated ʻĪao Aquifer System as a GWMA in 2003, requiring WUPs for all non-individual domestic groundwater uses. Source owners must meet several criteria to justify withdrawals and obtain a WUP. Requests for government agency and public comments are an important part of the WUP process (CWRM, 2024).

1.3.2.2 DHHL Water Reservations

To ensure that Department of Hawaiian Homeland's (DHHL's) future water needs are provided for, the CWRM has established water reservations pursuant to HRS §174C-49(d) in designated water management areas, and by CWRM action in non-designated areas per the Water Resources Protection Plan (WRPP, 2019). These water reservations are counted against available sustainable yield (SY) and are allocated for DHHL use only. DHHL reservations are established based on projected agency demand in the State Water Projects Plan (SWPP, 2017).

1.3.2.3 Ka Paʻakai Analysis Requirements

A Ka Paʻakai analysis is now required for all new water source development in Hawaiʻi. The Hawaiʻi Constitution requires the State to protect all rights customarily and traditionally exercised for subsistence, cultural, and religious purposes and possessed by ahupuaʻa tenants who are descendants of Native Hawaiians who inhabited the Hawaiian Islands prior to 1778. The Hawaiʻi Supreme Court case Ka Paʻakai o Ka ʻAina v Land Use Commission (2002) established an analytical framework for addressing the preservation and protection of customary and traditional native practices specific to Hawaiian communities.

The Ka Paʻakai framework has three parts: (1) identify whether any valued cultural, historical, or natural resources are present and identify the extent to which any traditional and customary native Hawaiian rights are exercised, (2) identify the extent to which those resources and rights will be affected or impaired by the actions under consideration, and (3) specify the feasible action, if any, to be taken by the regulatory body to reasonably protect native Hawaiian rights if they are found to exist (Ka Paʻakai o Ka ʻAina, 2002).

A Ka Paʻakai analysis conducted at the level of a feasibility study like this report is broader than a water source development project-level analysis where more specific locations and proposed actions are known. The Ka Paʻakai analysis for this study is part of an effort to engage Native Hawaiian practitioners early and often to guide the management of water resources.

Figure 12 shows the permitting requirements for groundwater resources in Hawaiʻi.

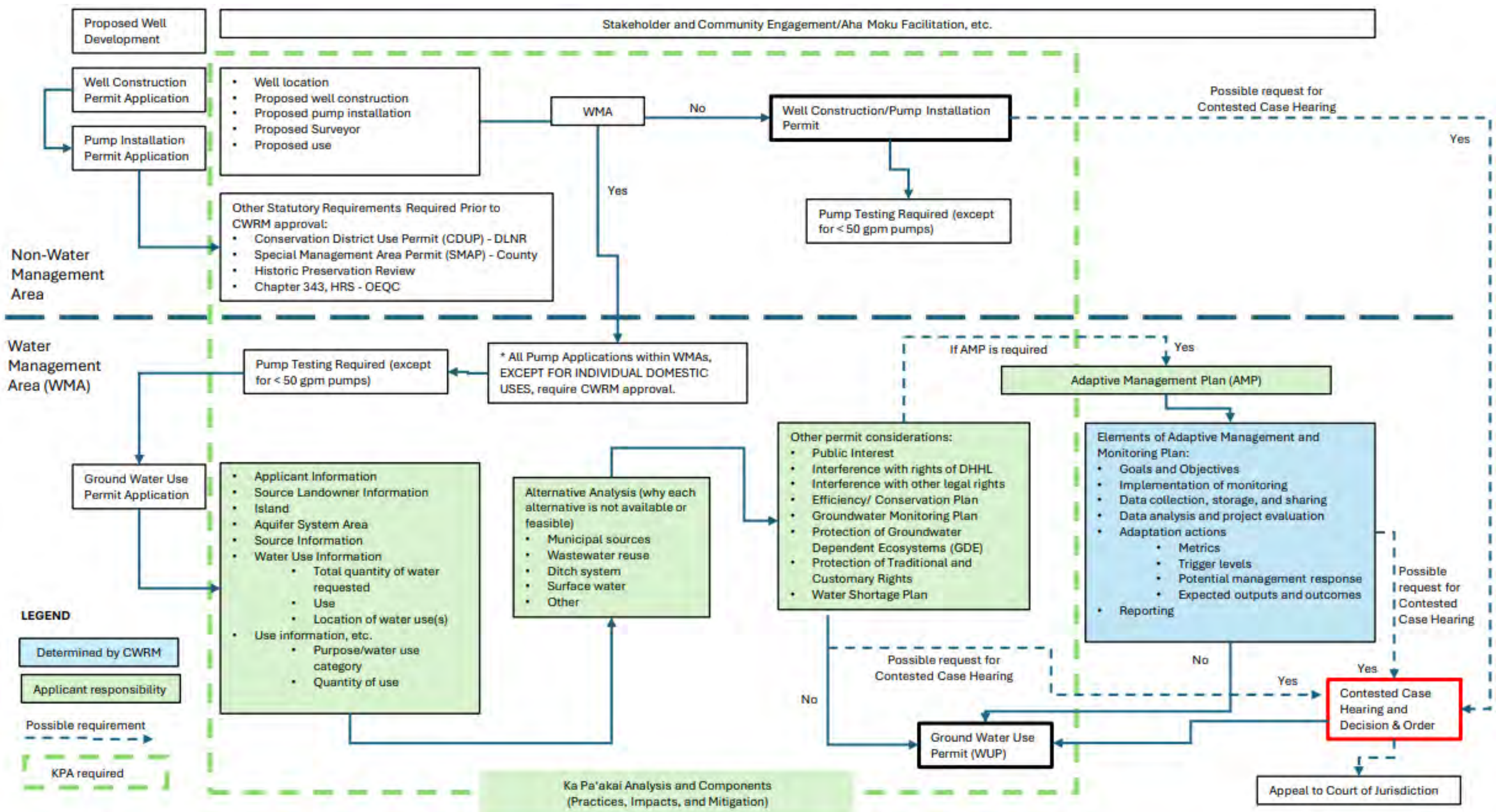

Figure 12. Permitting requirements for groundwater resources

As shown in Figure 12, Well Construction Permit and Pump Installation Permit applications within a GWMA (and non-GWMAs) are subject to CWRM approval. A WUP is also required for any withdrawal or consumptive use of water within a GWMA, except for domestic consumption of water by individual users for which a permit is not required. Groundwater Use Permit applicants within a GWMA must meet specific criteria and current regulatory provisions for issuance of a permit including an alternatives analysis and appropriate consideration of potential impacts to groundwater dependent ecosystems (GDE) and protection of traditional and customary (T&C) rights. The CWRM may determine that an Adaptive Management Plan is also necessary, which may include additional data collection, analysis, and triggers for specific adaptation actions.

Permit applications within and outside of GWMAs may be subject to potential requests for contested case hearings, which can contribute to lengthy and unpredictable permitting timeframes and outcomes.

1.3.3 Current Groundwater Availability

Available groundwater resources in each aquifer were calculated by subtracting the sum of the average pumpage and DHHL reservations from the aquifer SY. The SY is a metric used by the CWRM to quantify the amount of groundwater that can be withdrawn from an aquifer, “the maximum rate at which water may be withdrawn from a water source without impairing the utility or quality of the water source as determined by the commission (HRS §174C-3).” Reported water use data is collected by the CWRM to monitor water usage and to ensure demand is managed effectively—within established SY limits—within each aquifer system. BC summarized average groundwater pumpage from 2017 to 2022 using reported well usage data (CWRM, 2023).

Existing groundwater resources and demand are summarized in Table 5.

Table 5. Existing Groundwater Resources and Demand

Aquifer sector	Aquifer system	Sustainable Yield (SY) (mgd)[a]	Water Use 2017-2022 Average[b] (mgd)	DHHL Reservation[c]	SY Minus Pumpage and DHHL	Current Water Use as a Percent of SY	Percent SY remaining
Koʻolau	Haʻikū	24	0.860	-	23.140	4%	96%
Koʻolau	Honopou	16	0.019	-	15.981	0%	100%
Koʻolau	Waikamoi	37	-	-	37.000	0%	100%
Koʻolau	Ke’anae	75	0.055	0.003	74.942	0%	100%
Wailuku	Waikapū	3	0.045	-	2.955	1%	99%
Wailuku	Īʻao	20	17.960	0.020	2.020	90%	10%
Wailuku	Waiheʻe	8	4.448	-	3.552	56%	44%
Wailuku	Kahakuloa	5	-	-	5.000	0%	100%

Table 5. Existing Groundwater Resources and Demand							
Aquifer sector	Aquifer system	Sustainable Yield (SY) (mgd)[a]	Water Use 2017-2022 Average[b] (mgd)	DHHL Reservation[c]	SY Minus Pumpage and DHHL	Current Water Use as a Percent of SY	Percent SY remaining
Central	Kahului	1	8.194	-	-7.194	819%	-719%
Central	Pāʻia	7	1.570	-	5.430	22%	78%
Central	Makawao	7	0.673	-	6.327	10%	90%
Central	Kamaʻole	11	3.200	2.547	5.253	29%	71%

Notes:

a. *Water Resources Protection Plan 2019 Update*

b. *CWRM Well Report, October 2023*

c. *State Water Projects Plan DHHL 2017 Update*

Figure 13 shows a map of groundwater aquifer system SY and percent SY remaining.

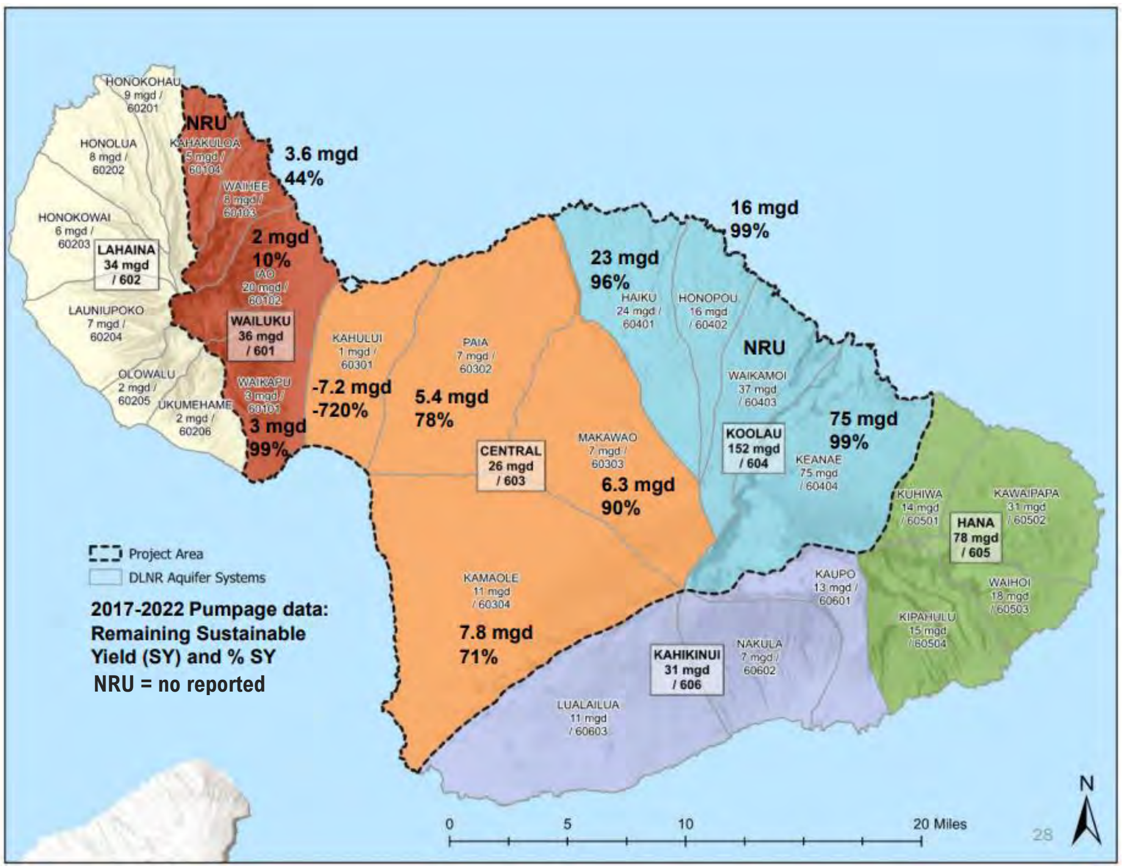

Figure 13. Groundwater aquifer system sustainable yields

The following sections describe current groundwater availability in each of the aquifer systems and sectors within the study area.

1.3.3.1 Wailuku Aquifer Sector

Groundwater resources in the Wailuku aquifer sector are within the Waikapū, Īʻao, Waiheʻe, and Kahakuloa aquifers. Respectively, Waikapū aquifer has 2.96 mgd, Waiheʻe aquifer has 3.55 mgd, and Kahakuloa aquifer has 5 mgd remaining SY potentially available. Īʻao aquifer has less than 10 percent remaining SY available, which means further pumpage will not be permitted. DHHL reservations account for 0.02 mgd in the Īʻao aquifer.

1.3.3.2 Central Aquifer Sector

Groundwater resources in the Central aquifer sector are within Makawao, Pāʻia, Kahului, and Kamaʻole aquifers. Respectively, Makawao aquifer has 6.33 mgd, Pāʻia aquifer has 5.43 mgd, and Kamaʻole aquifer 7.80 mgd remaining SY potentially available. According to the Community Plan Area boundary, the Upcountry district region includes the portion of Kamaʻole aquifer above 600 feet and the South Maui region includes the portion of Kamaʻole aquifer below 600 feet. DHHL reservations account for 2.547 mgd of groundwater in the Kamaʻole aquifer.

1.3.3.3 Koʻolau Aquifer Sector

Groundwater resources in the East Maui region are within Haʻikū , Honopou, Waikamoi, and Ke'anae aquifers. Respectively, Haʻikū aquifer has 23.14 mgd, Honopou aquifer has 15.98 mgd, Waikamoi aquifer has 37 mgd, and Ke'anae aquifer has 74.95 mgd remaining SY potentially available. DHHL reservations account for 0.003 mgd of groundwater from the Keʻanae aquifer.

1.3.4 Long-term Groundwater Availability

Long-term availability of groundwater is affected by land cover, rainfall, runoff, evapotranspiration, climate change, geology, recharge and extraction rates. This section discusses the projected mid- and long-term effects of climate change on groundwater availability and impacts to source resilience.

1.3.4.1 Climate Change Impacts

A 2023 United States Geological Survey (USGS) study projected changes to groundwater recharge across the state of Hawai'i for three future-climate scenarios: mid-century (2041), dry-climate (2071), and wet-climate (2080). Groundwater recharge is projected to decrease by 5 to 55 percent for mid-century and dry-climate scenarios but may increase by 2 to 43 percent for the wet-climate scenario (Kāne et al, 2023).

Figure 14 shows the changes projected for Maui under the mid-century (2041) scenario.

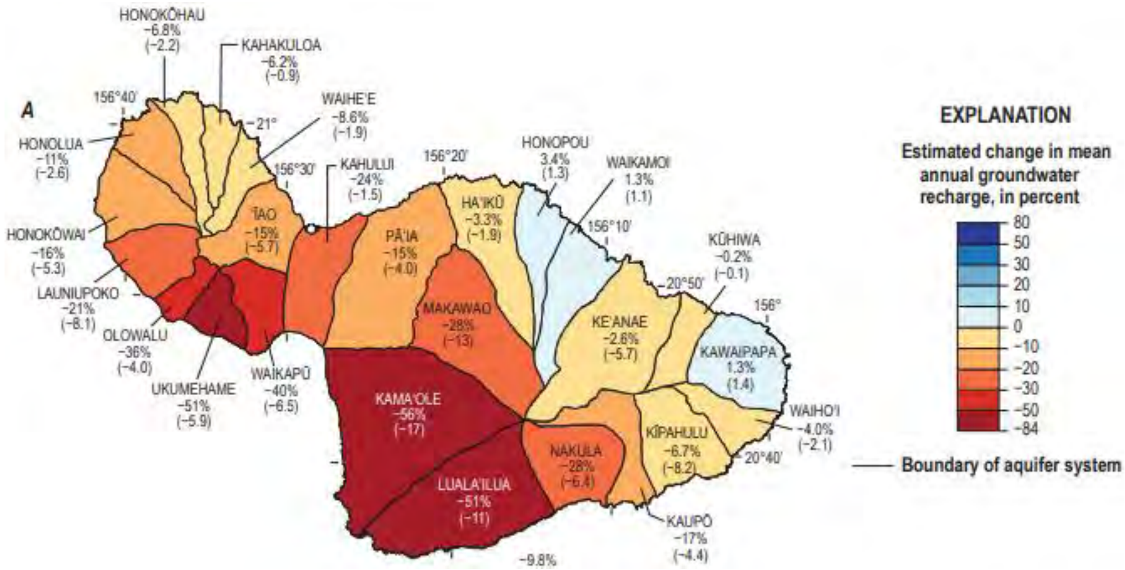

Figure 14. Estimated change in annual groundwater recharge by mid-century

Source: Timm 2015 and Kāne, 2023

Leeward and central Maui are projected to get drier, while much of East Maui is projected to get wetter. In the mid-century scenario, groundwater recharge for Maui overall is estimated to decrease by nearly 10 percent compared to the 1978-2007 scenario. Decreases in aquifer-system recharge are estimated for all but three of Maui's aquifer systems, except for Honopou, Waikamoi, and Kawaipapa. The greatest decreases in aquifer-system recharge are estimated for the Kamaʻole and Makawao aquifer systems. Changes in groundwater recharge could affect water availability, groundwater levels, and salinity—impacting drinking water and ecosystems (Kāne et al, 2023).

1.3.4.2 Operational Limitations and Source Resilience

Groundwater is a relatively reliable source of water, since it is less vulnerable to short-term fluctuations in rainfall than surface water. However, the long-term resiliency of groundwater resources may be impacted by reduced recharge rates under future climate scenarios.

Watershed management is key to improving the long-term resilience of groundwater resources. The WUDP includes a strategy to "Continue Maui County financial support for watershed management partnerships' fencing and weed eradication efforts protecting and restoring the resilience of natural aquatic ecosystems and thereby protecting ground and surface water resources and a range of ecosystem services (Department of Water Supply [DWS], 2022)."

Demand response plans could help address water shortages and changes in aquifers. The WUDP calls for "MDWS and private purveyors to formalize action plans and alternative pump rate scenarios for all wells in response to declining water levels, increases in chlorides or escalated pumpage to protect aquifer health (MDWS, 2022)."

Energy requirements for pumping groundwater pose operational limitations. Potential natural hazards (e.g., wildfires, hurricanes, etc.) can have devastating impacts to water and power infrastructure and appropriate planning and consideration of infrastructure resilience is important for protecting Maui's water supply.

The current lack of connection between the MDWS Central system and Upcountry system limits the ability to transfer water between regions.

1.4 Potential Surface Water Resources

Surface water resources in the study area range from intermittent streams and gulches to perennial streams and ditches. The study area encompasses 66 watersheds (a.k.a. surface water hydrologic units) in Central, Upcountry, and East Maui. On the western side, the watersheds reach from Waikapū in the south to Poelua in the north. On the eastern side, the watersheds reach from Waiakoa in the south to Makapipi in the northeast. This section will review hydrological and environmental constraints, legal and permitting considerations, and current and future availability of potential surface water sources in the study area.

1.4.1 Hydrological and Environmental Constraints

Maui's streams are fed by rainfall and surface runoff and underground sources of water (subsurface flow). Streams provide habitat for native fish and wildlife, support recreational activities like swimming and fishing, maintain wetland and estuary ecosystems, and support traditional and customary Hawaiian practices including taro cultivation. In gaining streams or reaches, groundwater flows through the subsurface (i.e., from below ground) into the stream contributing to the streamflow volume. In losing streams or reaches, water seeps from the stream infiltrating through the streambed into the underlying ground formation decreasing the overall streamflow (Oki, 2012).

Many streams have been altered by hardening or diversions that supply agricultural, domestic, and public water uses. For over a century beginning in the mid-1800's, large volumes of water were diverted from streams in East Maui and Na Wai ʻEhā to feed sugarcane plantations. Reduced streamflow led to habitat loss, increased water temperatures, constraints on T&C uses like kalo farming, and potential impacts to nearshore ecosystems. Following the decline of the sugar industry in the mid-1900's and the rise of tourism and real estate development, water has continued to be diverted from wet areas of the island to dry areas (Knudson, 2022).

Estimating natural stream flow is not an exact science, especially in Hawaiʻi with wet and dry seasons, large storm events, steep watersheds, varied underlying geologic features, and a long history of stream diversions. While a small number of Maui's streams have long-term flow records, theoretical models are often used to estimate flow in most streams (CWRM, 2022).

As rainfall patterns shift with climate change, longer periods with little to no rainfall will affect surface water resource availability. High intensity rain events lead to high stream flows and flooding in irregular intervals (Hawaii Climate Portal, 2024).

1.4.2 Legal and Permitting Considerations

Article XI, Section I of the Hawaiʻi State Constitution requires the state and its political subdivisions to conserve and protect all natural resources, including water, for the benefit of present and future generations. Struggles over water rights continue in Na Wai ʻEhā and East Maui, where taro farmers and environmental groups have battled with developers and landowners for decades over diversion of stream water. Permitting the use of surface water is a complex topic with timelines and outcomes that are difficult to predict.

1.4.2.1 CWRM Stream Protection and Management Branch

CWRM's Stream Protection and Management (SPAM) Branch regulates the State's surface water resources and is responsible for permitting of stream channel alterations and surface water diversions. The SPAM Branch protects stream channels from alteration whenever possible and manages the sharing of surface water resources through a regulatory permitting system.

A Stream Channel Alteration Permit (SCAP) is required for any temporary or permanent activity within the stream bed or banks that may: (1) obstruct, diminish, destroy, modify, or relocate a stream channel, (2) change the direction of flow of water in a stream channel, (3) place any materials or structures in a stream channel, or (4) remove any material or structure from a stream channel.

A Stream Diversion Works Permit (SDWP) is required for the removal of water from a stream into a channel, ditch, tunnel, pipeline, or other conduit for off-stream purposes including, but not limited to, domestic, agricultural, and industrial uses. Construction of a new stream diversion structure or alteration of an existing structure require a SDWP (CWRM, 2024).

1.4.2.2 Surface Water Management Areas

Surface Water Management Areas (SWMAs) are areas designated by the CWRM where users of surface water from streams, diversions, and ditches are required to obtain surface water use permits (SWUPs) to withdraw and use surface water. The State Water Code authorizes the CWRM to designate SWMA where there are serious disputes occurring over the use of surface water. The CWRM must consult with the Mayor, County Council, and DWS and conduct a public hearing prior to designating a SWMA (CWRM 2024). Designated SWMAs within the Phase 3 study area are the surface water hydrologic units of Waiheʻe, Waiehu, Wailuku, and Waikapū.

1.4.2.3 Instream Flow Standards

Under the State Water Code, the CWRM has the responsibility of establishing instream flow standards (IFS) on a stream-by-stream basis to protect the public interest in the waters of the State. CWRM initially set interim instream flow standards (IIFS) at “status quo” levels. These IIFS were defined as the amount of water flowing in each stream with consideration for the natural variability in stream flow and conditions at the time the administrative rules governing them were adopted in 1988—HAR §13-169-44 for East Maui and HAR §13-169-48 for West Maui (HAR, 1988).

The CWRM has adopted a process for amending IFS. Upon receiving or initiating a petition to amend an existing IIFS, CWRM staff will conduct a preliminary inventory of best available information. Staff will then seek agency review and comments on the information compiled in an Instream Flow Standard Assessment Report (IFSAR) and issue a public notice for a public fact gathering meeting to be held in or near the hydrologic unit of interest. The CWRM action to amend IIFS often becomes the subject of a contested case hearing, potentially leading to decades of public proceedings. New or modified stream diversion permits cannot be granted until an IIFS is established (CWRM, 2024).

1.4.2.4 IIFS for East Maui streams

Huelo Area Streams

In November 2022, the CWRM approved a “Petition to Amend Interim Instream Flow Standard for Huelo-Region Surface Water Hydrologic Units to Reserve a Portion of the Flow for the DHHL Reservation.” The staff submittal included recommendations to protect instream uses for Surface Water Hydrologic Units of Hoʻolawa (6035), Waipiʻo (6036), Hoalua (6038), Hanawana (6039), Kailua (6040), Nailiilihaele (6041), Puehu (6042), ʻOʻopuola (6043), Kaʻaiea (6044), Punaluʻu (6045), and Kōlea (6046). The CWRM approved staff recommendations for IIFS for the 15 streams in 11 hydrologic units but deferred a decision on the requested DHHL reservation of 1.33 mgd (CWRM, 2022).

BLNR License Area

In June 2018, the CWRM issued a Findings of Fact, Conclusions of Law, & Decision and Order (D&O) to amend IIFS for Honopou, Hanehoi/Puolua, Waikamoi, Alo, Wahinepeʻe, Puohokamoa, Haʻipuaʻena, Punalau/Kolea, Honomanu, Nuaʻailua, Piʻinaʻau, Palauhulu, ʻOhia (Waianu), Waiʻokamilo, Kualani (Hamau), Wailuanui, Waikani, West Wailuaiki, East Wailuaiki, Kopiliula, Puakaʻa, Waiohue, Paʻakea, Waiaʻaka, Kapaula, Hanawi, and Makapipi Streams (CCH-MA13-01). CWRM classified streams in four broad categories that represent different priorities and management strategies: (1) kalo and community streams, (2) habitat streams, (3) public use streams, and (4) other streams.

The Board of Land and Natural Resources (BLNR) authorizes the amount of water that can be diverted into the East Maui Irrigation (EMI) system. The ditch system diverts water from State lands in East Maui covered under prior water leases issued by the BLNR. The BLNR has issued a series of annual revocable permits for the continued use of water from the EMI system streams for diversified agriculture and public drinking water. The amount of water that can be diverted for off-stream use is governed by the IFS set by the CWRM. These permits have been successfully challenged in court, leading to a further reduction in off-stream surface water use in East Maui.

The maximum amount of water that can be awarded through a water lease/revocable permit is what is available for diversion after implementation of the IIFS set in the 2018 and 2022 CWRM Orders. Actions taken since 2018 affecting the amount of water available from Wailoa Ditch include:

- October 2019, the BLNR limited EMI diversions to 45 mgd.
- July 2021, a First Circuit Court judge reduced EMI’s permitted water diversions so as not to waste the balance of EMI’s unused 45 mgd allocation.
- April 2022, the Environmental Court further lowered the amount to 20 mgd until the BLNR decides on a contested case over the 2021 and 2022 revocable permits.
- November 2022, Maui voters approved the formation of an East Maui Regional Community Board (aka ʻAha Wai o Maui Hikina Regional Community Board, aka East Maui Water Authority) to investigate, acquire, manage, and control water collection and delivery systems in the State license areas.
- November 2022, the BLNR approved one-year revocable permits allowing EMI to divert up to 41.5 mgd: (1) 27.91 mgd for Mahi Pono, (2) 6 mgd for the Maui County DWS, (3) 1.5 mgd for the county’s Kula Ag Park, (4) 0.07 mgd for historic/industrial uses, (5) 2.2 mgd for other uses such as reservoirs, dust and fire, and (6) a cushion of 2.79 mgd.
- June 2023, the Environmental Court reduced EMI diversions to 31.5 mgd.
- December 2023, the BLNR issued a revocable permit with total cap amount to Alexander & Baldwin (A&B) and EMI of 38.25 mgd averaged annually, with 31.25 mgd granted to the permittee for agricultural use, 6 mgd to the County for Kamole Treatment Center, and 1 mgd to Kula Ag Park.
- April 2024, the Intermediate Court of Appeals overturned a lower court decision requiring the BLNR to hold a contested case hearing, challenging the continued use of revocable permits for water diversion.
- September 2024, a proposed 30-year EMI water license for 85 mgd was removed from consideration from the BLNR agenda.

The BLNR conditions for the A&B/EMI 2024 Revocable Water Permit require quarterly status reports on stream diversion removals/modifications to comply with the 2018 D&O, stream flow restoration, estimated losses from seepage and evaporation, debris removal from diverted streams, interim committee meetings, and the amount of water used on a monthly basis for the (1) County DWS and the County Kula Agricultural Park, (2) diversified agriculture, (3) industrial and non-agricultural uses, and (4) reservoir/fire protection/hydroelectric uses.

Pursuant to a contractual agreement with the County (EMI Water Delivery Agreement, 2018), a minimum of approximately 7.175 mgd (reduced to 6 mgd by a BLNR permit in 2022) must be reliably made available to the County at Kamole Weir so that MDWS has flexibility regarding when to run the Kamole Weir Water Treatment Facility (WTF) depending on weather conditions, demand, water available from its Pi'iholo WTF, etc. Additionally, a minimum of approximately 1.5 mgd must be reliably made available to the County for the Kula Agricultural Park. Water that is not used by the County remains in the ditch system, is transported to Central Maui, and any excess is directed to reservoirs located on the farm (EMI, 2024).

The EMI allocation for Kamole Weir per agreements with amendments is as follows:

- The 1973 EMI Water Delivery Agreement permits MDWS to withdraw 12 mgd and an additional 4 mgd upon one-year written notice by MDWS to EMI.
- The 5th amendment from 1998 states: "EMI will make available to MDWS up to 8.675 mgd per 24 hour period, with 7.175 mgd at Kamole Weir and up to 1.5 mgd per 24 hour period from Hamakua Ditch to the Kula Ag Park."
- The 6th to 8th amendments do not change the allocation. Therefore, the 5th amendment allocation of 7.175 mgd at Kamole with no option to increase applies (EMI Water Delivery Agreement, 2018).

Ha'ikū Area Streams

Streams to the west of Huelo, between Kakipi Gulch and Kailua Gulch, do not have amended IIFS. Streams in this area are depicted in Exhibit A of the 2003 Consent Decree and are the subject of EMFS Phase 4 Stream Restoration Program.

1.4.2.5 'Aha Wai o Maui Hikina Regional Community Board

The 'Aha Wai o Maui Hikina Regional Community Board (aka East Maui Regional Community Board, aka East Maui Water Authority) was established by public vote on a County charter amendment in November 2022. The Board is made up of eleven members appointed by the County Council and Mayor. It oversees efforts to manage East Maui's watersheds in the Nāhiku, Ke'anae, Honomanū, and Huelo license areas and grow water supply for future generations. A director was appointed by the regional community board with the approval of the County Council, whose powers and duties include but are not limited to:

- Acquire water systems and leases to be managed by the water authorities, including East Maui water licenses.
- Seek funding for water authority operation, maintenance, and capital improvements.
- Manage the distribution of water under the control of the water authorities, including providing water to the Department of Water Supply (Maui County Charter, 2023) .

Implications of the newly formed Board on water source permitting processes and timelines are yet to be determined.

1.4.2.6 IIFS for Na Wai 'Ehā Streams

Amended IIFS are established for four streams of Na Wai 'Ehā in a 2021 CWRM Decision (CCH-MA 15-01) following two decades of contested case hearings. The decision allocated water for instream and off-stream permitted uses. In June 2024, the State of Hawai'i Supreme Court ruled that the

CWRM failed to restore adequate streamflow to Waiheʻe, Waiehu, Wailuku, and Waikapū streams after the closure of the Hawaiian Commercial & Sugar Company (HC&S) sugar plantation in 2016. The case now returns to the CWRM for further investigation, deliberation, and establishment of new IIFS requirements.

The EMFS Phase 3 report relies on the IIFS values established by the 2021 CWRM D&O—the most current information available at this time. However, due to the Supreme Court ruling, IIFS values may change again, and less surface water may be available for off-stream reasonable and beneficial use or for public drinking water supply in the future. Any strategy to use more surface water for MDWS public water supply will require extensive permitting processes and potential contested case hearings, which could delay water source development for several years.

Figure 15 shows the IFS status of streams within the study area.

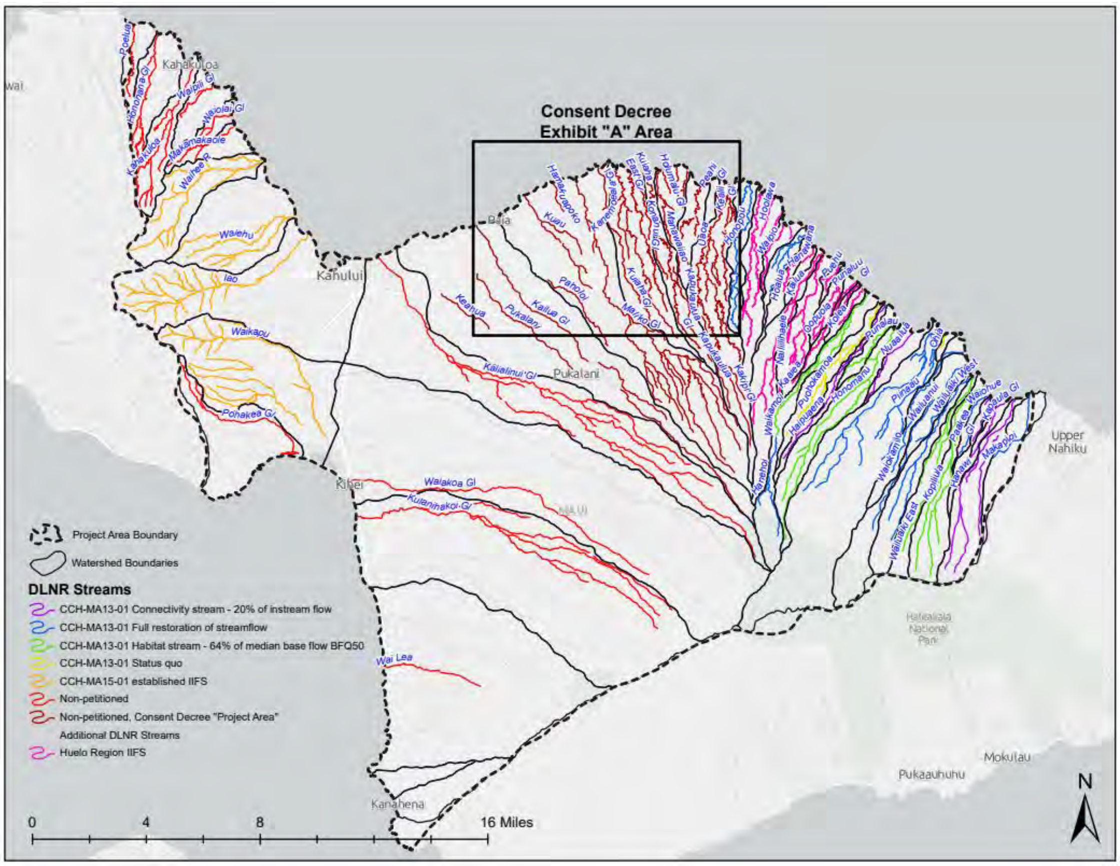

Figure 15. Status of Interim Instream Flow Standards

1.4.3 Current Surface Water Availability

Surface water availability reported in this section is organized into three areas that correspond with aquifer sectors: Na Wai ʻEhā (Wailuku aquifer sector), Central and Upcountry Maui (Central aquifer sector) and East Maui (Koʻolau aquifer sector).

1.4.3.1 Na Wai ʻEhā and the Wailuku Aquifer Sector

Surface water resources in Na Wai ʻEhā and the Wailuku aquifer sector include Waikapū Stream, Wailuku River, Waiehu Stream, and Waiheʻe River. The distribution system from the Na Wai ʻEhā rivers and streams includes the Wailuku Water Company ditch system and the Mahi Pono ditch system, which feed agricultural uses, County drinking water, and kuleana ditches and pipes. There are two major ditches in the system—the Waiheʻe and Spreckels Ditches. The ditches receive river and stream waters via seven active diversions, two on Waiheʻe River, one on South Waiehu Stream, two on Wailuku River, and two on Waikapū Stream.

The 2021 CWRM D&O provides comprehensive information including estimated flows at median flow (Q_{50}), moderate flow (Q_{70}), and low flow (Q_{90}), IIFS, permitted public trust uses, system loss though ditch seepage, permitted off-stream reasonable and beneficial uses, and remaining streamflow. Data provided for Waiehu Stream includes total streamflow and IIFS (CWRM, 2021).

Table 6 shows Na Wai ʻEhā surface water resources, a subset of the Wailuku aquifer sector resources.

Table 6. Wailuku Aquifer Sector Surface Water Resources - Na Wai ʻEhā Streams

Surface Water Hydrologic Unit Code	Stream Name	Status	Total streamflow at Q_{50} (mgd)	Interim Instream Flow Standard[b] (IIFS) (mgd)	Instream Public Trust Use (mgd)	System Loss (mgd)	Maui DWS Permitted Use (mgd)	Permitted off-stream public trust uses (mgd)	Permitted off-stream reasonable beneficial uses (mgd)	Remaining streamflow available at Q_{50}
6001	Waikapū Stream	2021 Amended IIFS (CCH-MA15-01)	5.3[a]	2.9	n/a	0.2	-	0.22	0.55	1.44
6022	Waiheʻe River	2021 Amended IIFS (CCH-MA15-01)	34	10	1.44	2.13	-	4.88	3.17	12.38
6023	North Waiehu Stream	2021 Amended IIFS (CCH-MA15-01)	3.2	All natural flow	-	-	-	-	-	0
6023	South Waiehu Stream	2021 Amended IIFS (CCH-MA15-01)	2.3	0.3	-	-	-	-	-	2.0
6024	Wailuku River	2021 Amended IIFS (CCH-MA15-01)	25	9.3	0.67	0.4	3.2	0.63	0.87	9.9

Source: CWRM Decision and Order CCH-MA15-01, 2021

Notes:

a. Includes Q_{50} of stream at 1160 ft above South Waikapū Ditch plus stream inflow at 1050 ft below South Waikapū Ditch.

b. Note that IIFS and other values are subject to change based on a 2024 Supreme Court decision requiring CWRM to reevaluate IIFS.

Additional surface water hydrologic units in the Wailuku aquifer sector are listed in Table 7.

Table 7. Additional Surface Water Resources in Wailuku Aquifer Sector			
Surface Water Hydrologic Unit	Unit Code	Stream/Gulch Name	IIFS Status
Pohakea	6002	Pohakea Stream, Kanaio Stream, Ma‘alaea Stream, Malalowai‘aole Gulch	HAR §13-169-48
Poelua	6016	Poelua Stream, Alapapa Gulch, Owaluhi Gulch, Papanahoa Gulch	HAR §13-169-48
Honanana	6017	Honanana Stream	HAR §13-169-48
Kahakuloa	6018	Kahakuloa Stream	HAR §13-169-48
Waipili	6019	Waipili Gulch, Makalina Gulch, Wailena Gulch	HAR §13-169-48
Waiolai	6020	Waiolai Gulch, Wai o Kila Gulch	HAR §13-169-48
Makamaka‘ole	6021	Makamaka‘ole Stream, Kupaa Gulch, Maluhia Stream	HAR §13-169-48
Waiehu	6023	Kalae‘ili‘ili Stream, Kalepa Gulch, Kope Gulch, Maniania Gulch	HAR §13-169-48
‘Īao	6024	Kaiapaoka‘ilio Stream, Pu‘ulio Stream	HAR §13-169-48

1.4.3.2 Upcountry and Central Maui

Surface water resources in the Central and Upcountry Maui regions (Central aquifer sector) include 21 streams and gulches located in nine hydrologic units, shown in Table 8. Current streamflow data is not available for streams and gulches in this region, and IIFS status is established by HAR §13-169-44 as existing flow in 1988.

Table 8. Central and Upcountry Maui Surface Water Resources			
Surface Water Hydrologic Unit	Unit Code	Stream/Gulch Name	IIFS Status
Kalialinui	6025	Kalialinui	HAR §13-169-44
Kailua Gulch	6026	Kailua Gulch	HAR §13-169-44
Kailua Gulch	6026	Keahua, Pukalani	HAR §13-169-44
Māliko	6027	Māliko Gulch, Hamakuapoko Gulch, Kanemoeala Gulch, Ku‘au Stream, Paholoi	HAR §13-169-44
‘Āhihi Kinau	6108	n/a	HAR §13-169-44
Mo‘oloa	6109	Mo‘oloa	HAR §13-169-44
Wailea	6110	Wailea, Kapuaikea, Keawakapu, Liilioholo	HAR §13-169-44
Hāpapa	6111	Kulanihakoi Gulch, Waimahaihai, Waipuilani Gulch,	HAR §13-169-44
Waiakoa	6112	Waiakoa	HAR §13-169-44

Stormwater capture for aquifer recharge is a potential water source for Upcountry and Central Maui. The WUDP includes a strategy to "explore and promote opportunities for large volume stormwater runoff for agricultural irrigation (MDWS, 2022)." The Hawai'i Stormwater Reclamation Appraisal Report, and Study Element 3: An Appraisal of Stormwater Reclamation and Reuse Opportunities in Hawai'i (USBR, 2008) assesses a Wai'ale Road Stormwater Drainage option that would use an existing stormwater drainage channel and detention pond located along Wai'ale Road to capture and convey stormwater into the Waihe'e and Spreckels Irrigation Ditch Systems for agricultural irrigation to the south and east.

The Kihei Drainage Master Plan is a comprehensive plan to mitigate flood risk in eight drainage districts corresponding to drainage paths and major gulches. The 2022 study conducted hydrologic analysis for the mauka and makai drainage basins, assessed the existing infrastructure capacity and incorporated future development in the analysis, and recommend possible flood mitigation improvements and estimate the associated costs. Recommendations include construction of detention basins mauka of Pi'ilani Highway for the purposes of both flood and erosion control (R.M. Towill, 2022). Detention basins could also support aquifer recharge.

EMFS Phase 2 explored aquifer storage and recovery (ASR) as a water resources management technique for actively storing water underground during wet periods for recovery when needed, usually during drier periods. The timeframe can range from months to decades. There are two main methods for transfer of water into the aquifer: infiltration (spreading basins) and artificial recharge (injection wells). Historically and currently, spreading basins are the primary technique used for artificial recharge. Surface infiltration systems require permeable soils and unsaturated zones to get water into the ground and to a high-capacity aquifer. Aquifers recharged from infiltration basins must be unconfined and allow lateral flow of water away from the infiltration sites to prevent excessive groundwater mounding. In addition, soils should be free of significant contamination. Injection wells are used to recharge deep aquifers where land application is not effective (USGS, 2018).

There are several challenges for the implementation of stormwater reclamation and reuse programs in Hawai'i, such as water treatment requirements, lack of funding, streamflow standards, and siting of injection wells, which must be at least one-quarter mile from groundwater wells (United States Bureau of Reclamation [USBR], 2008). Stormwater and stream water are both defined as "surface water" in the Hawai'i State Water Code. Regulatory agencies may consider recharge using stream water during high flows differently than stormwater runoff from urbanized areas due to differences in source water quality. Stormwater may require large volumes of at-grade storage to effectively capture flows due to the large volume of stormwater generated over a relatively short period of time.

Regulatory considerations for aquifer storage and development in Hawai'i are in an early stage. The CWRM is open to the idea of using surface water for groundwater recharge, though the potential ramifications to IIFS, methods of recharge, and water treatment requirements need to be further considered. These factors, as well as the recharge location and underlying aquifer type, would affect the CWRM's position on proposed aquifer storage and recovery option. The level of treatment required by DOH depends on the method of recharge and the aquifer system. Direct injection could require treatment to the level of the quality of water in the aquifer being recharged, for example, potable if injecting directly into a potable aquifer. Potential beneficial impacts as well as any potential liabilities or harmful impacts of ASR would need to be further explored.

Increased groundwater SY resulting from using surface water to recharge aquifers could be treated as natural recharge, as applied in SY estimates. The Water Resources Protection Plan (WRPP) includes the CWRM's official estimate of SY, but the CWRM can reassess and adopt new SY outside of the WRPP update process. The CWRM will initiate the process of reevaluating the statewide SY based on the 2023 USGS estimates of future recharge.

Based on an informal discussion with CWRM staff, the CWRM is just beginning to contemplate whether increased SY resulting from surface water recharge could lead to approval of an equivalent increase in groundwater withdrawal. ASR is a topic of interest across Hawaiʻi, warranting further discussion with the CWRM and water supply agencies. The Honolulu Board of Water Supply (BWS) commissioned a study on the "Implications of Climate Change on Water Budgets and Reservoir Water Harvesting of Nuʻuanu Area Watersheds, Oʻahu, Hawaiʻi (Kadi, 2017)." The study assessed the impact of climate change on the water budgets of the Nuʻuanu area watersheds, and most importantly, on the potential of water harvesting from Nuʻuanu Reservoir 4. The harvest approach includes water diversion from the reservoir to artificially supplement groundwater recharge through injection into the subsurface.

It remains to be studied whether ASR would work in Hawai'i's confined versus unconfined aquifers, injection well provisions that may apply, and level of treatment required. Evaluation of the receiving aquifer formation, determination of any required modeling or further verification needed to quantify the potential groundwater benefits and the timeframe required for such validation, will also need to be determined.

1.4.3.3 East Maui

Surface water resources in the East Maui region include (1) water conveyed in Wailoa Ditch to the Kamole Water Treatment Facility, (2) water conveyed in the Upper Kula system to the Olinda Treatment Facility, and (3) water conveyed in the Lower Kula system to the Piʻiholo Treatment Facility.

Although the EMI system includes multiple ditches, the Wailoa Ditch is the primary focus of this analysis since it currently conveys surface water used by MDWS. Wailoa Ditch diverts water primarily from Waikamoi, Puohokamoa, Haʻipuaʻena, Kōlea, Kaʻaiea, Oʻopuloa, Makanali, Nailiʻilihaele, Kailua, Hoalua, Hoʻolawa, and Honomanū streams.

A 2022 CWRM report on Low-Flow Characteristics and Surface Water Availability in East Maui estimated flows for the Wailoa Ditch using mean daily flow at continuous-record ditch-flow gaging stations and subtracting out mean daily flow from streams with continuous-record gaging stations. Table 9 summarizes information on the MDWS Upper and Lower Kula systems, and EMI's Wailoa Ditch from the report (CWRM, 2022).

Table 9. East Maui Surface Water Resources - Ditches

System	Q_{50}	Q_{70}	Q_{90}
Upper Kula System	0.86	0.32	0.11
Lower Kula System	13.7	7.1	2.7
Wailoa Ditch	69	31	17

Note: Discharge in mgd for selected percentages of time that the indicated discharge was equaled or exceeded.

Data from surface water gaging stations on ditches is compiled monthly by the CWRM. Figure 16 shows monthly surface water gaging data from Wailoa Ditch at Opana Gulch. A significant decrease is seen following the 2016 closure of the HC&S sugar plantation.

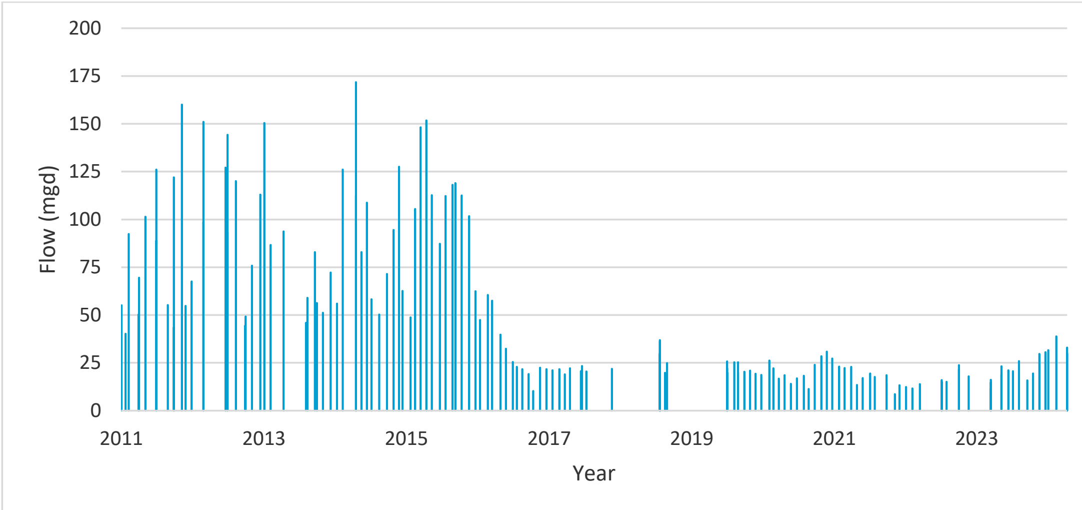

Figure 16. Monthly Surface Water Gaging Data: Wailoa Ditch at Opana

Use of surface water from the EMI system is currently permitted through annual revocable permits from the BLNR, which have been challenged in court. In December 2023, the total cap amount of the permit to A&B and EMI was 38.25 mgd averaged annually, with 31.25 mgd granted to the permittee for agricultural use, 6 mgd to the County for Kamole Weir, and 1 mgd to Kula Agricultural Park (BLNR, 2023). The cap amount is subject to current and future IIFS determinations. As of June 30, 2024, the annual average water usage for diversified agriculture was 28.43 mgd, for MDWS was 1.23 mgd at Kamole Weir, and for Kula Agricultural Park was 0.48 mgd (EMI, 2024).

Average water usage at Kamole Weir varies considerably month-to-month according to seasonal demand. Figure 17 shows monthly average water use measured as quantity of water processed at Kamole Weir from 2015 to 2024.

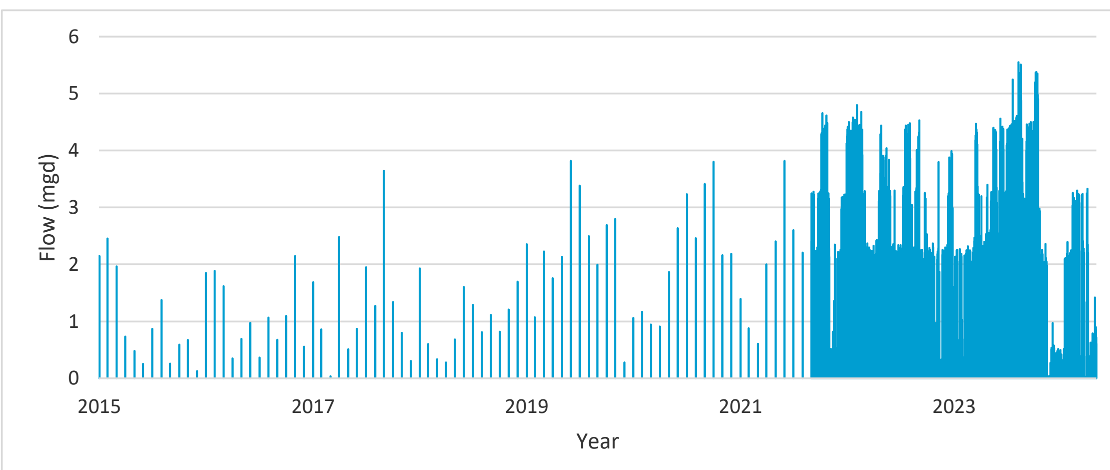

Figure 17. Monthly Surface Water Gaging Data: Kamole Weir

Source: CWRM 2024

Table 10 summarizes surface water resources within the East Maui region of the study area.

Table 10. East Maui Surface Water Resources - Streams

Surface Water Hydrologic Unit	Unit Code	Stream/Gulch Name	Status	Total streamflow at Q_{50} (mgd)	IIFS (mgd)
Kuiaha	6028	Kuiaha Stream, Konanui Gulch, Kuiaha East Gulch	HAR §13-169-44	-	Status quo
Kaupakulua	6029	Kaupakulua, Awalau, Opaepilau, Kalakohi	HAR §13-169-44	-	Status quo
Manawaiʻiao	6030	Manawaiʻiao, Holumalu, Manawai, Opana	HAR §13-169-44	-	Status quo
Uaoa	6031	Uaoa	HAR §13-169-44	-	Status quo
Kealiʻi	6032	Kealiʻi	HAR §13-169-44	-	Status quo
Kakipi	6033	Kakipi, Papalua, Kapalaʻalea, Halehaku, Makaʻa, Kaulu, Piʻiloi	HAR §13-169-44	-	Status quo
Honopou	6034	Honopou	CCH-MA13-01 Full restoration of streamflow	4.2	n/a
Hoʻolawa	6035	Hoʻolawaliilii	2022 Amended IIFS	1.78	Various
Hoʻolawa	6035	Hoʻolawanui	2022 Amended IIFS	1.61	Various
Hoʻolawa	6035	Honokala Gulch	HAR §13-169-44	-	Status quo
Hoʻolawa	6035	Mokupapa Gulch	HAR §13-169-44	-	Status quo
Waipiʻo	6036	Waipiʻo	2022 Amended IIFS	0.39	Various
Waipiʻo	6036	Waipiʻonui	HAR §13-169-44	-	Status quo
Hanehoi	6037	Huelo/Puolua	CCH-MA13-01 Full restoration of streamflow	0.95	n/a
Hanehoi	6037	Hanehoi	CCH-MA13-01 Full restoration of streamflow	1.64	n/a
Hoalua	6038	Hoalua	2022 Amended IIFS	0.70	Various
Hoalua	6038	East Hoalua	2022 Amended IIFS	0.59	Various
Hānawana	6039	Hānawana	2022 Amended IIFS	0.24	Various
Kailua	6040	Kailua	2022 Amended IIFS	5.38	Various
Kailua	6040	Oanui	2022 Amended IIFS	0.91	Various
Naʻiliʻilihaele	6041	Naʻiliʻilihaele	2022 Amended IIFS	7.00	Various
Puehu	6042	Pa	2022 Amended IIFS	0.05	Various
Oʻopuola	6043	West Oʻopuola	2022 Amended IIFS	0.19	Various
Oʻopuola	6043	Oʻopuola Tributary	2022 Amended IIFS	0.13	Various
Oʻopuola	6043	Oʻopuola	2022 Amended IIFS	0.54	Various
Oʻopuola	6043	Makanali	2022 Amended IIFS	0.15	Various
Kaʻaiea	6044	Kaʻaiea	2022 Amended IIFS	2.05	Various
Punaluʻu	6045	Punaluʻu	2022 Amended IIFS	0.26	Various
Kōlea	6046	West Kōlea	2022 Amended IIFS	0.35	Various
Kōlea	6046	East Kōlea	2022 Amended IIFS	0.16	Various

Table 10. East Maui Surface Water Resources - Streams					
Surface Water Hydrologic Unit	Unit Code	Stream/Gulch Name	Status	Total streamflow at Q_{50} (mgd)	IIFS (mgd)
Waikamoi	6047	Wahinepe'e	HAR §13-169-44	-	Status quo
Waikamoi	6047	Waikamoi	CCH-MA13-01 Habitat stream - 64% of median base flow BFQ_{50}	4.33	2.46
Puohokamoa	6048	Puohokamoa	CCH-MA13-01 Status quo	5.43	0.71
Haʻipuaʻena	6049	Haʻipuaʻena	CCH-MA13-01 Connectivity stream - 20% of instream flow	3.17	0.88
Punalau/Kōlea	6050	Punalau/Kōlea	CCH-MA13-01 Habitat stream - 64% of median base flow BFQ_{50}	2.91	1.87
Honomanū	6051	Honomanū	CCH-MA13-01 Habitat stream - 64% of median base flow BFQ_{50}	2.71	2.71
Nuaʻailua	6052	Nuaʻailua	CCH-MA13-01 Connectivity stream - 20% of instream flow	0.18	1.42
Piʻinaʻau	6053	Piʻinaʻau	CCH-MA13-01 Full restoration of streamflow	9.05	n/a
Piʻinaʻau	6053	Palauhulu	CCH-MA13-01 Full restoration of streamflow	7.11	n/a
ʻŌhiʻa/Waianu	6054	ʻŌhiʻa/Waianu	HAR §13-169-44	3.04	Status quo
Waiokamilo	6055	Waiokamilo	CCH-MA13-01 Full restoration of streamflow	2.52	n/a
Wailuānui	6056	Wailuānui	CCH-MA13-01 Full restoration of streamflow	3.94	n/a
W. Wailuāiki	6057	W. Wailuāiki	CCH-MA13-01 Full restoration of streamflow	3.88	n/a
E. Wailuāiki	6058	E. Wailuāiki	CCH-MA13-01 Habitat stream - 64% of median base flow BFQ_{50}	3.75	2.39
Kopiliʻula	6059	Puaʻakaʻa	CCH-MA13-01 Connectivity stream - 20% of instream flow	0.71	0.13
Kopiliʻula	6059	Kopiliʻula	CCH-MA13-01 Habitat stream - 64% of median base flow BFQ_{50}	3.23	2.07
Waiohue	6060	Waiohue	CCH-MA13-01 Full restoration of streamflow	3.23	n/a
Paʻakea	6061	Paʻakea	CCH-MA13-01 Connectivity stream - 20% of instream flow	0.58	0.12
Waiaʻaka	6062	Waiaʻaka	CCH-MA13-01 Connectivity stream - 20% of instream flow	0.49	0.49
Kapāʻula	6063	Kapāʻula	CCH-MA13-01 Connectivity stream - 20% of instream flow	1.81	0.36
Hanawī	6064	Hanawī	CCH-MA13-01 Connectivity stream - 20% of instream flow	2.97	0.59
Makapipi	6065	Makapipi	CCH-MA13-01 Full restoration of streamflow	0.84	n/a

1.4.4 Long-term Surface Water Availability

Long-term surface water availability is dependent on regulatory, legal, and environmental factors. Any efforts to change the amount of surface water available for off-stream uses including public water supply will require community input and approval from regulatory authorities, which could take many years. Climate change is anticipated to affect surface water resources in both the near- and long-term (Hawaii Climate Change Portal, 2024).

1.4.4.1 Climate Change Impacts

There have been substantial declines in rainfall over the last century, particularly from 1984 to 2013 coupled with recent droughts (CWRM, 2022). The projected mean annual rainfall anomalies for a mid-century scenario indicates drying across much of central and leeward Maui along with wetting across parts of the windward slopes of Haleakalā. The greatest drying is projected to occur across leeward Maui and includes aquifer systems, where mean annual rainfall is projected to decrease by more than 30 percent. Windward areas of Haleakalā show increases in projected rainfall of as much as 10 percent. Island-wide mean annual rainfall is projected to decrease by 8.3 percent (Timm, 2015 and Kāne, 2023).

Figure 18 shows projected changes to mean annual rainfall for a mid-century climate scenario.

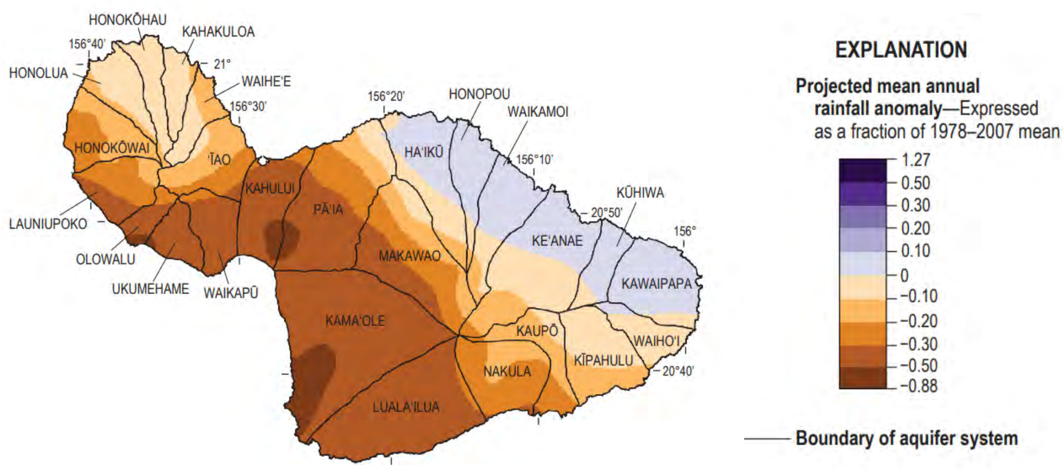

Figure 18. Maps of Mean Annual Rainfall Changes for a Mid-century Climate Scenario

Source: Timm, 2015 and Kāne, 2023

Areas with declining rainfall amounts will have reduced stream and ditch flows for longer periods, affecting the potential amount of surface water availability in the future.

1.4.4.2 Operational Limitations and Source Resilience

Surface water is subject to seasonal variations in rainfall. During periods of low flows, there is frequently not enough surface water to meet the demands of all users. Additional storage for raw surface water would enable MDWS to capture more water during normal and high flows, for use during drought periods. Surface water during heavy rainfall events becomes more turbid and thus more complicated to treat to drinking water standards. Reliance of Upcountry Maui on surface water could be reduced by interconnecting the Central and Upcountry water systems or developing new groundwater source within the area.

Watershed restoration and management are key to improving the long-term resilience of surface water resources. The WUDP includes a strategy to “continue Maui County financial support for watershed management partnerships’ fencing and weed eradication efforts…protecting and restoring the resilience of natural aquatic ecosystems and thereby protecting ground and surface water resources and a range of ecosystem services (MDWS, 2022).”

Section 2: Non-Economic Analysis

A multiple criteria decision analysis (MCDA) was used to rank water source alternatives according to a set of non-economic evaluation criteria. MDWS staff provided input on the criteria and confirmed the high-ranked water source alternatives for further analysis. This section outlines the alternatives considered, the evaluation criteria, ranking of alternatives, and sources carried forward into the cost-benefit analysis.

2.1 Methodology

The MCDA for Phase 3 built upon analysis conducted in Phase 2 of the EMFS, summarized below. Phase 3 evaluated the relative benefits of all potential water sources within the study area, including the top 12 strategies identified in Phase 2.

2.1.1 Phase 2 Analysis of Waikapū, ʻIao, and Waiheʻe Hydrologic Units Surface Water

Phase 2 of the EMFS included assessment of the surface water supply from the Waikapū, ʻIao, and Waiheʻe hydrologic units and an analysis of the costs and benefits of using these resources for public drinking water. Twenty-nine potential supply and development strategies were vetted through a non-economic MCDA that included water source, infrastructure, environment, and permitting considerations. The top 12 strategies were carried forward into the Phase 3 MCDA, with their associated calculations on the amount of water available, storage, and infrastructure requirements.

Streamflow data was analyzed for the ʻĪao and Waiheʻe hydrologic units. The 1987 to 2004 timeframe aligns with data used in the 2021 D&O (CWRM, 2021), while 2002 to 2022 represents a more recent dataset. In consultation with the CWRM, a 14-percent reduction was applied to the 2002 to 2022 streamflow data as an estimate of future streamflow in the Wailuku and Waiheʻe rivers to reflect climate change conditions. Due to limited historical streamflow data available for the Waikapū and Waiehu hydrologic units, streamflow data from the 2021 D&O with a 14-percent reduction factor were used to estimate current and future surface water availability for the Waikapū Stream.

The Phase 2 report summarizes the availability of the potential surface water sources under (1) current IIFS, (2) years 2002 to 2022 streamflow data, and (3) climate-adjusted 14-percent reduction. The amounts of surface water listed are the minimum supply during high flows above Q_{50} which do not impact existing IIFS and currently permitted surface water withdrawals. On many days throughout the year, there is greater flow than those minimums. The hierarchy of uses from the IIFS tables in the 2021 CWRM Order was followed, meaning that the first amount to decrease is remaining streamflow, followed by permitted off-stream reasonable and beneficial uses, then off-stream public trust uses.

The 12 surface water resource strategies carried from Phase 2 into Phase 3 are Diversion During High Flows Above Q_{50} for (1) Waikapū Stream, (2) Wailuku River, (3) Waiehu Stream and (4) Waiheʻe River; Diversion of Unallocated Remaining Streamflow for (5) Waikapū Stream, (6) Wailuku River, (7) Waiehu Stream, and (8) Waiheʻe River; and Reallocation of Off-Stream Reasonable & Beneficial Uses for (9) Waikapū Stream, (10) Wailuku River, (11) Waiehu Stream, and (12) Waiheʻe River. The amounts of surface water available for each of these strategies are based on the climate-adjusted scenario and are included in Section 1 of this report.

2.1.2 Phase 3 MCDA Methodology

The Phase 3 non-economic MCDA strategy evaluation methodology is as follows:

1. **Define the objective.** In this study, the objective is to find the top-ranked water source options to take forward to a cost-benefit analysis.
2. **Identify potential water sources.** Review groundwater and surface water sources within the Phase 3 study area. Assign unique identification (ID) numbers.
3. **Define general categories and criteria** used to evaluate and score strategies.
4. **Identify "fatal flaw" conditions.** Eliminate strategies with fatal flaws.
5. **Evaluate and score each strategy** based on criteria.
6. **Assign relative weights** to categories and criteria.
7. **Determine weighted ranking** for each strategy.
8. **Identify preferred strategies** based on weighted high scores.

This section will further describe each of the steps in the strategy evaluation methodology.

2.2 Potential Groundwater Water Sources

A total of 46 groundwater sources within the study area were identified as alternatives. Each aquifer within the study area was divided into applicable elevation ranges: (1) below 500 feet, (2) 501 – 1,500 feet, and (3) 1,501 – 4,000 feet. Initial alternatives for each aquifer elevation range included existing wells, legacy wells, or potential new well sites. Table 11 shows the potential groundwater sources evaluated in the non-economic analysis.

Table 11. Potential Groundwater Sources for Non-economic Analysis

ID No.	Aquifer Sector	Water Source Option
1	Ko'olau	Ha'ikū aquifer existing wells < 500 ft
2	Ko'olau	Ha'ikū aquifer existing wells 501 – 1,500 ft
3	Ko'olau	Ha'ikū aquifer new well(s) < 500 ft
4	Ko'olau	Ha'ikū aquifer new well(s) 501 – 1,500 ft
5	Ko'olau	Ha'ikū aquifer new well(s) 1,501 – 4,000 ft
6	Ko'olau	Honopou aquifer new well(s) < 500 ft
7	Ko'olau	Honopou aquifer new well(s) 501 – 1,500 ft
8	Ko'olau	Honopou aquifer new well(s) 1,501 – 4,000 ft
9	Ko'olau	Waikamoi aquifer new well(s) < 500 ft
10	Ko'olau	Waikamoi aquifer new well(s) 501 – 1,500 ft
11	Ko'olau	Waikamoi aquifer new well(s) 1,501 – 4,000 ft
12	Ko'olau	Ke'anae aquifer new well(s) < 500 ft
13	Ko'olau	Ke'anae aquifer new well(s) 501 – 1,500 ft
14	Ko'olau	Ke'anae aquifer new well(s) 1,501 – 4,000 ft
15	Wailuku	Kahakuloa aquifer new well(s) < 500 ft

Table 11. Potential Groundwater Sources for Non-economic Analysis		
ID No.	Aquifer Sector	Water Source Option
16	Wailuku	Kahakuloa aquifer new well(s) 501 – 1,500 ft
17	Wailuku	Kahakuloa aquifer new well(s) 1,501 – 4,000 ft
18	Wailuku	Waiheʻe aquifer existing wells 501 -1,500 ft
19	Wailuku	Waiheʻe aquifer new well(s) < 500 ft
20	Wailuku	Waiheʻe aquifer new well(s) 501 – 1,500 ft
21	Wailuku	Waiheʻe aquifer new well(s) 1,501 – 4,000 ft
22	Wailuku	ʻĪao aquifer existing wells < 500 ft
23	Wailuku	ʻĪao aquifer existing wells 501 -1,500 ft
24	Wailuku	ʻĪao aquifer new well(s) < 500 ft
25	Wailuku	ʻĪao aquifer new well(s) 501 – 1,500 ft
26	Wailuku	ʻĪao aquifer new well(s) 1,501 – 4,000 ft
27	Wailuku	Waikapū aquifer existing wells < 500 ft
28	Wailuku	Waikapū aquifer existing wells 501 – 1,500 ft
29	Wailuku	Waikapū aquifer new well(s) < 500 ft
30	Wailuku	Waikapū aquifer new well(s) 501 – 1,500 ft
31	Wailuku	Waikapū aquifer new well(s) 1,501 – 4,000 ft
32	Central	Makawao aquifer existing wells 1,501 – 4,000 ft
33	Central	Makawao aquifer new well(s) 1,000 – 1,500 ft
34	Central	Makawao aquifer new well(s) 1,501 – 4,000 ft
35	Central	Kahului aquifer existing wells < 500 ft
36	Central	Kahului aquifer legacy wells < 500 ft
37	Central	Kahului aquifer new well(s) < 500 ft
38	Central	Kamaʻole aquifer existing wells < 500 ft
39	Central	Kamaʻole aquifer legacy wells < 500 ft
40	Central	Kamaʻole aquifer new well(s) < 500 ft
41	Central	Kamaʻole aquifer new well(s) 501 – 1,500 ft
42	Central	Kamaʻole aquifer new well(s) 1,501 – 4,000 ft
43	Central	Pāʻia aquifer existing wells 501 – 1,500 ft
44	Central	Pā'ia aquifer legacy wells 501 – 1,500 ft
45	Central	Pāʻia aquifer new well(s) < 500 ft
46	Central	Pāʻia aquifer new well(s) 501 – 1,500 ft

Figure 19 shows a map of elevation bands by aquifer system.

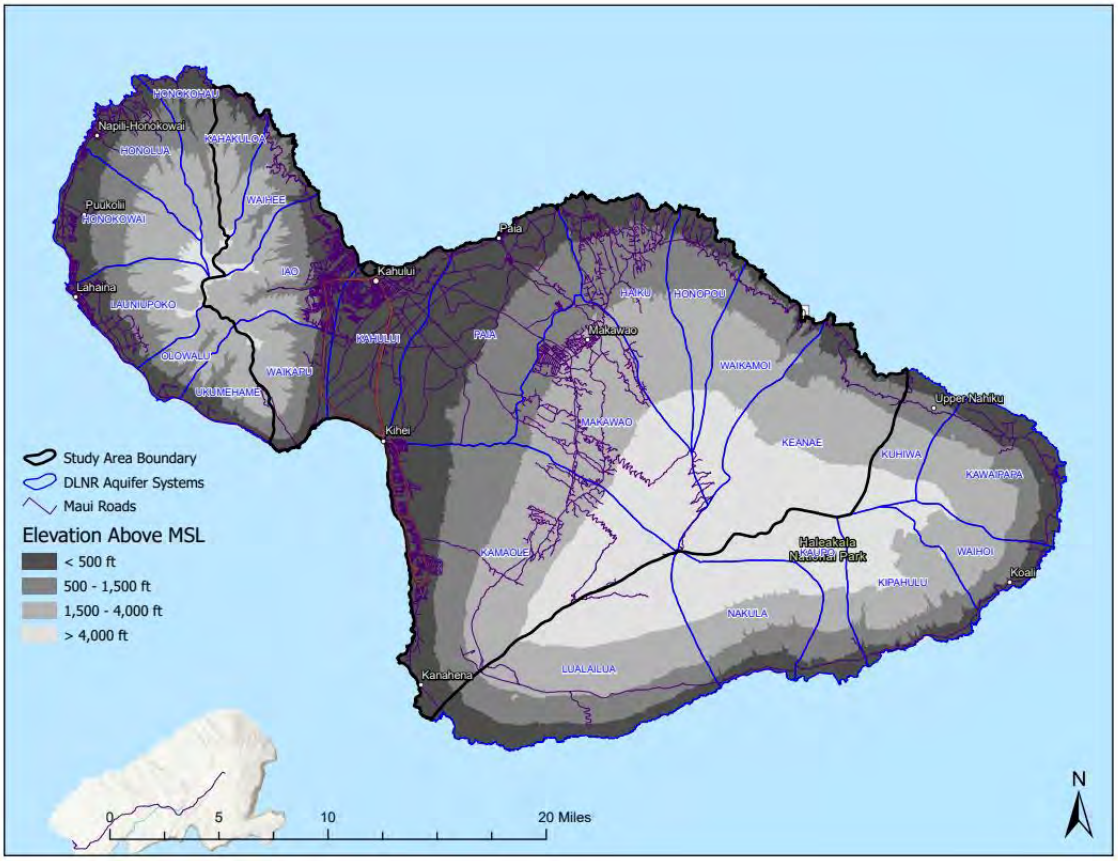

Figure 19. Elevation Bands by Aquifer System

2.3 Potential Surface Water Sources

A total of 22 surface water source options were identified as alternatives, grouped by (1) available base flow in the stream or ditch, (2) reallocate permitted uses, (3) improve ditches, (4) high stream or ditch flows, and (5) stormwater. Options 52 through 66 were analyzed in Phase 2 and carried forward into Phase 3 for evaluation against other potential water sources in Central, East, and Upcountry Maui. Table 12 shows potential surface water sources evaluated in the non-economic analysis.

Table 12. Potential Surface Water Sources for Non-Economic Analysis

ID No.	Aquifer Sector	Water Source Option
47	Ko'olau	East Maui available base flows in Wailoa Ditch
48	Ko'olau	Improve Wailoa Ditch
49	Ko'olau	East Maui reallocation of permitted uses from Wailoa Ditch

Table 12. Potential Surface Water Sources for Non-Economic Analysis		
ID No.	Aquifer Sector	Water Source Option
50	Koʻolau	East Maui high flows from Wailoa Ditch
51	Koʻolau	Lower Kula system expansion
52	Wailuku	Waiheʻe River available base flows
53	Wailuku	Waihe'e River reallocate permitted uses
54	Wailuku	Waihe'e River high flows
55	Wailuku	Improve Waihe'e Ditch
56	Wailuku	Wailuku River available base flows
57	Wailuku	Wailuku River reallocate permitted uses
58	Wailuku	Wailuku River high flows
59	Wailuku	Improve Spreckels Ditch
60	Wailuku	Waikapū Stream available base flows
61	Wailuku	Waikapū Stream reallocate permitted uses
62	Wailuku	Waikapū Stream high flows
63	Wailuku	Improve Waikapū Ditch
64	Wailuku	Waiehu Stream available base flows
65	Wailuku	Waiehu Stream reallocate permitted uses
66	Wailuku	Waiehu Stream high flows
67	Central	South Maui stormwater
68	Central	Upcountry stormwater

2.4 Evaluation Criteria

Evaluation criteria were developed for surface water sources and groundwater sources. Some criteria apply to both groundwater and surface water but may have different definitions. Other criteria are unique to the source type. Each set of criteria are organized into six categories: (1) water source, (2) diversity and supply-demand area, (3) environmental, (4) permitting, (5) infrastructure, and (6) energy. Figure 20 shows water source evaluation categories and criteria.

Category	Groundwater Criteria	Surface Water Criteria
Water Source	Quantity Groundwater sustainability Saltwater intrusion risk Groundwater quality	Quantity Surface water reliability Surface water quality
Diversity and Supply-Demand Area	Source Location and Type Diversity Supply-Demand Area	Source Location and Type Diversity Supply-Demand Area
Environmental	Groundwater Dependent Ecosystems (GDE) Climate impacts Drought resilience Wildfire risk	Surface Water Ecosystems Climate impacts Drought resilience Wildfire risk
Permitting	Groundwater permitting complexity Transmission permitting complexity	Surafce water permitting complexity Transmission permitting complexity
Infrastructure	Well elevation Topography Proximity to water system Treatment complexity	Raw surface water storage availability Proximity to water system Treatment complexity
Energy	Energy grid accessibility Energy grid capacity Energy grid risk	Energy grid accessibility Energy grid risk

Figure 20. Water Source Evaluation Criteria

2.4.1 Water Source

Criteria used to evaluate water source quantity, sustainability, saltwater intrusion risk, and quality are summarized in Figure 21. Data and definitions are further described in this section and a complete table of definitions is included in Appendix A.

Fatal Flaw Score = 0 | Least Favorable | Most Favorable

	Least Favorable	Most Favorable
Quantity	0 - 5 mgd sustainable yield (SY) or low surface water flow	> 20 mgd sustainable yield (SY) or > 10 mgd surface water flow
Sustainability/ Reliability	< 10 % SY remaining or < 50 % days flow available	> 60% SY remaining or > 75% days flow available
Saltwater intrusion risk (GW only)	High near-term risk of salinity reaching > 250 ppm	Low long-term risk of salinity reaching > 250 ppm
Quality	Many groundwater contamination sources, or high stream/ditch flows	Few contamination sources, or base stream/ditch flows

Figure 21. Water Source Criteria

2.4.1.1 Groundwater Quantity

The quantity of groundwater potentially available is calculated by subtracting current pumpage (CWRM, 2023) and DHHL reservations (SWPP, 2017 and CWRM, 2022) from each aquifer's SY. Aquifers are rated as favorable in the quantity criterion if they have more than 20 mgd remaining SY, moderate with 5 to 20 mgd remaining SY, least favorable with 0.1 to 5 mgd remaining SY, and fatally flawed if there is no remaining SY. Kahului Aquifer is fatally flawed for having a negative amount of remaining SY.

2.4.1.2 Groundwater Sustainability

Groundwater sustainability is quantified by calculating the percent of each aquifer's SY that is remaining. Aquifers are rated as favorable in the sustainability criterion if they have more than 60 percent of SY remaining, moderate with 30 to 60 percent SY remaining, least favorable with 10 to 30 percent SY remaining, and fatally flawed with less than 10 percent SY remaining. This fatal flaw condition is consistent with CWRM policy to not permit additional wells in aquifers with less than 10 percent SY remaining. Kahului and Īʻao aquifers are fatally flawed according to this criterion.

2.4.1.3 Groundwater Saltwater Intrusion Risk

Groundwater saltwater intrusion risk is estimated for elevation ranges in each aquifer. Aquifers are rated as favorable in this criterion if there is a low long-term risk of salinity reaching more than 250 parts per million (ppm), and least favorable if there is a high near-term risk of salinity reaching more than 250 ppm (INTERA, 2023).

2.4.1.4 Groundwater Quality

Groundwater quality is assessed based on known or potential contamination from a set of land uses or historic sources—historic pineapple and sugarcane cultivation with associated pesticides, onsite wastewater disposal systems like cesspools with associated nitrates, wastewater treatment facilities, commercial or industrial-zoned lands, airports, and leaking underground storage tanks with associated industrial contaminants (Hawaiʻi State GIS Data, 2023).

Aquifers are rated as favorable in the water quality criterion if fewer than two potential historic sources of contamination are present, moderate with three to four potential contamination sources (additional treatment may be needed), least favorable with five to seven potential contamination sources (granular activated carbon [GAC] or other treatment may be needed) and fatally flawed if contamination is not treatable to drinking water standards. Figure 22 through Figure 26 show examples of the potential contamination sources.

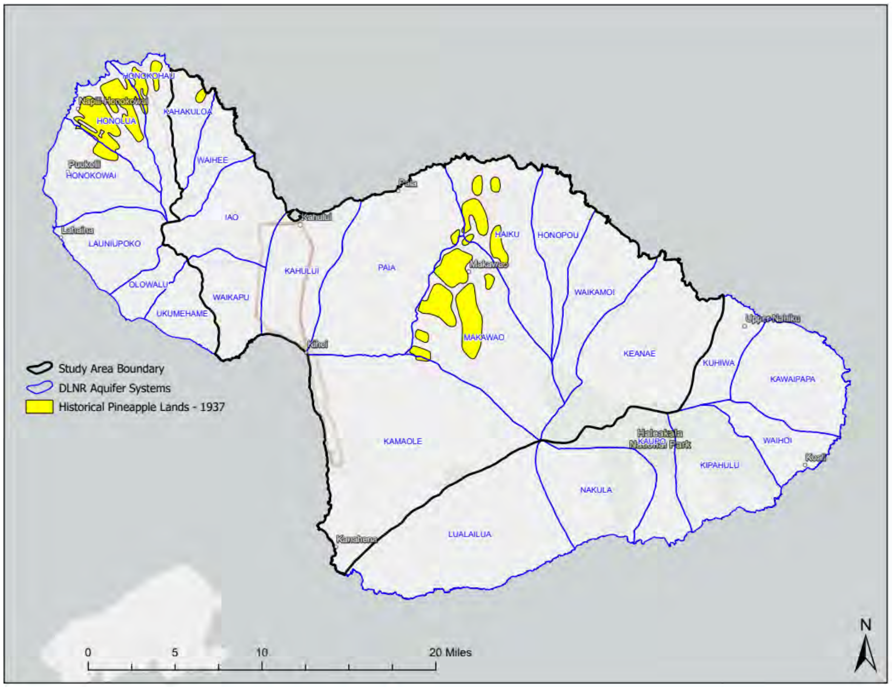

Figure 22. Map of Historical Pineapple Cultivation Lands

Source: DOH, 2007

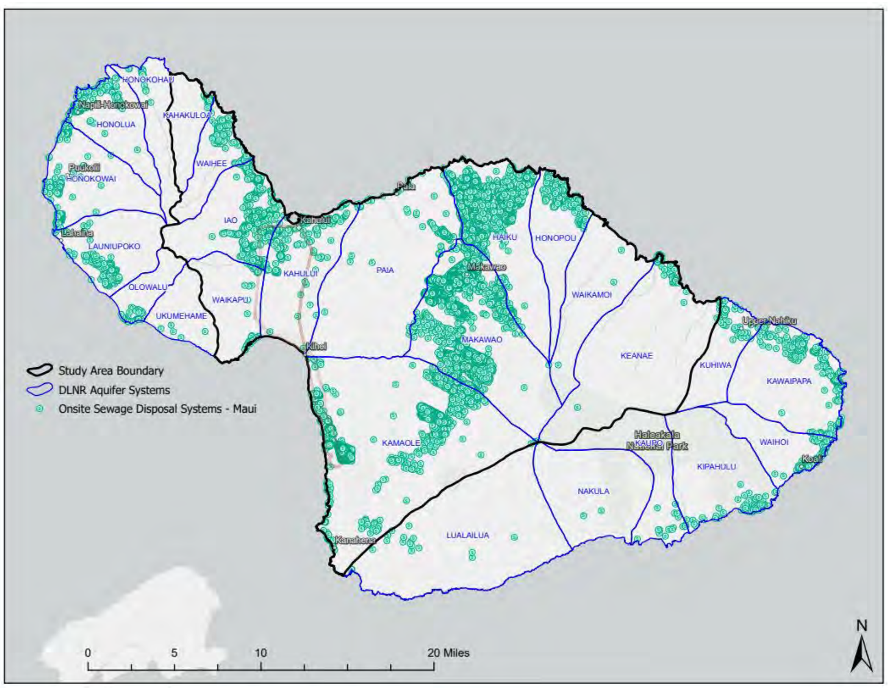

Figure 23. Map of Onsite Sewage Disposal Systems

Source: DOH, 2007

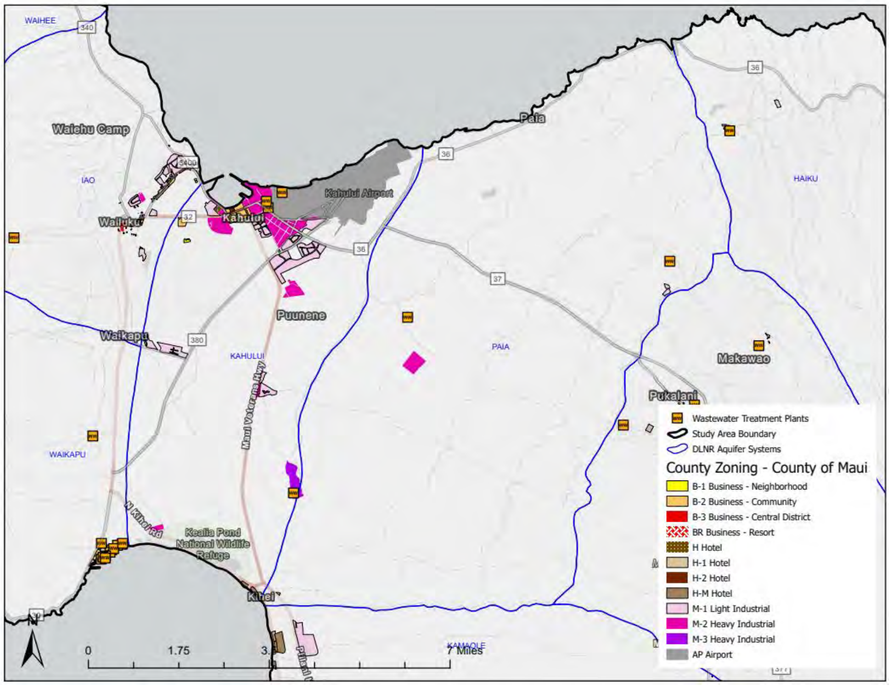

Figure 24. Map of Central Maui Land Use Zoning and WTFs

Source: Maui County, 2023

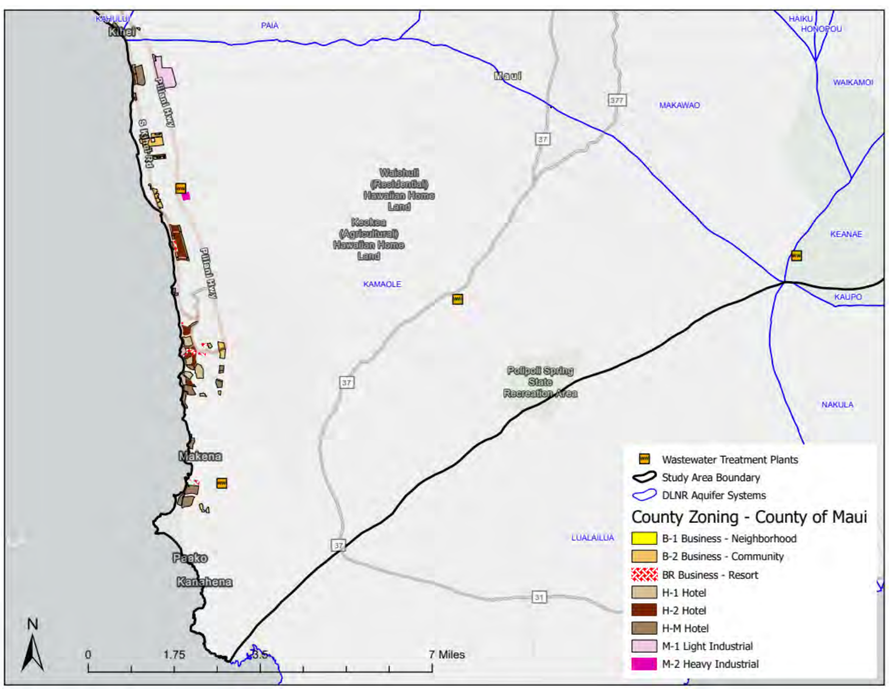

Figure 25. Map of South Maui Land Use Zoning and WTFs

Source: Maui County, 2023

Brown AND Caldwell

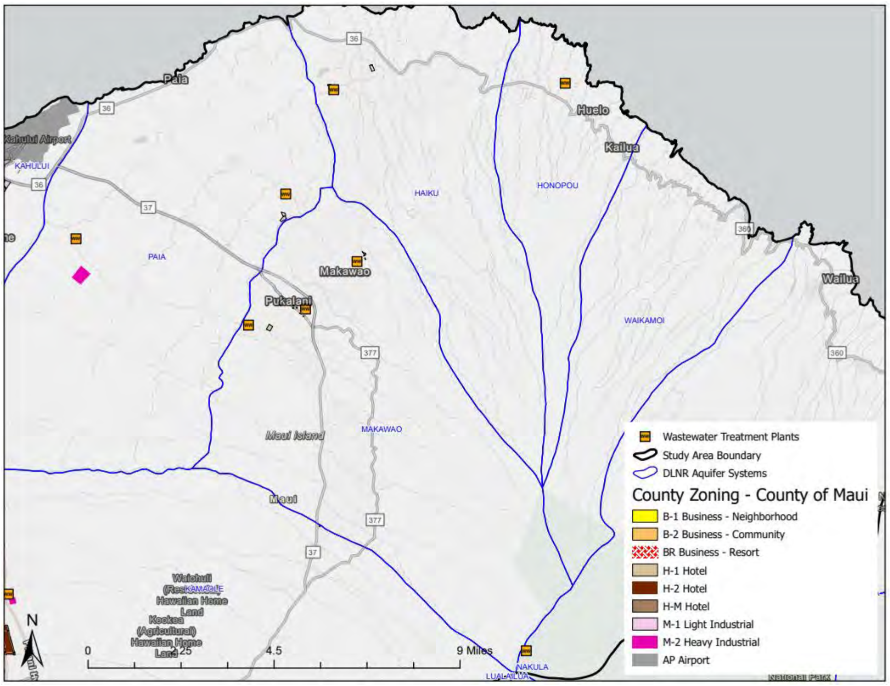

Figure 26. Map of Upcountry and North Shore Land Use Zoning and WTFs

Source: Maui County, 2023

2.4.1.5 Surface Water Quantity

Surface water quantity is estimated for each potential source using the most current data available from USGS, CWRM, or MDWS gages and meters as described in Section 1. Streams and ditches are rated as favorable in the quantity criterion if there is more than 10 mgd available, moderate with 5 to 10 mgd, least favorable with 1 to 5 mgd, and fatally flawed with less than 1 mgd. Waikapū and Waiehu streams are fatally flawed according to this criterion.

2.4.1.6 Surface Water Reliability

Surface water reliability is assigned based on the percent of days a given quantity of surface water is available from 1987 to 2004 for Waikapū Stream, Wailuku River, Waiehu Stream, and Waihe‘e River (BC, 2023), or from 1984 to 2013 for Wailoa Ditch, and the Lower and Upper Kula Water systems (CWRM, 2022). A stream or ditch is rated as favorable if the quantity specified is available more than 75 percent of days, moderate if available 51 to 75 percent of days, least favorable if available 50 percent of days or less, and fatally flawed if classified as intermittent.

2.4.2 Diversity and Supply-Demand Area Criteria

Criteria used to evaluate source location diversity, source type diversity, and supply-demand areas are summarized in Figure 27.

Fatal Flaw Score = 0	Least Favorable	Most Favorable
Source Location Diversity	Located in area where County currently has source	Located in area where County does not currently have source
Source Type Diversity	Would not diversify existing source(s)	Would diversify existing source(s)
Supply-Demand Areas	Located outside demand area	Located in a demand area (Kamaole, ʻĪao, Kahului, or Makawao aquifer)

Figure 27. Diversity and Supply-Demand Area Criteria

2.4.2.1 Source Location and Type Diversity

Water source location and type diversity is considered favorable if located in an area where the County does not currently have a source, moderate if located in an area where the County has an active source and the type (surface water or groundwater) would increase supply diversity, and least favorable if located in an area where the County currently has the same type of source.

2.4.2.2 Supply-Demand Areas

The supply-demand area criterion is considered least favorable for water sources located in an aquifer system outside of the MDWS Central or Upcountry system demand area, moderate for sources located in an aquifer system with moderate demand (Waikapū, Waihe'e, and Pāʻia aquifers), and most favorable for sources located in an aquifer system with current and future demand associated with the Central or Upcountry systems (Kamaʻole, Īʻao, Kahului, Haʻikū, or Makawao aquifers).

2.4.3 Environmental Criteria

Environmental criteria used to evaluate climate impacts, drought resilience, wildfire risk, and potential impacts to ecosystems are summarized in Figure 28.

Fatal Flaw Score = 0	Least Favorable	Most Favorable
Ecosystems	Multiple groundwater dependent ecosystems (GDE) impacted or diversion of base stream/ditch flows	Few or no GDEs impacted, or diversion of high flows
Climate impacts	Decrease in groundwater recharge projected	Increase in groundwater recharge projected
Drought resilience	Surface water	Groundwater
Wildfire risk	"High" risk communities	"Low" risk communities

Figure 28. Environmental Criteria

2.4.3.1 Groundwater Dependent Ecosystems

Groundwater dependent ecosystems (GDEs) are ecosystems that rely on subsurface flow of groundwater, such as fishponds (loko iʻa), anchialine pools, and nearshore ecosystems (INTERA, 2023). Potential impacts to groundwater ecosystems were rated as favorable for sources where one or fewer GDEs would potentially be impacted, moderate for sources where two GDEs would potentially be impacted, and least favorable for sources where three or more GDEs would potentially be impacted. Potential impacts to GDEs were evaluated based on maps of estuarine wetlands (Hawaii State GIS Program, 2023) and fieldwork knowledge from previous water resource studies.

2.4.3.2 Surface Water Ecosystems

Potential impacts to surface water ecosystems were considered favorable for diversion of high flows above Q_{50} where impacts are unknown, moderate for diversion of medium flows between Q_{75} and Q_{50} where impacts are more likely, and least favorable for diversion of lower flows below Q_{75} which may be most likely to impact surface water ecosystems.

2.4.3.3 Climate Impacts

Potential climate impacts are considered favorable for surface water and groundwater sources in aquifers where a 1- to 3-percent increase in groundwater recharge is projected (Kane, 2023), moderate for sources in aquifers where a 1- to 30-percent decrease in groundwater is projected, and least favorable for sources in aquifers where a 30- to 80-percent decrease in groundwater recharge is projected. Specific to potential surface water sources, status quo or increased stream flow (e.g., more high flow conditions) in areas with projected increase to groundwater recharge is considered favorable versus decreased stream flow in areas with projected decline in groundwater recharge is considered less favorable.

2.4.3.4 Drought Resilience

Groundwater sources are considered most favorable and drought resilient, surface water coming from a ditch or multiple streams is considered moderately favorable and less resilient, and surface water coming from an individual stream is considered least favorable and least resilient.

2.4.3.5 Wildfire Risk

Wildfire risk is assigned to communities based on a variety of factors such as land use and land cover (DLNR, 2017). Ratings of risk from wildland fires for major populated areas in the Hawaiian Islands were completed by the DLNR Division of Forestry and Wildlife (DOFAW), Fire Management Program, in 2007 and updated in 2017. Guided by the National Fire Plan and the Healthy Forests Restoration Act (HFRA), state wildland fire-fighting agencies and their federal and local partners are responsible for identifying communities at risk from wildland fires. Based on the guidelines developed by the National Association of State Foresters, DOFAW identified at-risk wildland-urban interface communities and rated each community's risk from wildland fires. Potential water sources in or near “low” fire risk communities are considered most favorable, sources in “medium” risk communities are considered moderate, and sources in “high” risk communities are considered least favorable.

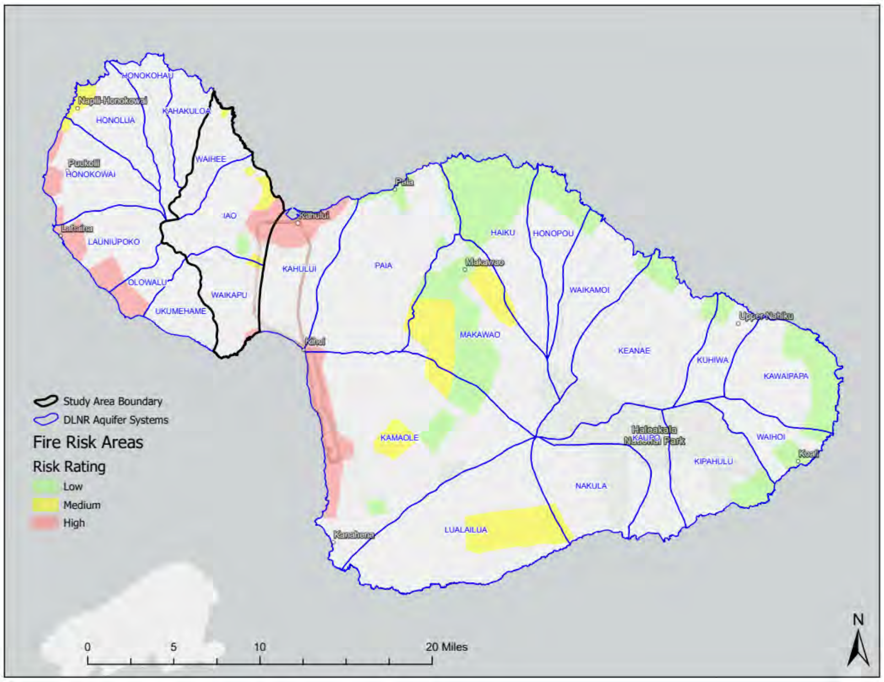

Figure 29. Map of Community Wildfire Risk Rating

Source: DLNR, 2017

2.4.4 Permitting Criteria

Permitting criteria used to evaluate groundwater sources, surface water sources, and transmission infrastructure is shown in Figure 30.

Fatal Flaw Score = 0	Least Favorable	Most Favorable
Groundwater	Water Use Permit and Well Permit for new well within Groundwater Management Area (GMA), or for high-level groundwater potentially affecting surface water	Well Permit for new well outside Groundwater Management Area (GMA), or increasing capacity of existing well outside of GMA
Surface water	New SWUP and SDWP/ Modification for flows below Q_{50} for sources within a SWMA, or East Maui Water Authority	SDWP for diversion outside a SWMA, or for stormwater
Transmission	New easements required (new pipe to new reservoir)	Makes use of existing easements (existing ditch or pipeline)

Figure 30. Permitting Criteria

2.4.4.1 Groundwater Source Permitting

Groundwater sources are considered favorable from a permitting standpoint for aquifers located outside of a GWMA, where a well construction permit and pump installation permit for a new well or amendment to increase capacity of an existing well would be required (CWRM, 2024). Aquifers rated as least favorable are located within a GWMA and thus require a WUP in addition to a well permit and pumping permit. High-level groundwater sources whose withdrawal would potentially affect surface water is also considered least favorable for permitting.

2.4.4.2 Surface Water Source Permitting

Surface water sources located outside a SWMA may require a SDWP and are considered favorable for permitting (CWRM, 2024). Sources rated as moderate include high flows within a SWMA that may require a SWUP amendment and a SDWP. Sources considered least favorable for permitting are flows below Q_{50} within a SWMA that require a SWUP and SDWP, or streams under the purview of the East Maui Water Authority due to additional time and uncertainty in the permitting process. It is uncertain at this time how the purview of the East Maui Water Authority will be applied or govern, and how this conflicts, or not, with the CWRM's role and regulatory responsibilities and oversight.

2.4.4.3 Transmission Infrastructure Permitting

Transmission infrastructure is considered favorable for permitting if it makes use of an existing ditch or pipeline easements (CWRM, 2023). A new pipe to an existing reservoir is rated as moderate since that may require modifying existing easements. A new pipe to a new reservoir is considered least favorable for permitting since new easements would be required.

2.4.5 Infrastructure Criteria

Infrastructure criteria used to evaluate operations and maintenance (O&M) needs (groundwater only), storage availability (surface water only), proximity to the County water system, and treatment complexity are shown in Figure 31.

	Least Favorable	Most Favorable
Well elevation O&M Needs (GW only)	Max elevation >4000 ft	Max well elevation <500 ft
Storage availability (SW only)	New reservoirs required	Use existing reservoirs as-is
Proximity to water system	> 10 miles from water system point of adequacy or ditch system	< 1 mile away from water system point of adequacy or ditch system
Treatment complexity	Stormwater treatment	Groundwater treatment

Figure 31. Infrastructure Criteria

2.4.5.1 Well Elevation O&M Needs

The approximate elevation of a well gives an indication of the amount of O&M needs, since deeper wells generally require more O&M. Favorable groundwater sources from an O&M perspective are located below 500 feet elevation, moderate sources are at 501 to 1,500 feet elevation, and least favorable sources are at 1,501 to 4,000 feet elevation. Sources above 4,000 feet are excluded from this analysis (Hawaii State GIS Data, 2023).

2.4.5.2 Storage Availability

Raw water storage for surface water is considered favorable if using existing reservoirs as-is, moderate if modification to existing reservoirs is required, and least favorable if new reservoirs are required (CWRM, 2023).

2.4.5.3 Proximity to Water System

Water sources are considered favorable if located less than one mile from a MDWS water system point of adequacy or existing ditch system (MDWS, 2021), moderate if located 1 to 10 miles from a water system, and least favorable if located more than 10 miles from a water system.

2.4.5.4 Treatment Complexity

Treatment of groundwater is considered least complex and therefore most favorable. Treatment of surface water from streams and ditches is considered moderately complex, and treatment of stormwater is considered most complex and least favorable.

2.4.6 Energy Criteria

Energy criteria used to evaluate energy grid accessibility and energy grid risk are shown in Figure 32.

Energy grid accessibility	> 10 miles to electrical distribution system	< 1 mile to electrical distribution system
Risk	High risk of power outages, longer duration	Low risk of power outages, shorter duration

Figure 32. Energy Criteria

2.4.6.1 Energy Grid Accessibility

Energy grid accessibility is rated as favorable for water sources located less than 1 mile from the existing electrical distribution system, moderate for sources between 1 to 10 miles from the electrical distribution system, and least favorable for sources located more than 10 miles from the electrical distribution system (BC, 2023).

2.4.6.2 Energy Grid Risk

Energy grid risk is considered favorable for water sources in areas with low risk of power outages of short duration, moderate for sources in areas with medium risk of power outages of medium duration, and least favorable for sources in areas with high risk of power outages of longer duration (BC, 2023).

2.5 Evaluation of Options

A score of "0" to "3" was assigned to each criterion for all the 68 possible water sources based on the criteria definitions and water source analysis. Results are summarized in Appendix A.

2.6 Category Weights

Categories of evaluation criteria were weighted according to relative importance at a workshop held on March 1, 2023. The average weight was calculated in real time based on survey results from MDWS workshop participants. The weights were incorporated into the process to rank water source options. Figure 33 shows category weights by percentage.

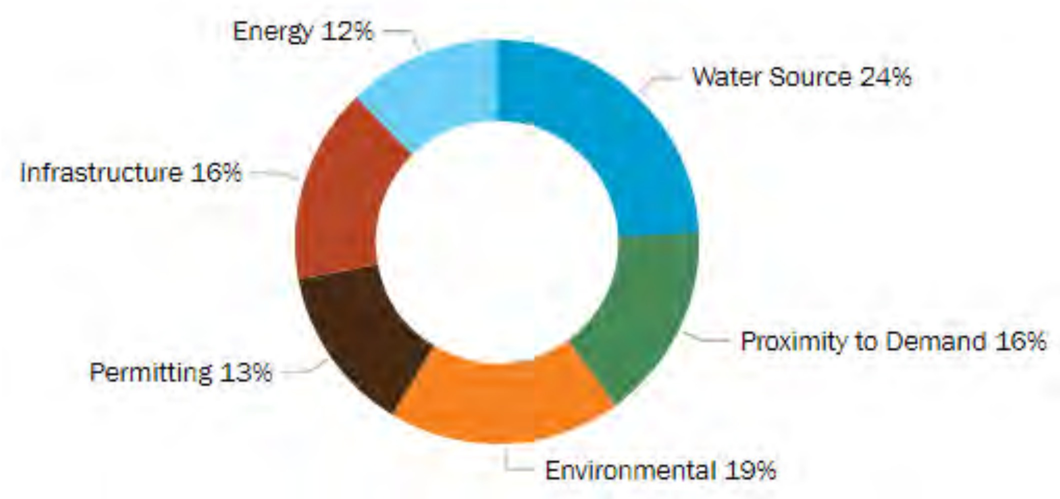

Figure 33. Category Weights by Percentage

"Water Source" and "Environmental" were considered the most important categories, followed by "Proximity to Demand" and "Infrastructure," and finally "Permitting" and "Energy."

2.7 Weighted Ranking

Water source options were ranked by multiplying scores by category weights. The initial ranking of source options in the MCDA dashboard is shown in Figure 34.

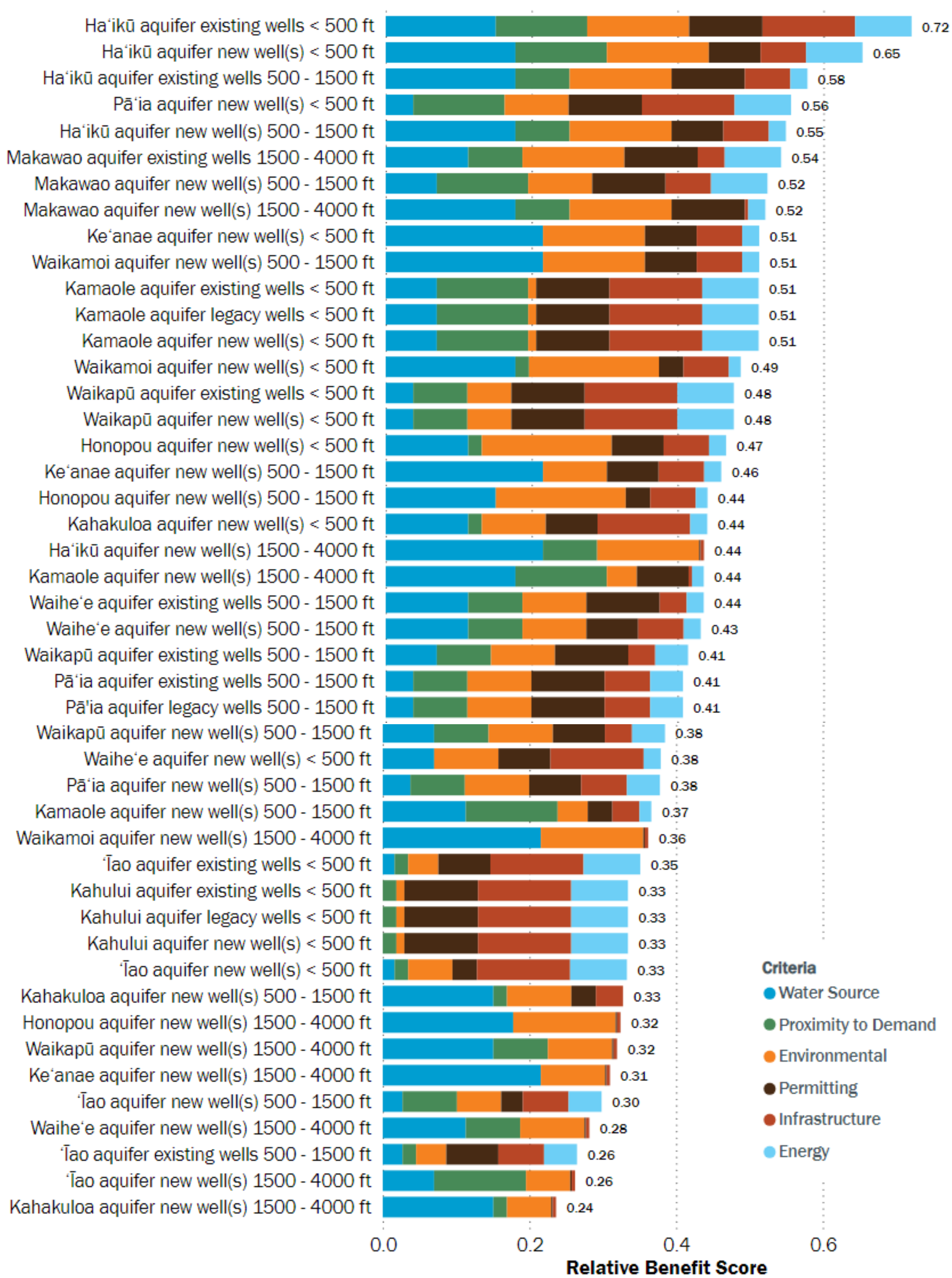

Figure 34. Ranking of Water Source Options in Non-Economic Analysis

The relative benefit scores shown in Figure 34 are the sum of scores for each criterion multiplied by the category weight. Each color bar corresponds to a category, revealing which factors contributed to the water source relative benefit score, and to what degree. This analysis allowed for a preliminary ranking of the water sources according to the criteria evaluation.

2.8 Water Source Options for Further Analysis

Water source options were further refined through discussions with MDWS to select the top-ranking sources to advance into the strategy development and economic analysis. A summary of each source option—grouped by hydrologic unit with comments on non-economic analysis findings—is provided in Table 13.

Table 13. Water Source Options for Further Analysis

ID	Groundwater Elevation Range/ Stream Locations	Comments
A	Haʻikū aquifer groundwater at elevation <500 feet Haʻikū aquifer groundwater at elevation 501-1,500 feet Haʻikū aquifer groundwater at elevation 1,501-4,000 feet	• Relatively large amount of groundwater potentially available in the aquifer. • Potential contamination sources (historic pineapple cultivation, onsite sewage disposal systems) in some areas. • Potential to impact GDEs (coastal wetlands and estuaries). • Area may have slightly less groundwater recharge in a future climate scenario. • Infrastructure requirements may include construction of an access road from the nearest public road to the well site, well drilling, storage tank, transmission infrastructure, and treatment as required.
B	Makawao aquifer groundwater at elevation 501-1,500 feet Makawao aquifer groundwater at elevation 1,501-4,000 feet	• Medium amount of groundwater potentially available in the aquifer. • Few potential contamination sources (historic pineapple cultivation, onsite sewage disposal systems). • Minimal impact to GDEs. • Area may have less groundwater recharge in a future climate scenario. • Infrastructure requirements may include construction of an access road from the nearest public road to the well site, well drilling, storage tank, transmission infrastructure, and treatment as required.
C	Kamaʻole aquifer groundwater at elevation <500 feet Kamaʻole aquifer groundwater at elevation 1,501-4,000 feet	• Medium amount of groundwater potentially available in the aquifer. • Potential contamination sources in some areas (historic pineapple cultivation, onsite sewage disposal systems) and risk of saltwater intrusion at low elevations. • Potential impacts to GDEs. • Area may have less groundwater recharge in a future climate scenario. • Infrastructure requirements may include construction of an access road from the nearest public road to the well site, well drilling, storage tank, transmission infrastructure, and treatment as required.
D	Waikamoi aquifer groundwater at elevation <500 feet Waikamoi aquifer groundwater at elevation 501-1,500 feet	• Relatively high amount of groundwater potentially available in the aquifer. • Few potential contamination sources. • Potential impacts to GDEs. • Area may have more groundwater recharge in a future climate scenario. • Infrastructure requirements may include construction of an access road from the nearest public road to the well site, well drilling, storage tank, transmission infrastructure, and treatment as required.

Table 13. Water Source Options for Further Analysis		
ID	Groundwater Elevation Range/ Stream Locations	Comments
E	Pāʻia aquifer groundwater at elevation <500 feet	• Medium amount of groundwater potentially available in the aquifer. • Multiple potential contamination sources (historic pineapple cultivation, onsite sewage disposal systems). • Potential impacts to GDEs. • Area may have less groundwater recharge in a future climate scenario. • Infrastructure requirements may include construction of an access road from the nearest public road to the well site, well drilling, storage tank, transmission infrastructure, and treatment as required.
F	Waikapū aquifer groundwater at elevation <500 feet	• Relatively small amount of groundwater potentially available in the aquifer. • Potential contamination sources in some areas (historic pineapple cultivation, onsite sewage disposal systems) and risk of saltwater intrusion. • Minimal impact to GDEs. • Area may have less groundwater recharge in a future climate scenario. • Infrastructure requirements may include construction of an access road from the nearest public road to the well site, well drilling, storage tank, transmission infrastructure, and treatment as required.
G	Keʻanae aquifer groundwater at elevation <500 feet	• Relatively large amount of groundwater potentially available in the aquifer. • Few potential contamination sources. • Potential impacts to GDEs. • Area may have more groundwater recharge in a future climate scenario. • Infrastructure requirements may include construction of an access road from the nearest public road to the well site, well drilling, storage tank, transmission infrastructure, and treatment as required.
H	Honopou aquifer groundwater at elevation 501-1,500 feet	• Medium amount of groundwater potentially available in the aquifer. • Few potential contamination sources. • Potential impacts to GDEs. • Area may have more groundwater recharge in a future climate scenario. • Infrastructure requirements may include construction of an access road from the nearest public road to the well site, well drilling, storage tank, transmission infrastructure, and treatment as required.
I	Waiheʻe aquifer groundwater at elevation 501-1,500 feet	• Relatively low amount of groundwater potentially available in the aquifer. • Few potential contamination sources. • Potential impacts to GDEs. • Area may have less groundwater recharge from rain in the future. • Close to roads and existing water system. • Infrastructure requirements may include construction of an access road from the nearest public road to the well site, well drilling, storage tank, transmission infrastructure, and treatment as required.
J	Wailoa Ditch reallocate agricultural water (permitted off-stream reasonable and beneficial uses)	• Relatively large amount of surface water potentially available. • Moderate reliability of surface water throughout the year. • Infrastructure requirements may include: – No new stream diversions. Utilize existing stream diversions and ditch to convey raw water. – Construct new reservoirs near Kamole WTF. – Construct a new WTF or expand Kamole WTF.

Table 13. Water Source Options for Further Analysis

ID	Groundwater Elevation Range/ Stream Locations	Comments
K	Wailuku area reallocate agricultural water (permitted off-stream reasonable and beneficial uses)	• Medium amount of surface water potentially available. • Moderate reliability of surface water throughout the year. • Infrastructure requirements may include: – Utilize existing reservoirs and raw water transmission systems. – Construct a new WTF.
L	Lower Kula System increase the capacity of raw water transmission infrastructure	• Medium amount of surface water potentially available. • Moderate availability of surface water throughout the year. • Potential impacts to downstream ecosystems and users. • Infrastructure requirements may include: – No new stream diversions. Replace existing pipes with larger ones. – Construct an additional reservoir with raw water transmission pipes and connection to the Piʻiholo WTF.
M	Wailoa Ditch high flows Q_{50} and above	• Relatively large amount of surface water available. • Limited availability of high flows throughout the year. • Infrastructure requirements may include: – No new stream diversions. Utilize existing stream diversions and ditch to convey raw water. – Construct new reservoirs near Kamole WTF. – Construct a new WTF or expand Kamole WTF.
N	Waiheʻe River high flows Q_{50} and above	• Medium amount of surface water available. • Limited availability of high flows throughout the year. • Infrastructure requirements may include: – Construct a new diversion to capture high flows only on Waiheʻe River near the Spreckels Ditch diversion. – Construct a new reservoir and a new WTF.
O	Wailuku River high flows Q_{50} and above	• Medium amount of surface water available. • Limited availability of high flows throughout the year. • Infrastructure requirements may include: – Construct a new diversion to capture high flows only on Wailuku River near the Spreckels Ditch diversion. – Improve existing Waiʻale Reservoir, construct a new reservoir, and construct a new WTF.

Section 3: Supply and Development Strategies

Water supply and development strategies identified in Section 2 for further analysis are presented in more detail in this section.

3.1 Groundwater Strategies

Groundwater supply and development strategies are identified for water sources in the aquifers selected for further analysis through the multicriteria decision process described in the previous section. Strategies include conceptual well fields and associated infrastructure for each aquifer. The maximum yield for each strategy consists of the lesser of:

- Remaining SY in the aquifer (up to 90 percent of CWRM values).
- 12.0 mgd.

Assumed individual well capacity was estimated for each groundwater strategy based on chloride concentrations in existing high-capacity wells, basal water levels, and hydrogeology (INTERA, 2023). Well capacity estimates will be confirmed with future well testing if (and when) siting is refined for the strategy.

This section describes assumptions and methodology for creating supply and development strategies.

3.1.1 Strategy A: Haʻikū Aquifer Groundwater

Strategy A consists of developing groundwater wells within the Haʻikū Aquifer to meet future MDWS demand in the Central and Upcountry systems. Individual well sites were not identified for this initial feasibility study. Assumptions used to evaluate the strategy are presented in Table 14. Basal water levels in Haʻikū Aquifer vary from 2 to 12 feet above mean sea level (MSL). Chloride concentrations in high-capacity wells are less than 150 milligrams per liter (mg/L). There is a high probability that a large diameter well at most sites above the 300-foot elevation will yield 1,000 gallons per minute (gpm) (INTERA, 2023).

In addition to wells, the strategy includes booster pump stations, transmission pump stations, pipelines, water tanks, access road improvements, electrical supply improvements, and other considerations. Figure 35 presents the strategy.

Table 14. Strategy A: Haʻikū Aquifer Groundwater – Analysis Assumptions

Description	Value
Maximum strategy yield	12 mgd annual average 18 mgd peak month
Individual well capacity	1,000 gpm
Total number of wells (includes 1 redundant well)	14
Number of low elevation (0 – 500 feet MSL) wells	4
Number of medium elevation (501 – 1,500 feet MSL) wells	5
Number of high elevation (1,501 – 4,000 feet MSL) wells	5
GAC treatment	Medium elevation wells

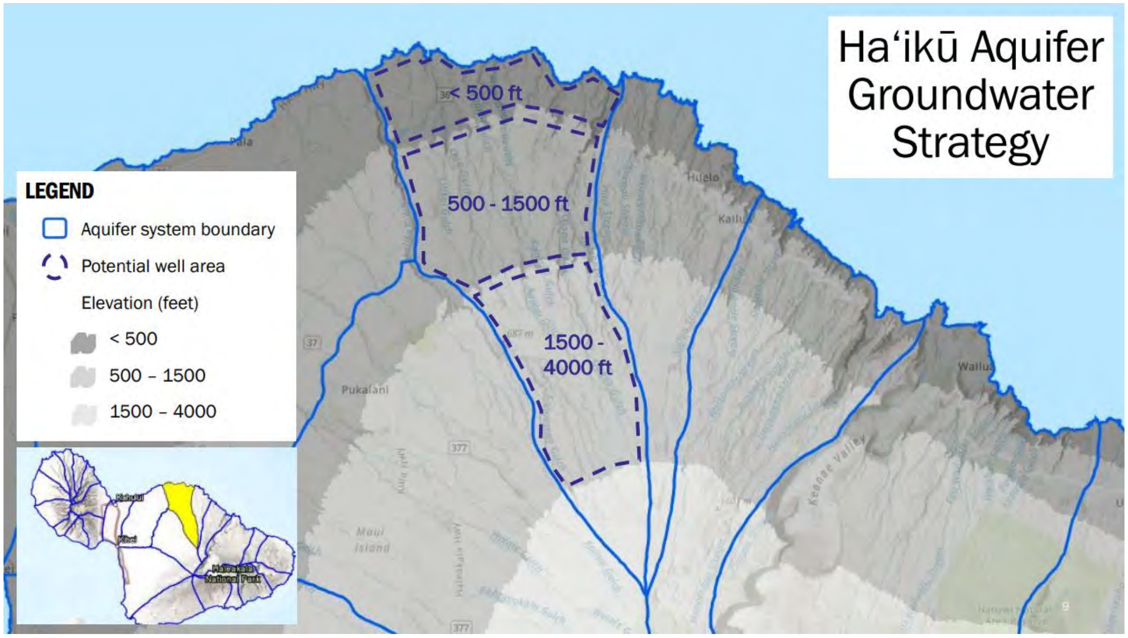

Figure 35. Strategy A: Haʻikū Aquifer Groundwater

3.1.2 Strategy B: Makawao Aquifer Groundwater

Strategy B consists of developing groundwater wells within the Makawao Aquifer to meet future MDWS demand in the Central and Upcountry systems. Individual well sites were not identified for this initial feasibility study. Assumptions used to evaluate the strategy are presented in Table 15. Basal water levels in Makawao Aquifer vary from 5 to 12 feet above MSL. Chloride concentrations in high-capacity wells are less than 100 mg/L, with the notable exception of the Pukalani Golf Course Well (400 mg/L Cl).

There is a high probability that a large diameter well at most sites above the 1200-foot elevation will yield 750 gpm. Lower elevation wells may also yield adequate water, but some may have elevated salinity (INTERA, 2023). In addition to wells, the strategy includes booster and transmission pump stations, pipelines, water tanks, access road improvements, electrical supply improvements, and other considerations. Figure 36 presents the strategy.

Table 15. Strategy B: Makawao Aquifer Groundwater – Analysis Assumptions

Description	Value
Maximum strategy yield	5.4 mgd annual average 5.4 mgd peak month
Individual well capacity	750 gpm
Total number of wells (includes 1 redundant well)	6
Number of low elevation (0 – 500 feet MSL) wells	0
Number of medium elevation (501 – 1,500 feet MSL) wells	3
Number of high elevation (1,501 – 4,000 feet MSL) wells	3
GAC treatment	None

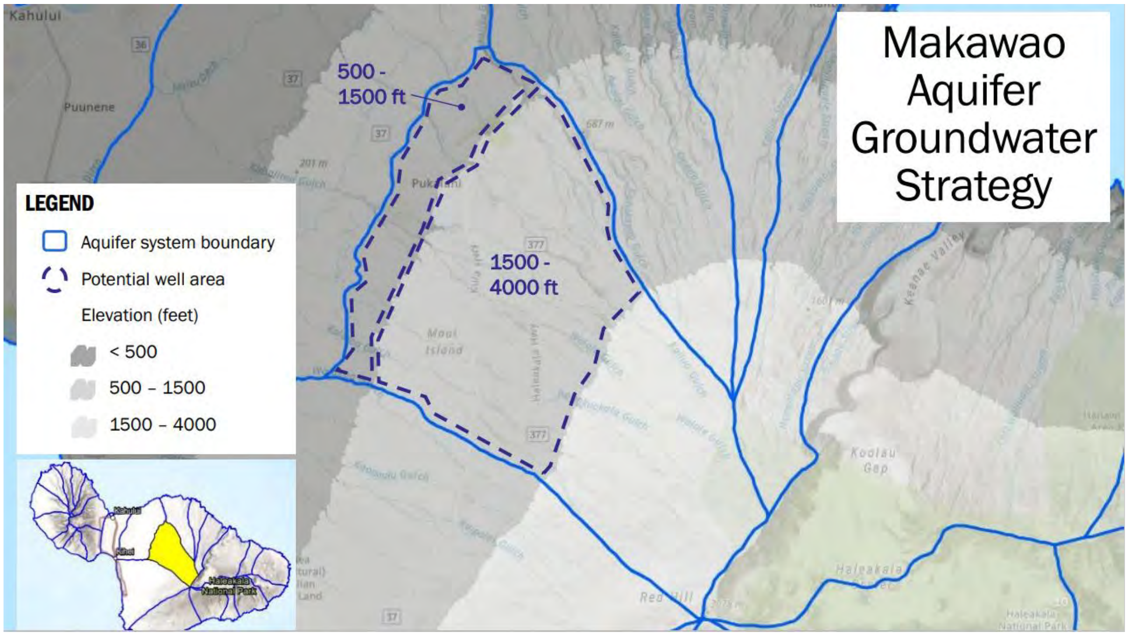

Figure 36. Strategy B: Makawao Aquifer Groundwater

3.1.3 Strategy C: Kamaʻole Aquifer Groundwater

Strategy C consists of developing groundwater wells within the Kamaʻole Aquifer to meet the future MDWS demand in the Central and Upcountry systems. Individual well sites were not identified for this initial feasibility study. Assumptions used to evaluate the strategy are presented in Table 16. Basal water levels in the higher elevations of Kamaʻole vary from 5 to 9 feet above MSL. Chloride concentrations in high-capacity wells are between 50 and 160 mg/L.

There is a good probability that a large diameter well at most sites above the 1500-foot elevation will yield 750 gpm. Lower elevation wells may also yield adequate water at 350 gpm but some may have elevated salinity (INTERA, 2023). In addition to wells, the strategy includes booster and transmission pump stations, pipelines, water tanks, access road improvements, electrical supply improvements, and other considerations. Figure 37 presents the strategy.

Table 16. Strategy C: Kamaʻole Aquifer Groundwater – Analysis Assumptions

Description	Value
Maximum strategy yield	6.6 mgd annual average 6.6 mgd peak month
Individual well capacity	350 gpm
Total number of wells (includes 1 redundant well)	14
Number of low elevation (0 – 500 feet MSL) wells	7
Number of medium elevation (501 – 1,500 feet MSL) wells	0
Number of high elevation (1,501 – 4,000 feet MSL) wells	7
GAC treatment	None

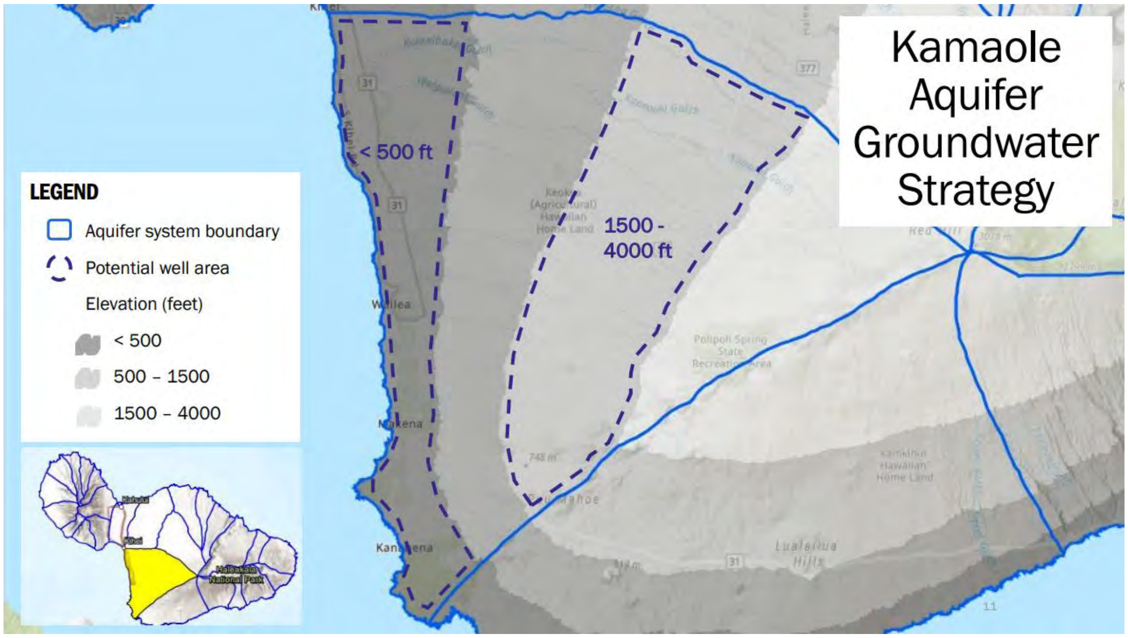

Figure 37. Strategy C: Kamaʻole Aquifer Groundwater

3.1.4 Strategy D: Waikamoi Aquifer Groundwater

Strategy D consists of developing groundwater wells within the remote and largely unexplored Waikamoi Aquifer to meet future MDWS demand in the Central and Upcountry systems. Individual well sites were not identified for this initial feasibility study. Assumptions used to evaluate the strategy are presented in Table 17. Waikamoi is an entirely undeveloped aquifer system. Based on a comparison with the adjacent Keʻanae Aquifer system, wells near the 500-foot elevation should be able to develop basal water at 1,000 gpm. Lower elevation wells may also develop basal water but are likely to have lower capacities at around 500 gpm to maintain reasonable salinity levels. At higher elevations groundwater may be perched or high-level and there is a good probability that wells will yield 1,000 gpm. These wells may also affect streamflow (INTERA, 2023). In addition to wells, the strategy includes booster and transmission pump stations, pipelines, water tanks, access road improvements, electrical supply improvements, and other considerations. Figure 38 presents the strategy.

Table 17. Strategy D: Waikamoi Aquifer Groundwater – Analysis Assumptions

Description	Value
Maximum strategy yield	12 mgd annual average 18 mgd peak month
Individual well capacity	1,000 gpm
Total number of wells (includes 1 redundant well)	14
Number of low elevation (0 – 500 feet MSL) wells	7
Number of medium elevation (501 – 1,500 feet MSL) wells	7
Number of high elevation (1,501 – 4,000 feet MSL) wells	0
GAC treatment	None

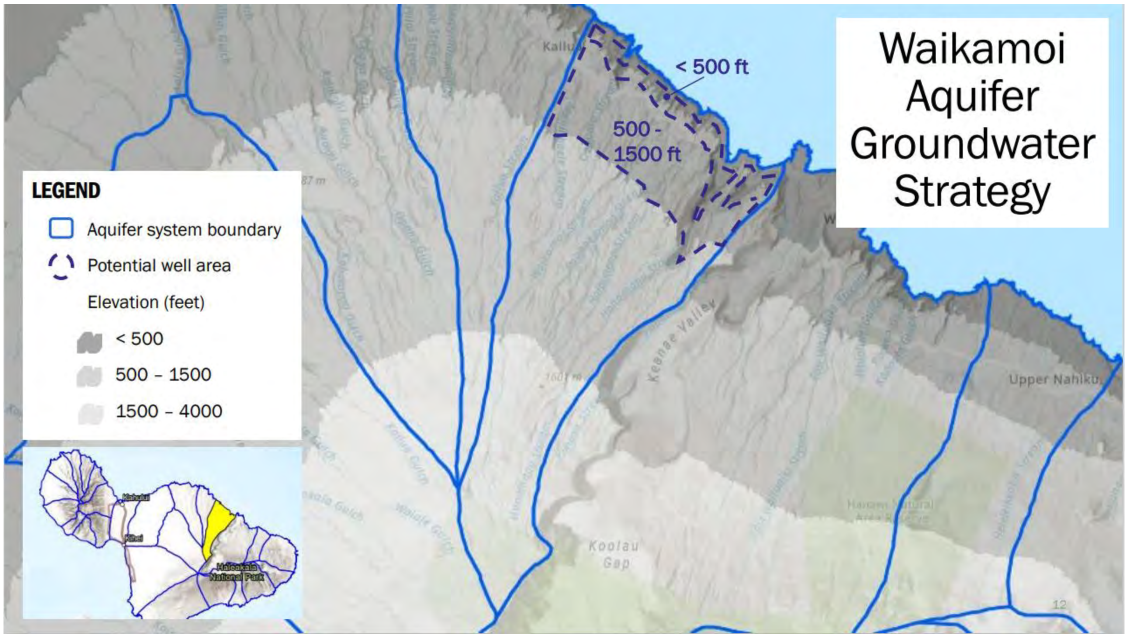

Figure 38. Strategy D: Waikamoi Aquifer Groundwater

3.1.5 Strategy E: Pāʻia Aquifer Groundwater

Strategy E consists of developing groundwater wells within the Pāʻia Aquifer to meet future MDWS demand in the Central and Upcountry systems. Individual well sites were not identified for this initial feasibility study. Assumptions used to evaluate the strategy are presented in Table 18. Basal water well levels vary from 3 to 5 feet above MSL.

Chloride concentrations in high-capacity wells vary from 60 to 210 mg/L. Water wells in the higher elevations of the Pāʻia Aquifer system will probably yield 500 gpm at acceptable salinities. The MDWS Hāmākuapoko well was tested at 850 gpm with a chloride concentration of 49 ppm (INTERA, 2023).

In addition to wells, the strategy includes booster and transmission pump stations, pipelines, water tanks, access road improvements, electrical supply improvements, and other considerations. Figure 39 presents the strategy.

Table 18. Strategy E: Pāʻia Aquifer Groundwater – Analysis Assumptions

Description	Value
Maximum strategy yield	4.3 mgd annual average 4.3 mgd peak month
Individual well capacity	500 gpm
Total number of wells (includes 1 redundant well)	7
Number of low elevation (0 – 500 feet MSL) wells	7
Number of medium elevation (501 – 1,500 feet MSL) wells	0
Number of high elevation (1,501 – 4,000 feet MSL) wells	0
GAC treatment	Low elevation wells

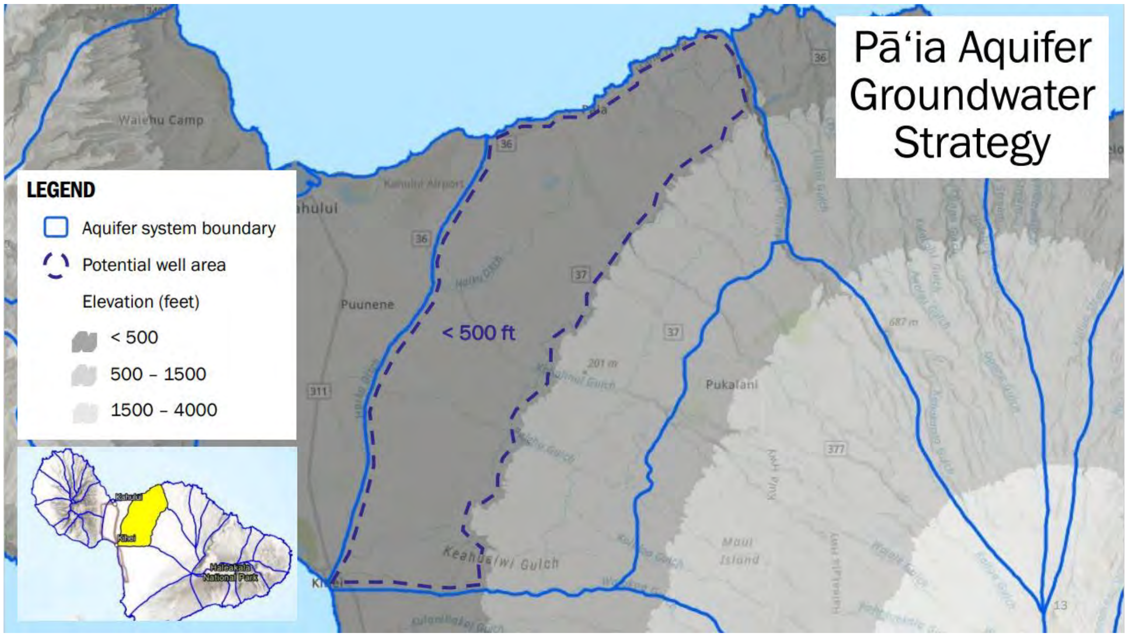

Figure 39. Strategy E: Pāʻia Aquifer Groundwater

3.1.6 Strategy F: Waikapū Aquifer Groundwater

Strategy F consists of developing groundwater wells within the Waikapū Aquifer to meet future MDWS demand in the Central and Upcountry systems. Individual well sites were not identified for this initial feasibility study. Assumptions used to evaluate the strategy are presented in Table 19. Basal water levels in Waikapū vary from 1 to 12 feet above MSL.

Chloride concentrations in high-capacity wells vary from 15 to over 200 mg/L. There is a good probability that a well at many sites below the 500-foot elevation will yield 350 gpm at acceptable chloride levels. The private Pohakea wells yielded about 350 gpm at chloride concentrations ranging from 160 to 180 mg/L (INTERA, 2023).

In addition to wells, the strategy includes booster and transmission pump stations, pipelines, water tanks, access road improvements, electrical supply improvements, and other considerations. Figure 40 presents the strategy.

Table 19. Strategy F: Waikapū Aquifer Groundwater – Analysis Assumptions

Description	Value
Maximum strategy yield	2.5 mgd annual average 2.5 mgd peak month
Individual well capacity	350 gpm
Total number of wells (includes 1 redundant well)	6
Number of low elevation (0 – 500 feet MSL) wells	6
Number of medium elevation (501 – 1,500 feet MSL) wells	0
Number of high elevation (1,501 – 4,000 feet MSL) wells	0
GAC treatment	None

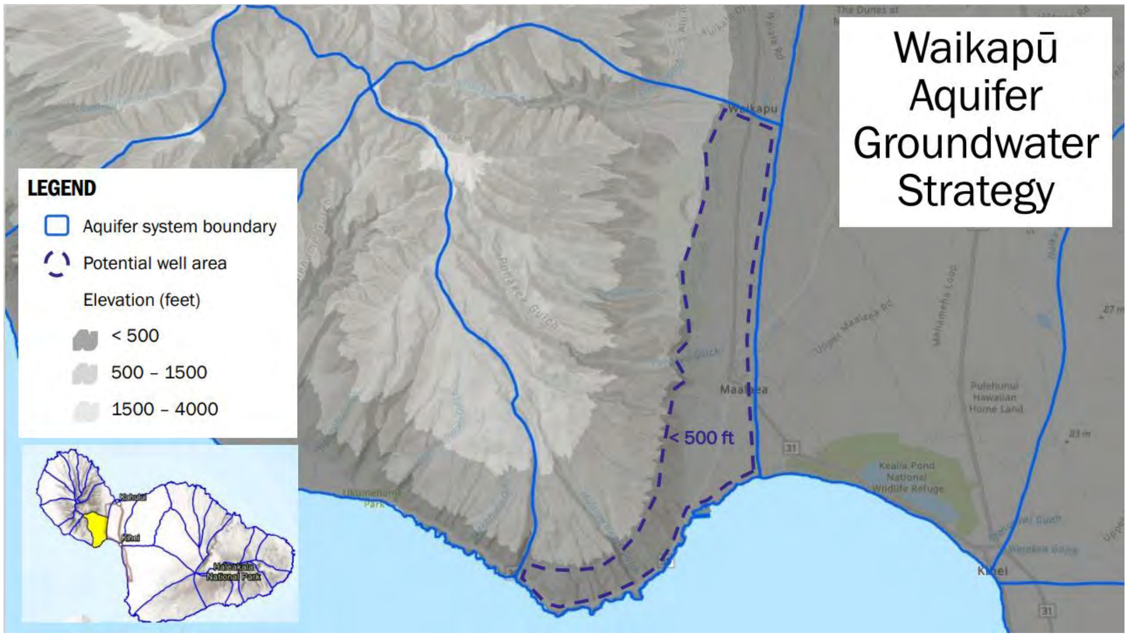

Figure 40. Strategy F: Waikapū Aquifer Groundwater

3.1.7 Strategy G: Keʻanae Aquifer Groundwater

Strategy G consists of developing groundwater wells within the remote Keʻanae Aquifer to meet future MDWS demand in the Central and Upcountry systems. Individual well sites were not identified for this initial feasibility study. Assumptions used to evaluate the strategy are presented in Table 20. Keʻanae is mostly undeveloped; further, MDWS owns two wells in the western portion (Keʻanae wells).

Water levels were about 6 feet above MSL, indicating basal conditions. Chloride concentrations were low at 12 to 18 mg/L, while pumping at about 300 gpm. Wells at higher elevations will intersect high-level and perched water. Ke'anae wells may also affect streamflow (INTERA, 2023).

In addition to wells, the strategy includes booster and transmission pump stations, pipelines, water tanks, access road improvements, electrical supply improvements, and other considerations. Figure 41 presents the strategy.

Table 20. Strategy G: Keʻanae Aquifer Groundwater – Analysis Assumptions

Description	Value
Maximum strategy yield	12 mgd annual average 18 mgd peak month
Individual well capacity	750 gpm
Total number of wells (includes 1 redundant well)	18
Number of low elevation (0 – 500 feet MSL) wells	18
Number of medium elevation (501 – 1,500 feet MSL) wells	0
Number of high elevation (1,501 – 4,000 feet MSL) wells	0
GAC treatment	None

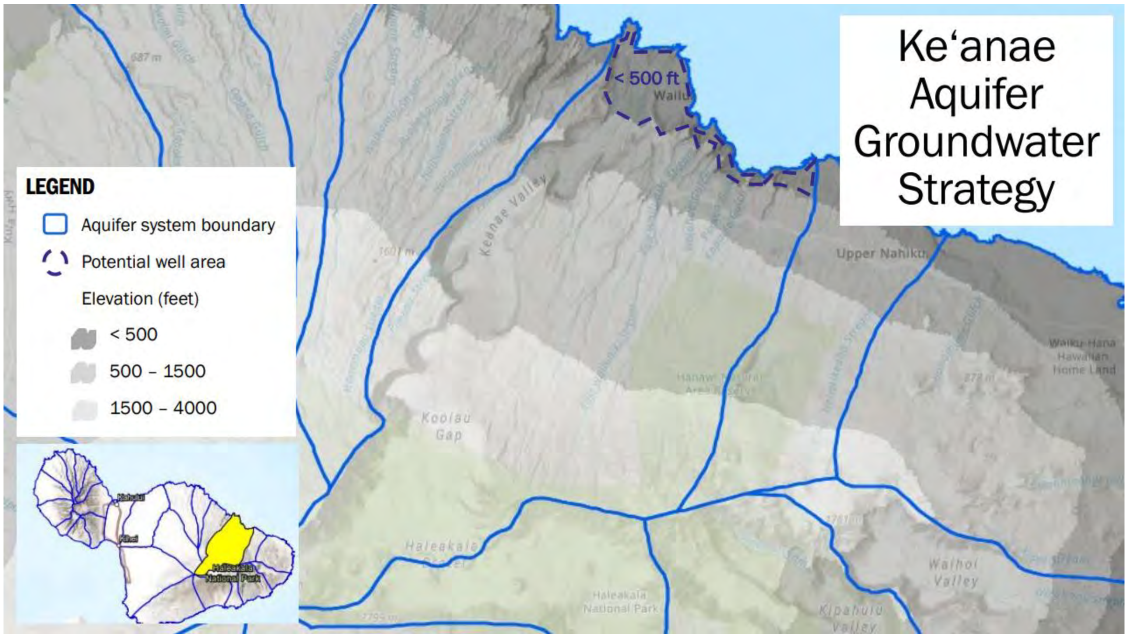

Figure 41. Strategy G: Ke’anae Aquifer Groundwater

3.1.8 Strategy H: Honopou Aquifer Groundwater

Strategy H consists of developing groundwater wells within the Honopou Aquifer to meet future MDWS demand in the Central and Upcountry systems. Individual well sites were not identified for this initial feasibility study. Assumptions used to evaluate the strategy are presented in Table 21. Mostly, there are only domestic low-capacity wells in Honopou and no high-capacity wells to use for analysis. Basal water levels vary from 2 to 5 feet above MSL with some higher perched water, and chloride concentrations highly variable between 30 and 400 mg/L.

New wells will require careful siting to help ensure acceptable salinity. Despite this, there is a good probability that wells above 500-foot elevation will yield adequate water. Wells in Honopou may affect streamflow (INTERA 2023). In addition to wells, the strategy includes booster and transmission pump stations, pipelines, water tanks, access road improvements, electrical supply improvements, and other considerations. Figure 42 presents the strategy.

Table 21. Strategy H: Honopou Aquifer Groundwater – Analysis Assumptions

Description	Value
Maximum strategy yield	12 mgd annual average 14.4 mgd peak month
Individual well capacity	500 gpm
Total number of wells (includes 1 redundant well)	21
Number of low elevation (0 – 500 feet MSL) wells	0
Number of medium elevation (501 – 1,500 feet MSL) wells	21
Number of high elevation (1,501 – 4,000 feet MSL) wells	0
GAC treatment	None

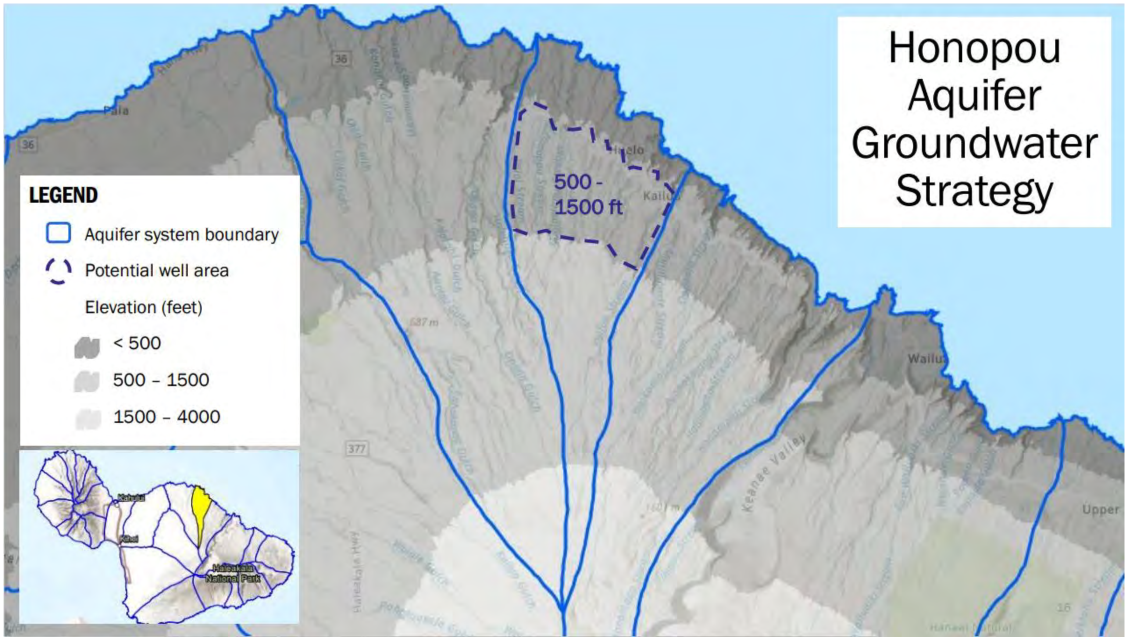

Figure 42. Strategy H: Honopou Aquifer Groundwater

3.1.9 Strategy I: Waiheʻe Aquifer Groundwater

Strategy I consists of developing groundwater wells within the Waiheʻe Aquifer to meet future MDWS demand in the Central and Upcountry systems. Individual well sites were not identified for this initial feasibility study. Assumptions used to evaluate the strategy are presented in Table 22.

There are extensive data on pumping high-capacity wells in Waiheʻe. Although basal water levels are relatively low at 4 to 9 feet above MSL, chloride concentrations are relatively low at pumpage rates over 500 gpm. High-capacity wells between 500- and 1500-feet elevation should be able to sustain 1,000 gpm at reasonable chloride concentrations (INTERA, 2023).

In addition to wells, the strategy includes booster and transmission pump stations, pipelines, water tanks, access road improvements, electrical supply improvements, and other considerations. Figure 43 presents the strategy.

Table 22. Strategy I: Waiheʻe Aquifer Groundwater – Analysis Assumptions

Description	Value
Maximum strategy yield	2.7 mgd annual average 2.7 mgd peak month
Individual well capacity	1,000 gpm
Total number of wells (includes 1 redundant well)	3
Number of low elevation (0 – 500 feet MSL) wells	0
Number of medium elevation (501 – 1,500 feet MSL) wells	3
Number of high elevation (1,501 – 4,000 feet MSL) wells	0
GAC treatment	None

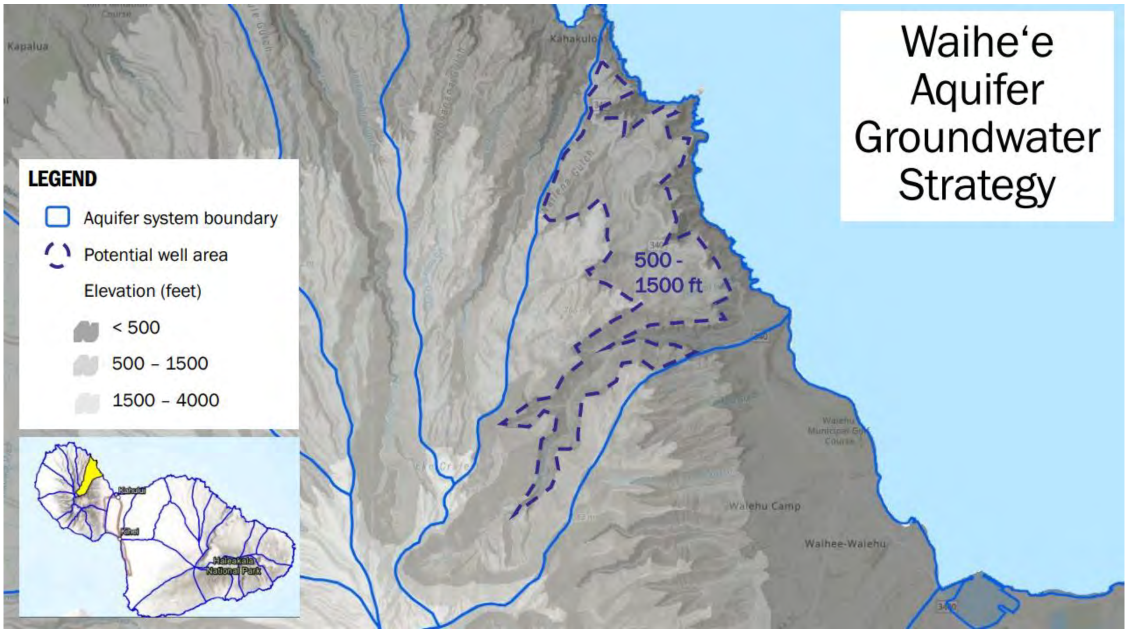

Figure 43. Strategy I: Waihe‘e Aquifer Groundwater

3.2 Surface Water Strategies

The surface water strategies identified for further evaluation are summarized below.

3.2.1 Strategy J: Capture Wailoa Ditch High Flows

Strategy J consists of capturing and storing high flows (defined as Q_{50} and above) from Wailoa Ditch for treatment and use. The Wailoa Ditch would continue to be used by EMI District to convey raw water from the East Maui watersheds in accordance with IFS requirements established by CWRM; there would be no new stream diversions. Raw water storage reservoirs would be constructed near Kamole WTF. The Kamole WTF would be expanded to provide additional treatment capacity.

Following implementation of IIFS under the 2018 CWRM D&O, Wailoa Ditch at Maliko is estimated to have a Q_{50} flow of 69 mgd, a Q_{70} flow of approximately 31 mgd, and a Q_{90} flow of 17 mgd (CWRM, 2022). In December 2023, the total cap amount of the revocable permit to A&B and EMI was 38.25 mgd averaged annually, with 31.25 mgd granted to the permittee for agricultural use, 6 mgd to the County for Kamole Treatment Center, and 1 mgd to Kula Agricultural Park (BLNR, 2023).

High flows are defined as Q_{50} and above, which means that 50 percent of the time Wailoa Ditch flows are 69 mgd or greater. Accounting for IIFS and permitted uses totaling 38.25 mgd, Wailoa Ditch theoretically has over 20 mgd of additional water available during periods of high flow. For this analysis, 12 mgd represents the total demand and is therefore assumed to be the maximum strategy yield. Assumptions used to evaluate the strategy are presented in Table 23. Figure 44 presents the strategy.

Table 23. Strategy J: Capture Wailoa Ditch High Flows – Analysis Assumptions	
Description	**Value**
Maximum strategy yield	12 mgd annual average 18 mgd peak month
Raw water storage reservoir volume	540 mgal
Kamole Weir WTF capacity expansion	18 mgd

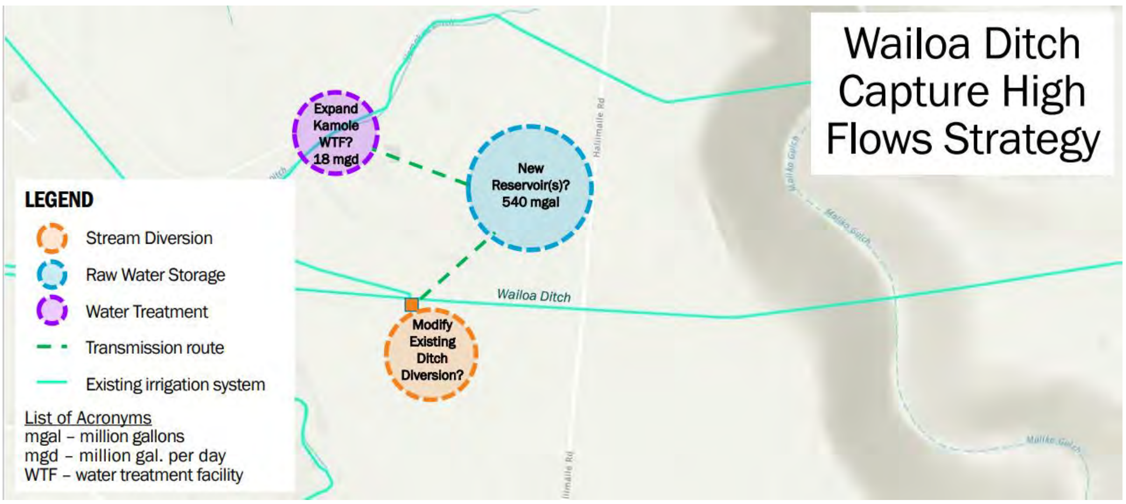

Figure 44. Strategy J: Capture Wailoa Ditch High Flows

3.2.2 Strategy K: Reallocate Agricultural Water from Wailoa Ditch

Strategy K consists of reallocating permitted off-stream reasonable and beneficial uses of Wailoa Ditch water to the County. The Wailoa Ditch would continue to be used by EMI District to convey raw water from the East Maui watersheds in accordance with IFS requirements established by CWRM; there would be no new stream diversions. Raw water storage reservoirs would be constructed with new reservoirs near Kamole WTF. The Kamole WTF would be expanded to provide additional treatment capacity.

Assumptions used to evaluate the strategy are presented in Table 24. Figure 45 presents the strategy.

Table 24. Strategy K: Reallocate Agricultural Water from Wailoa Ditch – Analysis Assumptions	
Description	**Value**
Maximum strategy yield	12 mgd annual average 18 mgd peak month
Raw water storage reservoir volume	180 mgal
Kamole Weir WTF capacity expansion	18 mgd
Agricultural land area needing alternative water supplies	3,800 acres

Figure 45. Strategy K: Reallocate Agricultural Water from Wailoa Ditch

3.2.3 Strategy L: Lower Kula System Expansion

Strategy L consists of improving the infrastructure to increase the capacity of Lower Kula System raw water transmission system between the existing stream diversions and Piʻiholo Reservoir. There would be no new stream diversions, although existing diversions could potentially be rehabilitated or improved. The raw water transmission pipeline would be replaced with a higher capacity pipeline to increase collection efficiency. An additional reservoir would be constructed to increase raw water storage at the Piʻiholo WTF. Piʻiholo WTF capacity would be expanded to treat the additional water supply.

Assumptions used to evaluate the strategy are presented in Table 25. Figure 46 presents the strategy.

Table 25. Strategy L: Lower Kula System Expansion – Analysis Assumptions

Description	Value
Maximum strategy yield	3.2 mgd annual average 4.8 mgd peak month
Raw water storage reservoir volume	75 mgal
Piʻiholo WTF capacity expansion	4.8 mgd

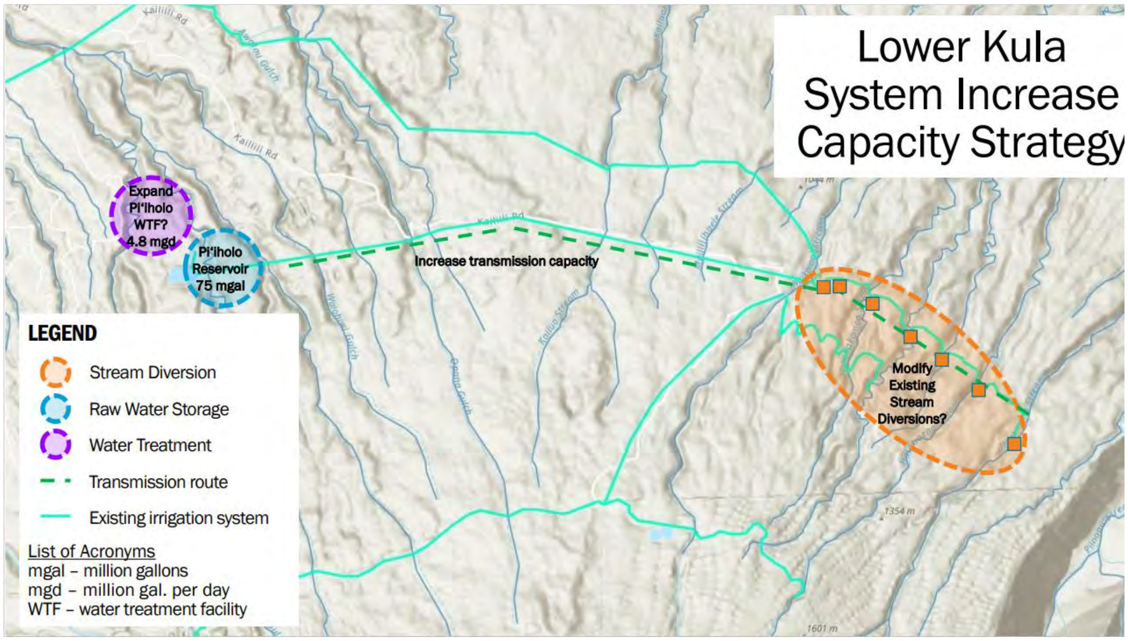

Figure 46. Strategy L: Lower Kula System Expansion

3.2.4 Strategy M: Capture Waiheʻe River High Flows

Strategy M consists of capturing and storing high flows (defined as Q_{50} and above) from the Waiheʻe River for treatment and use. A new stream diversion and new transmission pipe within the existing Spreckels Ditch alignment could deliver surface water to new and existing reservoirs. The raw water would be treated in a new treatment facility, and potable water could be distributed with new or existing pipelines.

Assumptions used to evaluate the strategy are presented in Table 26. Figure 47 presents the strategy.

Table 26. Strategy M: Capture Waiheʻe River High Flows – Analysis Assumptions

Description	Value
Maximum strategy yield	5.1 mgd annual average 7.7 mgd peak month
Raw water storage reservoir volume	250 mgal
New WTF capacity	7.7 mgd

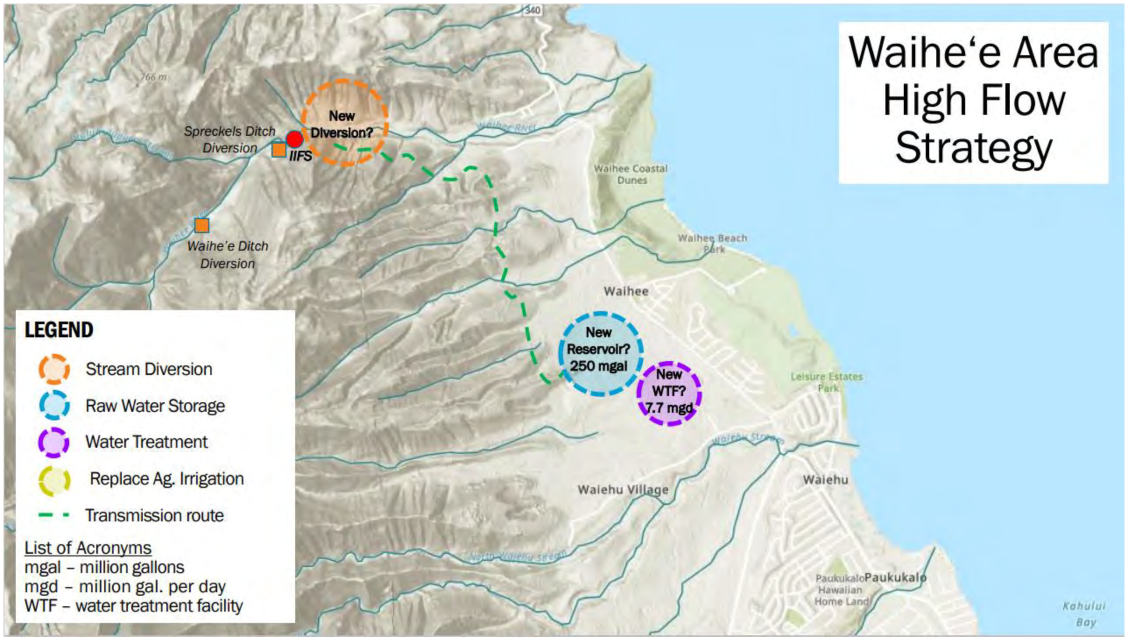

Figure 47. Strategy M: Capture Waihe‘e River High Flows

3.2.5 Strategy N: Wailuku Area Reallocate Agricultural Water

Strategy N consists of reallocating permitted off-stream reasonable and beneficial uses of Wailuku area surface water to the County. There would be no new stream diversions; water that is currently used for agricultural irrigation would be treated and used for municipal supply, and alternative water supplies (e.g., groundwater or recycled water) could potentially be used for irrigation. Raw water storage reservoirs would be constructed, and existing reservoirs improved, to meet future MDWS demand in the Central and Upcountry systems. A new WTF would be constructed to treat the raw water prior to distribution to customers.

Assumptions used to evaluate the strategy are presented in Table 27. Figure 48 presents the strategy.

Table 27. Strategy N: Wailuku Area Reallocate Agricultural Water – Analysis Assumptions

Description	Value
Maximum strategy yield	1.9 mgd annual average 2.9 mgd peak month
Raw water storage reservoir volume	145 mgal
New WTF capacity	2.9 mgd
Agricultural land area needing alternative water supplies	750 acres

Figure 48. Strategy N: Wailuku Area Reallocate Agricultural Water

3.2.6 Strategy O: Capture Wailuku River High Flows

Strategy O consists of capturing and storing high flows (defined as Q_{50} and above) from the Wailuku River for treatment and use. A new stream diversion and new transmission pipe within the existing Spreckels Ditch alignment could deliver surface water to new and existing reservoirs. The raw water would be treated in a new treatment facility, and potable water could be distributed with new or existing pipelines.

Assumptions used to evaluate the strategy are presented in Table 28. Figure 49 presents the strategy.

Table 28. Strategy O: Capture Wailuku River High Flows – Analysis Assumptions

Description	Value
Maximum strategy yield	6.6 mgd annual average 9.9 mgd peak month
Raw water storage reservoir volume	255 mgal
New WTF capacity	9.9 mgd

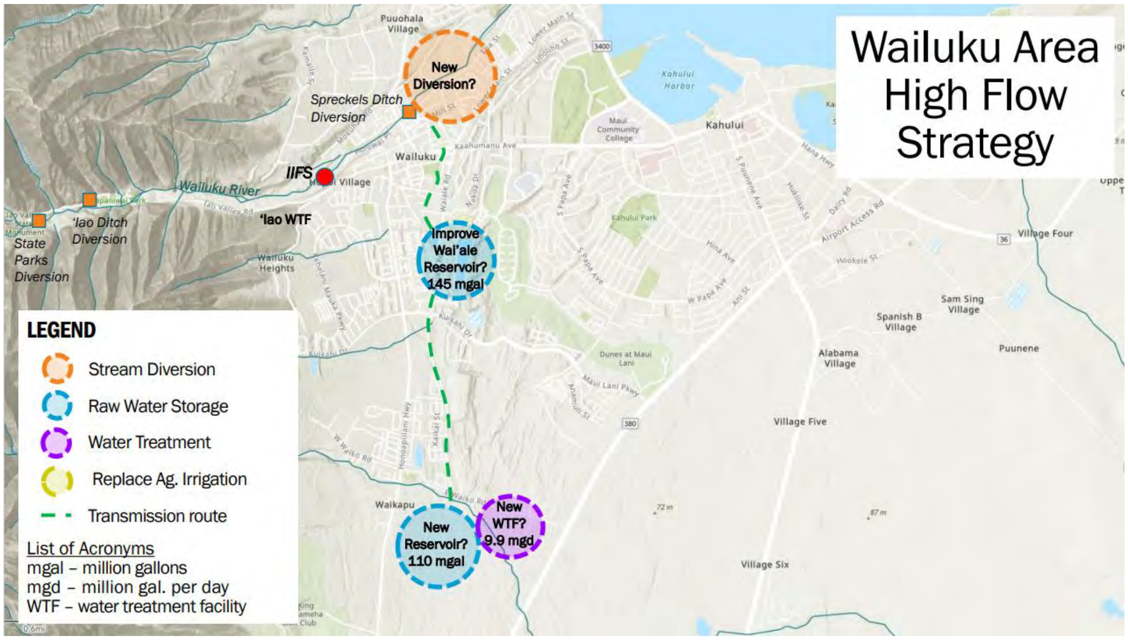

Figure 49. Strategy O: Capture Wailuku River High Flows

3.3 Infrastructure Types Overview

This section provides an overview of the infrastructure that may be required to develop new water sources.

3.3.1 Groundwater Wells

Infrastructure requirements for groundwater wells may include construction of an access road from the nearest public road to the well site, well drilling, storage tank, transmission infrastructure, and treatment as required. Other infrastructure associated with well development also includes backup generators, instrumentation, and pumps.

3.3.2 Surface Water Diversions

A portion of surface water flows could be diverted from the stream using a concrete weir intake designed to capture water at or above a certain flow rate, maintaining IIFS flows in the stream. Water would be directed into a pipeline sized according to the desired design capacity. Pumping of the raw water may be required if the intake is located at a lower elevation than the storage and treatment facilities but would be avoided if possible. Flow metering devices would be installed to confirm the maintenance of IIFS flows in the stream and to record diverted flow rates and volumes.

3.3.3 Transmission of Raw Water

Raw water transmission could potentially occur either through pipelines or improved (lined) ditches. Pipelines are likely to be preferred to minimize system losses. The transmission pipeline would travel from the diversion point to the raw water storage location, following the alignment of existing ditches where possible.

3.3.4 Storage of Raw Water

3.3.4.1 Existing Reservoirs

Surface water could be transmitted and stored in existing reservoirs, though storage capacity is limited and rates of loss due to seepage are high. Reservoir owners must have a valid certificate of approval to impound water in the reservoir, which requires submitting a dam inventory data sheet and a remediation plan for addressing any dam deficiencies. Many dams in Hawai'i have a potential to cause loss of life and considerable property damage if they were to fail. Owners of state-regulated high and significant hazard potential dams and reservoirs are required to establish an Emergency Action Plan (EAP) to assist the local community in effectively responding to a dam safety emergency.

3.3.4.2 New Reservoirs

Construction of new lined reservoirs is an option for storing high flows. The reservoirs would be sized according to storage requirements and subject to site constraints. Multiple small reservoirs could be used to achieve the total storage volume requirement to develop a source option. Floating covers could be used to reduce evaporation losses. Regulatory considerations for the construction of new reservoirs are significant to protect the public and down gradient properties.

3.3.4.3 Aquifer Storage and Recovery

Aquifer storage and recovery (ASR) is a water resources management practice for actively storing water underground in existing natural aquifers during wet periods for recovery when needed, usually during drier periods. There are two main methods for transfer of water into the aquifer: infiltration (spreading basins) and artificial recharge (injection wells). Surface infiltration systems require permeable soils and unsaturated zones to get water into the ground and to a high-capacity aquifer.

Regulatory considerations for aquifer storage and development in Hawai'i are in an early stage. The CWRM is open to the idea of using surface water for groundwater recharge, though the potential ramifications to IIFS, methods of recharge, and water treatment requirements need to be further evaluated. These factors, as well as the recharge location and underlying aquifer type, would affect CWRM's position on proposed ASR options. The level of treatment required by the DOH for water transferred into and subsequently recovered from the aquifer depends on the method of recharge and the receiving aquifer system. Direct injection could require injectant treatment to the quality level of the water in the aquifer being recharged.

3.3.5 Treatment

Raw surface water could be treated for potable use in an expanded existing WTF or in a new facility. New treatment facilities typically use membrane barrier filtration along with a non-hazardous onsite sodium hypochlorite generation system for disinfection, which uses salt, water, and electricity.

3.3.6 Distribution of Potable Water

Once treated, the potable water could be distributed with new or existing pipelines, or a combination of new and existing pipelines. If some (or all) of the additional surface water is treated in existing facilities, potable water could be distributed using existing pipelines. Hydraulic modeling would be required to determine if existing pipeline sizes are adequate to meet service area needs. If a new WTF is constructed, new pipelines will be needed to connect the treatment facility to surrounding MDWS service areas. If new areas are to be served with the additional water, new pipelines will be needed. Booster pump stations will be also required to move water to elevations that are higher than the WTF.

3.4 Potential Interconnections Between Upcountry and Central Maui Systems

To increase overall system reliability, MDWS may consider constructing one or more interconnection systems between the Upcountry and Central Maui water systems. Doing so would allow MDWS to transfer water between the two systems to meet customer water demands. The interconnection system would likely include:

- Transmission pump station(s) to transport water from the lower-elevation Central Maui system to the higher-elevation Upcountry system.
- Pipeline(s) between the two systems.
- Treatment systems to address water quality differences between the two systems.
- Additional treated water storage facilities to meet Hawaii Water Systems Standards storage and fire flow requirements.

MDWS currently operates interconnection systems between the three Upcountry water systems (Upper Kula, Lower Kula, and Makawao). The Upper Kula water system is operated at a higher pH and with different primary and secondary disinfectants (chloramines) than the Lower Kula and Makawao systems to address safe drinking water quality requirements, complicating water transfers to and from the Upper Kula system.

Water quality parameters of the Central Maui and the Upcountry water systems will need to be studied in detail to determine the scope of treatment systems that are required to transfer water between the Central Maui and Upcountry systems. Pilot testing may be required to obtain DOH SDWB approval for water transfers. Adjustments may be required to Maui County Code Title 14 to move water between the Upcountry and Central Maui systems.

A report outlining alignments and probable costs of interconnection systems for the unidirectional transfer of up to 6.3 mgd of water from the Central system to the Upcountry system was recently completed (Carollo, 2024). The interconnection systems in the report are located near the town of Pāʻia and routed via the Kamole WTF. As the source development strategies outlined in this EMFS are developed further, additional hydraulic modeling and feasibility analyses will be needed to determine whether interconnection could also be viable for uni-or dual-directional transfer between the systems at this or other locations.

Section 4: Engineering Economic Analyses

4.1 Introduction

Engineering economic analyses were prepared to evaluate the strategies presented in Section 3. The engineering economic analyses were designed to establish the overall value of each strategy on an equal basis to assist the County with selection of a preferred strategy (or combination of strategies) to advance to a subsequent implementation phase. The engineering economic evaluations included development of capital costs, annual O&M costs, and periodic rehabilitation and replacement (R&R) costs. The capital, O&M, and R&R costs were then combined in a business case evaluation (BCE) to establish life-cycle costs associated with each strategy.

4.1.1 Relationship to Cost Benefit Analysis

A cost benefit analysis was prepared separately by Plasch Econ Pacific (PEP) and is discussed in Section 5. The cost benefit analysis relies on the capital, O&M, and R&R estimates developed in this section, but also considers other economic assumptions and analysis techniques that are presented in Section 5.

4.2 Capital Cost Estimates

Conceptual cost estimates were developed for the fifteen strategies. The cost estimates were developed using construction bids from similar County projects, quantity take-offs, and other sources. The costs were adjusted to account for economies of scale and construction inflation since the bid opening dates. Where Hawa'i costs were unavailable, U.S. mainland costs were used after adjustment to reflect Maui Island conditions.

In accordance with the Association for the Advancement of Cost Engineering International (AACE) criteria, these are Class 5 estimates. A Class 5 estimate is defined as a Conceptual Level or Project Viability Estimate. Typically, engineering is from 0 to 2 percent complete. Class 5 estimates are used to prepare planning-level cost scopes or evaluation of alternative schemes, long range capital outlay planning, and can also form the base work for the Class 4 Planning Level or Design Technical Feasibility Estimate.

Expected accuracy for Class 5 estimates typically ranges from -50 to +100 percent, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. In unusual circumstances, ranges could exceed those shown.

Table 29 provides a summary of capital cost assumptions used.

Table 29. Capital Cost Estimating Assumptions

Description	Value
Estimate date	August 2024
Engineering News Record 20-Cities Average Construction Cost Index	13,600
Markup for estimating contingency	30 percent
Markup for engineering, permitting, project administration, and legal costs	25 percent

Table 30 provides a summary of the capital cost estimates, in current (2024) dollars. Detailed estimates can be found in. Appendix B The strategies are not equal with respect to the annual average and peak month yields that can be obtained; the capital estimates are based on developing the infrastructure to supply up to the maximum peak month strategy yield shown in the table. The capital costs are shown in dollars per gallons per day ($/gpd) of average annual capacity in the last column for unit cost comparison purposes.

Table 30. Summary of Capital Cost Estimates (2024 dollars)

Strategy	Description	Capital Cost Estimate	Maximum Annual Average Strategy Yield (mgd)	Maximum Peak Month Strategy Yield (mgd)	Capital Unit Cost ($/gpd of average annual capacity)
A	Ha‘ikū aquifer groundwater	$972 million	12	18	$81
B	Makawao aquifer groundwater	$449 million	5.4	5.4	$83
C	Kama‘ole aquifer groundwater	$718 million	6.6	6.6	$110
D	Waikamoi aquifer groundwater	$1,987 million	12	18	$166
E	Pā‘ia aquifer groundwater	$452 million	4.3	4.3	$105
F	Waikapū aquifer groundwater	$227 million	2.5	2.5	$90
G	Ke’anae aquifer groundwater	$2,207 million	12	18	$184
H	Honopou aquifer groundwater	$1,671 million	12	14.4	$139
I	Waihe‘e aquifer groundwater	$307 million	2.7	4.1	$112
J	Capture Wailoa Ditch high flows	$871 million	12	18	$73
K	Reallocate Wailoa Ditch agricultural water	$695 million	12	18	$58
L	Lower Kula system expansion	$345 million	3.2	4.8	$108
M	Capture Waihe‘e River high flows	$635 million	5.1	7.7	$125
N	Reallocate Wailuku Area agricultural water	$285 million	1.9	2.9	$150
O	Capture Wailuku River high flows	$580 million	6.6	9.9	$88

The capital unit costs are shown in Figure 50 for comparison purposes. The circles on the graph indicate the average annual yield from each strategy. The squares indicate the peak month yield for each strategy.

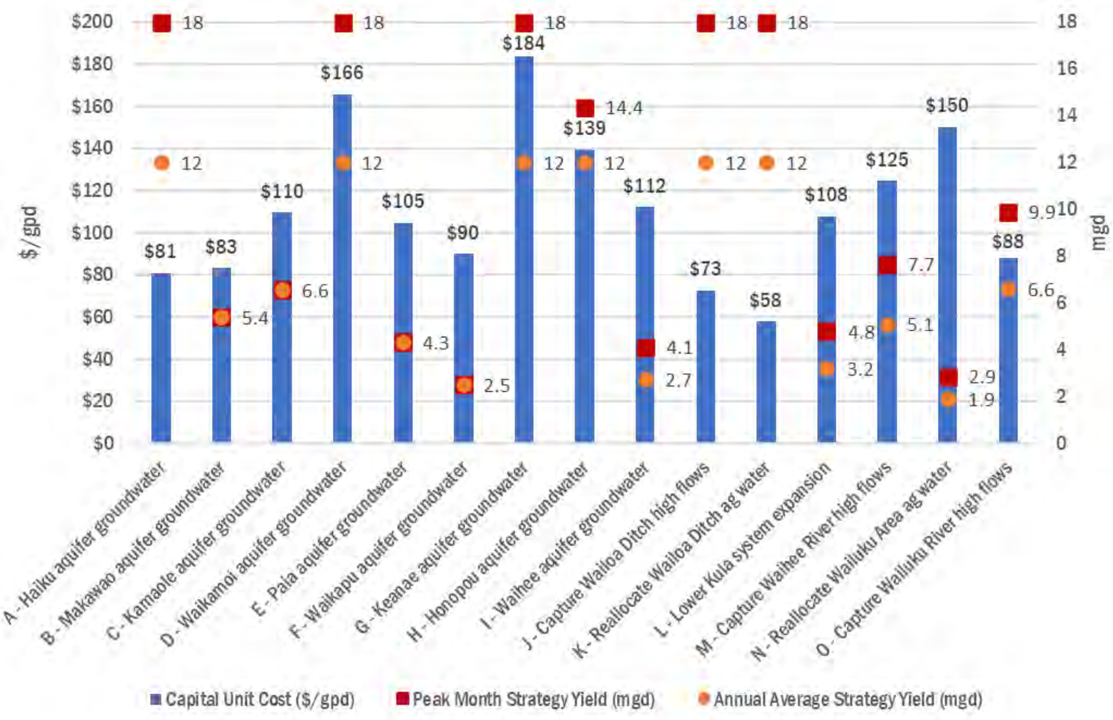

Figure 50. Capital Unit Cost Comparison

As described above, the capital cost estimates are Class 5 estimates in accordance with AACE criteria. Table 31 lists the potential ranges of capital costs that could be realized based on Class 5 accuracy.

Table 31. Class 5 Estimate Ranges (2024 dollars)

Strategy	Description	Capital Cost Estimate	Class 5 Estimate Range (-50% to +100%)
A	Ha‘ikū aquifer groundwater	$972 million	$486 – $1,945 million
B	Makawao aquifer groundwater	$449 million	$225 – $899 million
C	Kama‘ole aquifer groundwater	$718 million	$359 – $1,435 million
D	Waikamoi aquifer groundwater	$1,987 million	$994 – $3,975 million
E	Pā‘ia aquifer groundwater	$452 million	$226 – $904 million
F	Waikapū aquifer groundwater	$227 million	$113 – $454 million
G	Ke’anae aquifer groundwater	$2,207 million	$1,104 – $4,415 million
H	Honopou aquifer groundwater	$1,671 million	$835 – $3,342 million
I	Waihe‘e aquifer groundwater	$307 million	$154 – $615 million
J	Capture Wailoa Ditch high flows	$871 million	$436 – $1,743 million
K	Reallocate Wailoa Ditch agricultural water	$695 million	$347 – $1,390 million
L	Lower Kula system expansion	$345 million	$172 – $689 million

Table 31. Class 5 Estimate Ranges (2024 dollars)			
Strategy	Description	Capital Cost Estimate	Class 5 Estimate Range (-50% to +100%)
M	Capture Waihe'e River high flows	$635 million	$318 – $1,271 million
N	Reallocate Wailuku Area agricultural water	$285 million	$143 – $570 million
O	Capture Wailuku River high flows	$580 million	$290 – $1,160 million

The capital costs presented above are for the maximum yields that each strategy can deliver and reflect economies of scale that may not be realized if a strategy is developed at a lower capacity. Capital cost curves were developed for the strategies to facilitate capital cost estimating at reduced capacity using the general form:

$$Y = aX^{-0.4}$$

where: Y = *capital unit cost ($/gpd of capacity)*

a = *a unique coefficient derived for each strategy*

X = *strategy capacity (mgd)*

Figure 51 presents the capital cost curves.

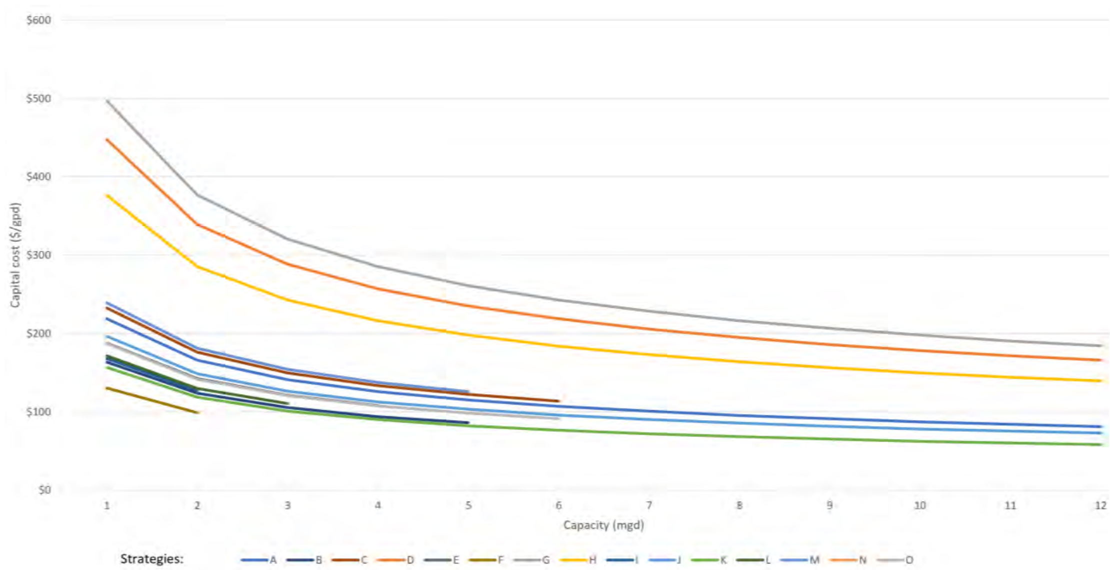

Figure 51. Capital Cost Curves

4.3 Operations and Maintenance Costs

Annual O&M costs estimates were developed for each of the strategies. The O&M cost estimates include estimates of labor, electricity consumption, chemicals, and GAC replacement as applicable. The O&M assumptions are listed in Table 32. The O&M estimates are based on providing the maximum strategy yield.

Table 32. O&M Cost Assumptions	
Description	**Value**
Labor cost	$100,000/full time equivalent
Electricity cost	$0.40/kWh
GAC replacement cost	$4.00/lb.
GAC consumption rate	100 lbs./mgal
Hypochlorite cost	$8.00/lb.
Hypochlorite consumption rate	16.7 lbs./mgal
Access road maintenance	$5,000/mi
Maintenance materials	1% of R&R Cost
Water treatment facility, inclusive costs (SW)	$4,000/mgal
Transmission pumping, variable costs (SW)	$530/mgal
Transmission pumping, fixed costs (SW)	$250,000
Stream diversion & reservoir, fixed costs (SW)	$300,000

Abbreviation: kWh = kilowatts per hour, mi = miles, SW = surface water

Notes:

a. *Fixed costs = costs that do not vary with respect to production rate. For example: labor and maintenance materials.*

b. *Variable costs = costs that vary with respect to production rate. For example: electricity and chemicals.*

c. *Inclusive costs = fixed + variable costs, based on MDWS records at existing facilities.*

The O&M estimates for the strategies are summarized in Table 33. Details can be found in Appendix B. The strategies are not equal with respect to the yield that can be obtained; therefore, the O&M costs are also shown on a $/1,000 gallon delivered basis in the last column for unit cost comparison purposes.

Table 33. Summary of Annual O&M Cost Estimates (2024 dollars)				
Strategy	**Description**	**Annual O&M Cost Estimate**	**Maximum Annual Average Strategy Yield (mgd)**	**O&M Unit Cost ($/1,000 gal delivered)**
A	Ha‘ikū aquifer groundwater	$21.4 million	12	$4.9
B	Makawao aquifer groundwater	$9.7 million	5.4	$4.9
C	Kama‘ole aquifer groundwater	$11.3 million	6.6	$4.7
D	Waikamoi aquifer groundwater	$18.8 million	12	$4.3
E	Pā‘ia aquifer groundwater	$6.8 million	4.3	$4.3
F	Waikapū aquifer groundwater	$3.3 million	2.5	$3.6
G	Ke’anae aquifer groundwater	$16.2 million	12	$3.7
H	Honopou aquifer groundwater	$19.8 million	12	$4.5
I	Waihe‘e aquifer groundwater	$3.4 million	2.7	$3.4
J	Capture Wailoa Ditch high flows	$22.7 million	12	$5.2
K	Reallocate Wailoa Ditch agricultural water	$22.7 million	12	$5.2

Table 33. Summary of Annual O&M Cost Estimates (2024 dollars)				
Strategy	Description	Annual O&M Cost Estimate	Maximum Annual Average Strategy Yield (mgd)	O&M Unit Cost ($/1,000 gal delivered)
L	Lower Kula system expansion	$5.9 million	3.2	$5.0
M	Capture Waiheʻe River high flows	$10.0 million	5.1	$5.4
N	Reallocate Wailuku Area agricultural water	$4.1 million	1.9	$5.9
O	Capture Wailuku River high flows	$12.8 million	6.6	$5.3

The O&M unit costs are shown graphically in Figure 52 for comparison purposes.

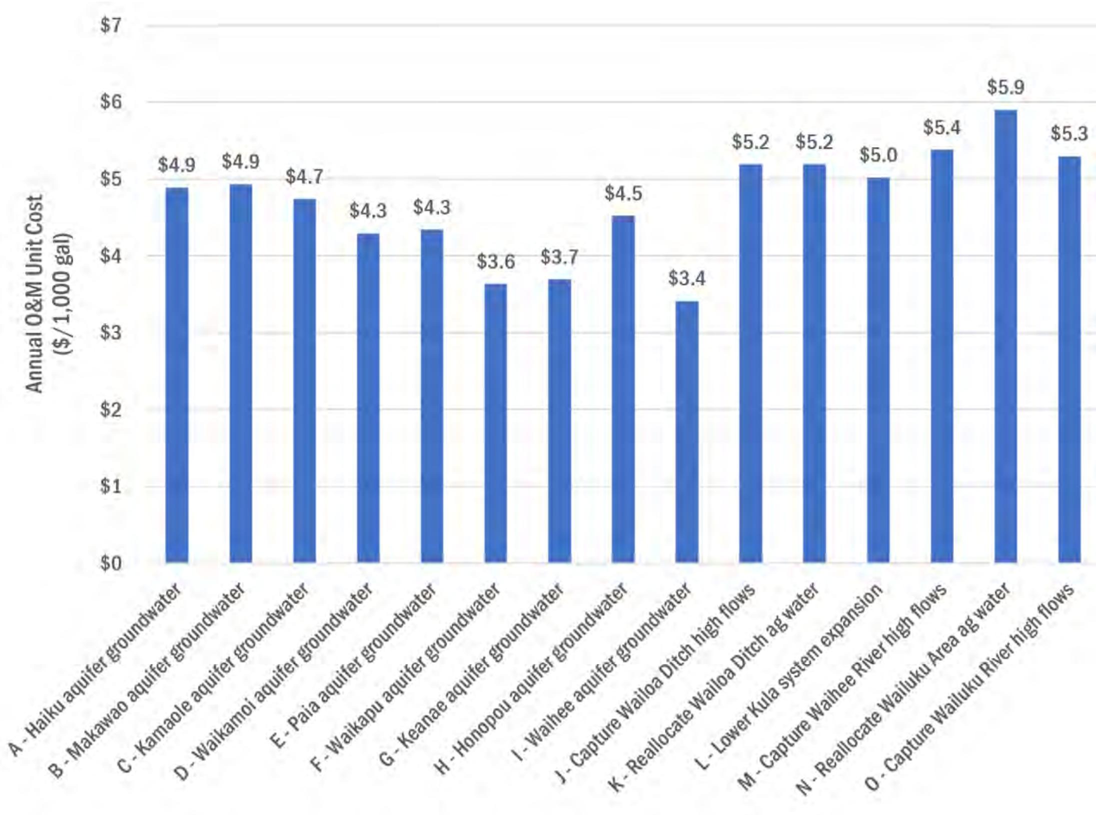

Figure 52. O&M Unit Cost Comparison

4.4 Rehabilitation and Replacement Costs

Infrastructure requires periodic R&R due to normal wear and tear. In general, mechanical equipment like pumps, valves, chemical feed systems, fans, air conditioners, and electrical and instrumentation systems require more frequent R&R than items like pipelines, tanks, roads, building structures, etc.

For cost estimating purposes, an R&R project was assumed for each strategy after 20 years of operation. The R&R project is assumed to focus on replacing mechanical, electrical, and instrumentation systems at the end of their useful service lives.

For cost estimating purposes, a percentage of the original construction cost for those strategy elements that contain systems that would require R&R (e.g., pump stations, wells, and treatment systems) was used to establish R&R costs. The R&R cost estimates are included in Appendix B. Further, R&R cost curves were developed for the strategies to allow estimation of R&R costs at reduced strategy capacities. The cost curves are presented in Figure 53.

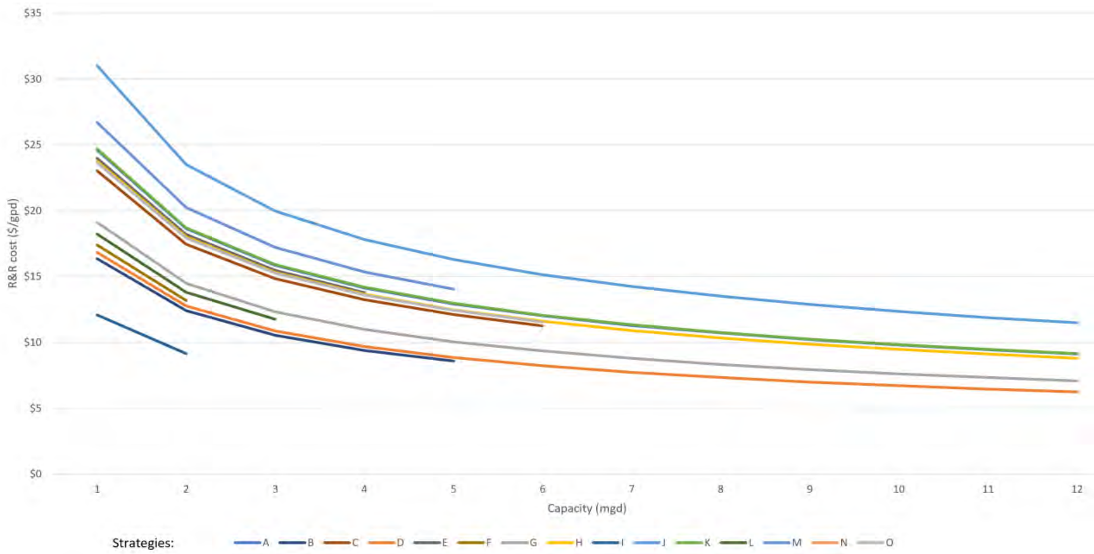

Figure 53. R&R Cost Curves

4.5 Life-Cycle Costs

An engineering economic evaluation was prepared to assess the potential life-cycle costs associated with each strategy. The strategies with the lowest life-cycle costs represent the overall best value from an engineering economic basis. The life-cycle economic evaluation consists of a net present value (NPV) comparison of cash flow patterns for each strategy. The NPV analysis includes capital, O&M, and R&R costs. An appropriate inflationary factor and discount rate are applied to obtain the NPV over a 30-year planning period. The NPV of an alternative represents the amount of money that would need to be set aside today (at a given interest rate) to pay the costs associated with the alternative over the entire planning period. The alternative with the lowest NPV is considered the most attractive from an engineering economic perspective. The evaluation results are included in Appendix B.

Table 34 summarizes the life-cycle cost evaluation assumptions.

Table 34. Life-Cycle Economic Assumptions	
Description	Value
Year of analysis	2025
Planning period	30 years
Capital implementation	Year 1
O&M costs incurred	Years 2 - 30
R&R project implementation	Year 20
Inflation rate	2.2 percent
Discount rate	4.2 percent

Table 35 summarizes the results of the life-cycle cost analysis. The life-cycle cost of each strategy was divided by the total water production during the planning period to obtain the cost per 1,000 gallons of water delivered during the planning period.

Table 35. Summary of Life-Cycle Cost Evaluation (2024 dollars)				
Strategy	Description	Life-Cycle Cost Estimate	Maximum Annual Average Strategy Yield (mgd)	Life-Cycle Unit Cost ($/1,000 gal delivered)
A	Haʻikū aquifer groundwater	$1,520 million	12	$11.9
B	Makawao aquifer groundwater	$690 million	5.4	$12.1
C	Kamaʻole aquifer groundwater	$1,010 million	6.6	$14.6
D	Waikamoi aquifer groundwater	$2,450 million	12	$19.3
E	Pāʻia aquifer groundwater	$640 million	4.3	$14.0
F	Waikapū aquifer groundwater	$320 million	2.5	$12.0
G	Ke'anae aquifer groundwater	$2,620 million	12	$20.6
H	Honopou aquifer groundwater	$2,180 million	12	$17.1
I	Waiheʻe aquifer groundwater	$400 million	2.7	$13.7
J	Capture Wailoa Ditch high flows	$1,460 million	12	$11.5
K	Reallocate Wailoa Ditch agricultural water	$1,270 million	12	$10.0
L	Lower Kula system expansion	$500 million	3.2	$14.7
M	Capture Waiheʻe River high flows	$900 million	5.1	$16.7
N	Reallocate agricultural water from Waiheʻe River	$400 million	1.9	$19.8
O	Capture Wailuku River high flows	$910 million	6.6	$13.0

Figure 54 presents the life-cycle unit costs of the strategies graphically for comparison purposes. The orange circles indicate the maximum annual average yield of each strategy, and the red squares indicate the maximum peak month yield of each strategy.

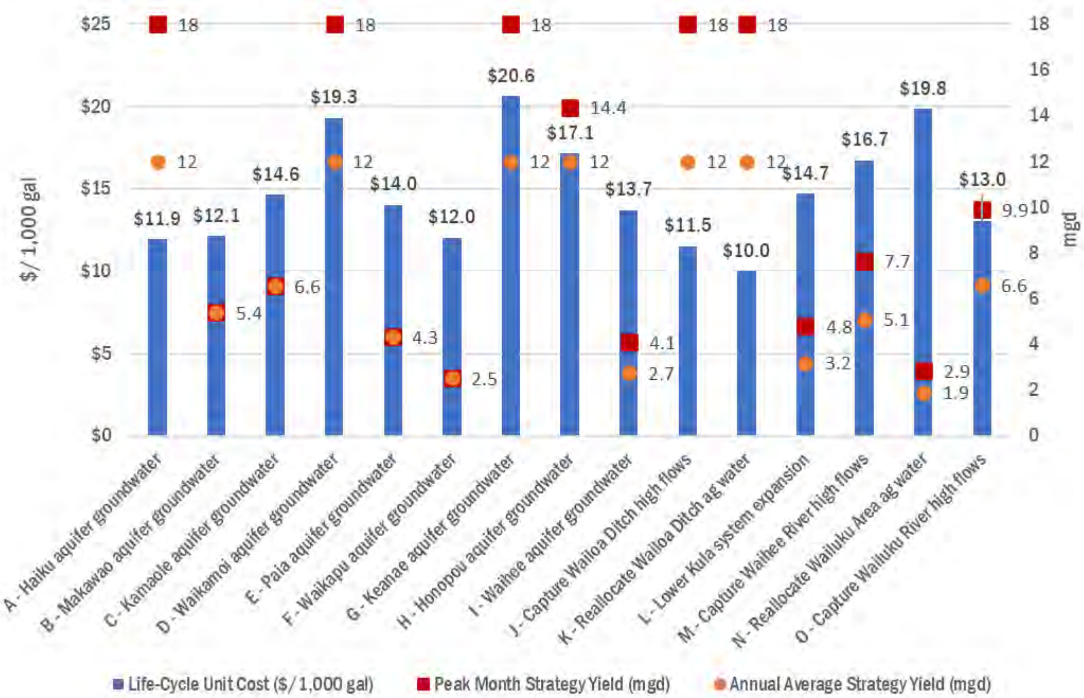

Figure 54. Life-Cycle Unit Cost Comparison

4.6 Combined Economic and Non-Economic Evaluation Results

The results of the life-cycle cost evaluation described above, and the non-economic evaluation described in Section 2 were combined, with the results shown in Figure 55. The most attractive strategies have lower life-cycle costs and higher non-economic scores, i.e., strategies in the upper left quadrant of the graph. The nine strategies within the red dashed lines on the graph were chosen as the most attractive, taking both economic and non-economic considerations into account.

Figure 55. Combined Economic and Non-Economic Evaluation Results

Table 36 lists the most attractive strategies, along with their respective maximum yields, life-cycle unit costs, and non-economic scores.

Table 36. Summary of Most Attractive Strategies

Strategy	Maximum Average Annual Yield (mgd)	Life-Cycle Unit Cost ($/1,000 gallons)	Non-Economic Score
A. Ha'ikū aquifer groundwater	12	$11.9	0.55 [a]
B. Makawao aquifer groundwater	5.4	$12.1	0.52 [a]
C. Kama'ole aquifer groundwater	6.6	$14.6	0.44 [a]
E. Pā'ia aquifer groundwater	4.3	$14.0	0.47 [a]
F. Waikapū aquifer groundwater	2.5	$12.0	0.43 [a]
I. Waihe'e aquifer groundwater	2.7	$13.7	0.41 [a]
J. Capture Wailoa Ditch high flows	12	$11.5	0.35
K. Reallocate Wailoa Ditch agricultural water	12	$10.0	0.48
L. Lower Kula system expansion	3.2	$14.7	0.38

Note:

a. *Average of elevation band scores within the aquifer.*

4.7 Alternatives for Cost-Benefit Analysis

Three of the nine strategies shown in Table 36 are capable of meeting future MDWS demand in the Central and Upcountry systems by themselves. Strategies were combined into 10 alternatives that would be capable of meeting the future water needs of 12 mgd, for cost-benefit evaluation as described in the next section. The 10 cost-benefit alternatives (CBAs) are presented in Table 37, along with a “no action” alternative. CBA-1 to CBA-9 were developed by BC and include up to three source strategies. CBA-11 was developed by MDWS staff and includes five source strategies, including an additional 3 mgd backup supply.

Table 37. Alternatives for Cost-Benefit Analysis

Identifier	Source Strategy 1		Source Strategy 2		Source Strategy 3		Total Flow (mgd)
	ID	Flow (mgd)	ID	Flow (mgd)	ID	Flow (mgd)	
CBA-1	A – Ha‘ikū aquifer groundwater	12	--	0	--	0	12
CBA-2	B – Makawao aquifer groundwater	5	I – Waihe‘e aquifer groundwater	2.7	A – Ha‘ikū aquifer groundwater	4.3	12
CBA-3	J – Capture Wailoa Ditch high flows	12	--	0	--	0	12
CBA-4	K – Reallocate Wailoa Ditch agricultural water	12	--	0	--	0	12
CBA-5	B – Makawao aquifer groundwater	3	L – Lower Kula System Expansion	2.4	C – Kama‘ole aquifer groundwater	6.6	12
CBA-6	F -Waikapū aquifer groundwater	2.5	I – Waihe‘e aquifer groundwater	2.7	K – Reallocate Wailoa Ditch agricultural water	6.8	12
CBA-7	F -Waikapū aquifer groundwater	2.5	K – Reallocate Wailoa Ditch agricultural water	5	B – Makawao aquifer groundwater	4.5	12
CBA-8	B – Makawao aquifer groundwater	4	K – Reallocate Wailoa Ditch agricultural water	4	E – Pā‘ia aquifer groundwater	4	12
CBA-9	B – Makawao aquifer groundwater	5	I – Waihe‘e aquifer groundwater	2.7	J – Capture Wailoa Ditch high flows	4.3	12
CBA-10	No Action						0
CBA-11 [a]	MDWS Identified Action						12

Note: Abbreviation: CBA = cost-benefit alternative

a. *MDWS Identified Action contains a diversified five-source strategy to generate 12 mgd of total flow with an additional 3 mgd backup flow. See Section 5 for additional information.*

The alternatives presented in Table 37 were carried forward into the cost-benefit analysis.

Section 5: Cost-Benefit Analysis

A rigorous cost-benefit analysis was prepared in accordance with federal guidelines. The cost benefit analysis is presented in detail in Appendix C:. This section summarizes the findings.

5.1 Cost-Benefit Alternatives (CBAs)

The most attractive groundwater and surface water supply and development strategies were combined into 10 cost-benefit alternatives (CBAs) that would be capable of meeting future water demands. The 10 CBAs are presented in Table 37, along with a "no action" alternative. CBA-1 to CBA-9 were developed by BC and include up to three source strategies. CBA-11 was developed by MDWS staff and includes five source strategies, including an additional 3 mgd basal backup supply.

5.2 Cost-Benefit Analysis Results

The cost benefit analysis considered impacts to the community in the form of lost economic benefits by assessing a "no action" alternative. Table 38 presents the cost-benefit analysis results. The results considered several discount rates as a sensitivity analysis. The discount rates in the table reflect the interest rate of bond funding minus inflation.

Table 38. Summary of Cost-Benefit Analysis Results

Alternative	Present Value at Discount Rate ($ million)			
	1.0%	2.0%	2.5%	4.0%
CBA-1: Haiku groundwater (baseline)	*$1,739*	*$1,410*	*$1,282*	*$998*
CBA-2: Makawao, Waihee, and Haiku groundwater	$1,961	$1,621	$1,487	$1,184
CBA-3: Wailoa ditch, high flows	$2,017	$1,588	$1,425	$1,070
CBA-4: Wailoa ditch, reallocate ag water	$1,837	$1,428	$1,274	$940
CBA-5: Makawao and Kama'ole groundwater, lower Kula system expansion	$2,073	$1,712	$1,571	$1,250
CBA-6: Waikapu and Waihee groundwater, reallocate ag water from Wailoa ditch	$1,906	$1,538	$1,396	$1,081
CBA-7: Waikapu and Paia groundwater, reallocate ag water from Wailoa ditch	$1,926	$1,555	$1,412	$1,094
CBA-8: Makawao and Paia groundwater, reallocate ag water from Wailoa ditch	$2,033	$1,654	$1,507	$1,178
CBA-9: Makawao and Waihee groundwater, high flows from Wailoa ditch	$2,048	$1,672	$1,526	$1,198
CBA-10: No action (lost economic benefits, partial)	$45,051	$30,995	$25,934	$15,697
CBA-11: MDWS Identified Action	$1,961	$1,612	$1,475	$1,167

Table Legend Notes:

Black italicized text: *Calculations for the baseline alternative.*
Bold column border: *The real discount rate for long-term County of Maui projects.*
Green text: *PVs that are lower than that for the baseline alternative.*
Red text: *PVs that are greater than that for the baseline alternative.*

Discount Rate Notes:

1%: *A low rate consistent with future inflation of construction and O&M costs exceeding general inflation by about 1% per year.*
2%: *The real discount rate for long-term County of Maui projects (4.2% bond interest rate – 2.2% inflation).*
2.5%: *The real discount rate for long-term federal projects.*
4%: *A high rate consistent with uncertainty over costs and impacts far into the future.*

Development of the County water system to accommodate planned population and economic growth would provide substantial economic benefits to the community at large (i.e., both the MDWS service areas and areas not serviced by MDWS).

These economic benefits would be lost under the “No Action” Alternative. The alternative with the lowest present value cost is Haʻikū Groundwater (CBA-1, the Baseline Alternative) with Alternative CBA-4 (Wailoa Ditch, Reallocate Ag Water) at a close second. These two alternatives remain the lowest cost even with reasonable changes in the discount rate (PEP, 2024 [Appendix C]).

Based only on expenditures by MDWS, the alternative that would provide the lowest PV cost to MDWS and the lowest water rates is CBA-4. Because it is presumed that alternate source would be found to replace agricultural water, this finding ignores the future loss of farm-related economic benefits due to reallocating ditch water from future farming in Central Maui to the County water system.

If the reallocated agricultural water was not replaced by alternate source, loss of that water could result in a change in the farm plan for Central Maui—i.e., decreased irrigated crop farming by about 2,280 acres and increased unirrigated pastureland by the same amount—with an estimated 114 future farm jobs possibly lost. Increasing the amount of unirrigated pastureland in windy Central Maui would also likely increase wind-blown dust, increase the risk of wildfires, require an increase in fire control services, and negatively impact watershed health (PEP, 2024 [Appendix C]).

With Alternative CBA-4, there is the risk of not being able to meet projected water demand within the required timeframe for two reasons. First, the planned use of ditch water may be subject to public opposition and legal challenges which, in turn, may delay development and/or reduce the planned amount of water to be reallocated. Second, once developed, the available flow of ditch water will be low during prolonged droughts, resulting in reduced water supply to meet demand (PEP, 2024 [Appendix C]) .

CBA-11 was developed by MDWS following the initial CBA analysis and contains a diversified five source strategy to generate 12 mgd of total flow with an additional 3 mgd backup flow. CBA-11 includes the following source strategies:

1. 1.5 mi Iao Ditch improvements to generate approximately 0.5 mgd of additional surface flow
2. Strategy A – Develop Haʻikū groundwater aquifer to generate approximately 8 mgd
3. Strategy B – Develop Makawao groundwater aquifer to generate approximately 3 mgd of backup flow
4. Strategy I – Develop Waiheʻe groundwater aquifer to generate approximately 0.5 mgd
5. Strategy K – Reallocate Wailoa Ditch agricultural water to generate approximately 3 mgd

All costs associated with CBA-11 have been normalized to account for the additional 3 mgd basal backup flow from source strategy B, which will not operate simultaneously with source strategy K. Costs associated with Iao Ditch improvements include 25 percent R&R, 30 percent contingency, and 25 percent engineering/administration/legal, which is in alignment with the other source strategy cost estimates.

Section 6: Ka Paʻakai Analysis

In August 2024, a Ka Paʻakai analysis was conducted for Phase 3 of the Feasibility Study for East Maui Water Source Development. Three virtual and two in-person meetings were convened to discuss Ka Paʻakai, and attended by ten and twelve participants, respectively. Two individuals participated in both one virtual meeting and one in-person meeting. Further, two people submitted their comments via email correspondence. In all, 22 people participated in the Ka Paʻakai analysis for this project.

The establishment of the Ka Paʻakai analysis framework was intended to address a specific geographic area, and more recently, was expanded to include such analysis in government actions, including rulemaking. Phase 3 encompasses 7 out of the 12 Maui moku, which covers more than half the island. Hence, the Ka Paʻakai analysis for this project encompasses both the larger context of a large geographic reference, values and legal framework, as well as site-specific resources. The Ka Paʻakai analysis discusses larger context of values and legal framework and summarizes information shared about specific locales. The complete Ka Paʻakai analysis can be found in Appendix D. A summary is provided below.

6.1 Values, Legal Framework and Justice

6.1.1 The Significance of Wai

Wai, or water, is a fundamental value held by Kānaka Maoli and Kanaka ʻŌiwi, or Native Hawaiians. For participants, wai is life and cannot be owned or sold. For participants, this Feasibility Study is deeply related to the value of wai. They noted that aquifers are phenomena of nature. With a Hawaiian cultural lens, the Kānaka ʻŌiwi understand these natural phenomena of aquifers are the embodiment of the Akua, a god or spirit, named Kanaloa. “Kanaloa i ka wai honua” means “Kanaloa in the depths of the deep Earth.” When drilling into an aquifer, this action pierces the shell of Kanaloa I Ka Wai Honua. When the water is depleted, the spring will stop flowing. Any development or extraction of groundwater in that area should consider adverse impacts to flows so that cultural significance and gathering rights are not affected.

Participants also did not believe that aquifers have “boundaries,” or that there is accurate information on the exact locations of water sources. They noted that the ocean is the outlet for all aquifers and land water sources. They believe that all water is connected, and questioned how depleting water from one aquifer affects other aquifers.

6.1.2 Legal Framework

Disregard for Kānaka Maoli Rights Provided for in Pre-Annexation Law

Participants felt that Native Hawaiian rights under the Nation of Hawaiʻi laws and constitution are not being honored or acknowledged. It was noted that the 1839 Constitution ensured protection for Kānaka Maoli, and that laws must conform to the laws of the kingdom, and nothing shall be taken from any individual except by express provision of the laws. It was further cited that, in the 1898 Joint Resolution to Provide for Annexing the Hawaiian Islands to the United States, it is said that “the existing laws of the United States relative to public lands shall not apply to such lands in the Hawaiian Islands.”

The 1900 Hawaiian Organic Act—that annexed the Territory of Hawaiʻi to the U.S.—stated that "the laws of Hawaiʻi not inconsistent with the Constitution or laws of the United States or the provisions of this Act shall continue in force, subject to repeal or amendment by the legislature of Hawaiʻi or the Congress of the United States." Participants did not cite any amendments or repeals and believed that the laws of Hawaiʻi prior to annexation are still in effect.

Subjugation of Kānaka Maoli Identity

In the Hawaiʻi Statehood Admission Act of 1959, it is stated that "nothing contained in this Act shall operate to confer United States nationality, nor to terminate nationality heretofore lawfully acquired, or restore nationality heretofore lost under any law of the United States or under any treaty to which the United States is or was a party." For participants this confirms the identity of Kānaka Maoli is that of the Lāhui, or nation, and not part of the United States of America. However, subsequent laws, rules and practices identify "Hawaiian" as a citizen of the United States.

Water Rights

The Penal Code of 1850 establishes that "the people shall also have a right to drinking water, and running water, and the right of way. The springs of water, and running water, and roads shall be free to all, should they need them, on all lands granted in fee simple . . .". The Hawaiʻi State Water Code codifies Native Hawaiian Water Rights in and states "Traditional and customary rights of ahupuaʻa tenants who are descendants of Native Hawaiians who inhabited the Hawaiian Islands prior to 1778 shall not be abridged or denied by this chapter.

Such T&C rights shall include, but not be limited to, the cultivation or propagation of taro on one's own kuleana and the gathering of hihiwai, ʻopae, oʻopu, limu, thatch, ti leaf, aho cord, and medicinal plants for subsistence, cultural, and religious purposes (HRS § 174C-101)." Further, these rights are not diminished by a failure to receive a water permit.

Participants believe that these provisions continue to endure and are not being followed by the government and that Kānaka Maoli are still required to go through the water permit process.

Fairness of Water Distribution and Long-Standing Injustice

Participants objected to the practice of transmitting water from their ahupuaʻa to another region, particularly resort areas, where precious water is being used to irrigate golf courses and fancy landscaping. They further noted that while water is being transported to support tourism, native residents are having difficulty obtaining water meters.

A deeper sense of injustice was explained in the context of the Apology Resolution of 1993 that outlined the illegal annexation of the Territory of Hawaiʻi. The Apology Resolution further acknowledged that the health and well-being of the Native Hawaiian people are intrinsically tied to their deep feelings and attachment to the land and that the long-range economic and social changes in Hawaiʻi have been devastating to the population and to the health and well-being of the Hawaiian people. Congress apologized to Native Hawaiians on behalf of the U.S. for the overthrow of the Kingdom of Hawaiʻi and expressed its commitment to acknowledge this action's ramifications—to provide a proper foundation for reconciliation between the U.S. and the Native Hawaiian people.

Participants felt that this formal apology was a start, but that the U.S. has not gone far enough in reconciliation and restitution. They stated there still needs to be restitution for "unjust enrichment," the term that characterizes how taking lands of the Hawaiian Kingdom unjustly enriched the U.S. when the Kingdom was overthrown, and that the State of Hawaiʻi benefited from the same when Hawaiʻi was admitted into the Union.

Participants felt that unjust enrichment is applicable to water, although they noted that there is still a long way to go in developing a remedy that would be within the context of water and reconciliation with Kānaka ʻŌiwi.

6.1.3 Manaʻo on Specific Locales

Participants shared manaʻo, or thoughts, regarding specific areas and resources that are valuable for their cultural practices and beliefs, as well as the ecosystem that sustains their cultural resources.

- The ʻŌhiʻa springs in Waianu—several springs are located in a small awāwa, or valley. Up on the ridgeline, on the Hāna side of the awāwa is a church complex called Pā Kanaloa, or the enclosure of Kanaloa. Now covered by foliage and vegetation growth, the church complex was a cultural gathering place and the ʻŌhiʻa Spring was a part of the Pā Kanaloa church complex. There is a story, or moʻolelo, of a priestess referred to as a moʻo who lived below the area and cared for the area where watercress patches are now. There was concern that drilling into the aquifer would deplete the water quantity, and the flow of the spring would stop.
- In Nāhiku in the 1940s there used to be a waterfall with a pond with ʻiliʻili stones at its base. The waterfall pushed the pebbles outward, thus forming a pond of freshwater right next to the ocean, where one could gather oʻopu and ʻōpae. Today, there is no more ʻōpae. When plantations came to Makapipi, the two loʻi kalo in Nāhiku dried up after the plantations installed a gate at top of the mountain and blocked off water.
- There was concern about the possible construction of a well at the 500-foot elevation on Honopou Stream. Kalo farmers downstream of this possible well depend on the stream water. Participants warned that tapping more aquifers will harm the ability of downstream kalo farmers to access water.
- Participants noted that there has been decreased abundance of fish in the Kanemoeala area, where they dived since childhood. There are two species of āweoaweo (endemic and native), or Hawaiian bigeye tuna. This endemic fish has become less abundant, possibly due to diminished freshwater seeps that provide habitat for planktonic fish that are part of its diet. Putting in wells for drinking water would decrease the freshwater supply in this area, thereby threatening the food supply.
- There are two native bee species in Kanemoeala that stretches to Pauwela Lighthouse and Manawaiʻiao Stream. The Hawaiian yellow-faced bees are pollinators for coastal vegetation. Both are ground-burrowing, and this indicates a relationship between the bees and spring water. There was concern that taking water from the aquifers would lead to less seepage and less habitat for native vegetation.
- One person from East Kuiaha reported that downstream water flow is decreasing even in times of heavy rains. He believes that underground tunnels are interrupting water flow and filed a complaint with the State of Hawaiʻi CWRM about the underground tunnel system. The CWRM noted that there are four diversions in this area and found that there was no need for IIFS for this stream because there is not enough water flow. The participant disagrees with these findings.

6.1.4 Feasible Actions to Protect Native Hawaiian Rights

Given the "big picture" nature of this Ka Paʻakai analysis, it is too early to identify or specify feasible actions to protect Hawaiian rights. There are no specific geographical locations and no specific actions.

Further, there are ongoing discussions on how to provide restitution for unjust enrichment. It is possible that by the time a project and locations are selected, the legal climate for water and Native Hawaiian rights will have evolved. In any event, continued application of the Ka Paʻakai analysis is highly recommended.

Section 7: Conclusions and Recommendations

Conclusions and recommendations based on the cost-benefit analysis of potential water source alternatives in Central, Upcountry, and East Maui are presented in this section.

7.1 Conclusions

MDWS is evaluating potential additional water sources to meet projected public water system demands of 12 mgd (annual average) and 18 mgd (peak month) for Central and Upcountry water systems. The EMFS Phase 3's comprehensive cost-benefit study of potential groundwater and surface water sources in Central, Upcountry, and East Maui regions considers environmental, cultural, hydrologic, legal, permitting, and economic factors. A MCDA and engineering economic analysis were prepared to identify groundwater and surface water strategies that are most attractive from both a cost and non-cost basis. Table 39 summarizes the strategy evaluation results of the MCDA and the engineering economic analysis.

Table 39. Summary of Most Attractive Strategies

Strategy	Maximum Average Annual Yield (mgd)	Life-Cycle Unit Cost ($/1,000 gallons)	Non-Economic Score
A. Haʻikū aquifer groundwater	12	$11.9	0.55 [a]
B. Makawao aquifer groundwater	5.4	$12.1	0.52 [a]
C. Kamaʻole aquifer groundwater	6.6	$14.6	0.44 [a]
E. Pāʻia aquifer groundwater	4.3	$14.0	0.47 [a]
F. Waikapū aquifer groundwater	2.5	$12.0	0.43 [a]
I. Waiheʻe aquifer groundwater	2.7	$13.7	0.41 [a]
J. Capture Wailoa Ditch high flows	12	$11.5	0.35
K. Reallocate Wailoa Ditch agricultural water	12	$10.0	0.48
L. Lower Kula system expansion	3.2	$14.7	0.38

Strategies involving Wailoa Ditch flows and Haʻikū Aquifer groundwater reflect the lowest life-cycle unit costs overall. Haʻikū and Makawao aquifer groundwater strategies result in the greatest non-economic benefits. Figure 56 presents the results graphically. The most attractive strategies have both higher non-economic scores and lower life-cycle costs, as indicated by the red box.

Figure 56. Combined Economic and Non-Economic Evaluation Results

The most attractive strategies shown in Figure 56 were then combined into 10 alternatives capable of supplying all future ADD for a thorough cost-benefit analysis prepared in accordance with federal guidelines, including one alternative identified by MDWS. Table 40 summarizes the alternatives for the cost-benefit analysis.

Table 40. Alternatives for Cost-Benefit Analysis

Identifier	Source Strategy 1		Source Strategy 2		Source Strategy 3		Total Flow (mgd)
	ID	Flow (mgd)	ID	Flow (mgd)	ID	Flow (mgd)	
CBA-1	A – Ha‘ikū aquifer groundwater	12	--	0	--	0	12
CBA-2	B – Makawao aquifer groundwater	5	I – Waihe‘e aquifer groundwater	2.7	A – Ha‘ikū aquifer groundwater	4.3	12
CBA-3	J – Capture Wailoa Ditch high flows	12	--	0	--	0	12
CBA-4	K – Reallocate Wailoa Ditch agricultural water	12	--	0	--	0	12

Table 40. Alternatives for Cost-Benefit Analysis							
Identifier	Source Strategy 1		Source Strategy 2		Source Strategy 3		Total Flow (mgd)
	ID	Flow (mgd)	ID	Flow (mgd)	ID	Flow (mgd)	
CBA-5	B – Makawao aquifer groundwater	3	L – Lower Kula System Expansion	2.4	C – Kamaʻole aquifer groundwater	6.6	12
CBA-6	F -Waikapū aquifer groundwater	2.5	I – Waiheʻe aquifer groundwater	2.7	K – Reallocate Wailoa Ditch agricultural water	6.8	12
CBA-7	F -Waikapū aquifer groundwater	2.5	K – Reallocate Wailoa Ditch agricultural water	5	B – Makawao aquifer groundwater	4.5	12
CBA-8	B – Makawao aquifer groundwater	4	K – Reallocate Wailoa Ditch agricultural water	4	E – Pāʻia aquifer groundwater	4	12
CBA-9	B – Makawao aquifer groundwater	5	I – Waiheʻe aquifer groundwater	2.7	J – Capture Wailoa Ditch high flows	4.3	12
CBA-10	No Action						0
CBA-11 [a]	MDWS Identified Action						12

a. *MDWS Identified Action contains a diversified five-source strategy to generate 12 mgd of total flow with an additional 3 mgd backup flow. CBA-11 includes 1.5 mi of Iao Ditch improvements to generate approximately 0.5 mgd of additional surface flow as well as the following source strategies and their associated flows:*

A – Haʻikū aquifer groundwater (8 mgd)

B – Makawao aquifer groundwater (3 mgd backup)

I – Waiheʻe aquifer groundwater (0.5 mgd)

K – Reallocate Wailoa Ditch agricultural water (3 mgd)

The cost-benefit analysis considered impacts to the community at large in the form of lost economic benefits by assessing a "no action" alternative. Table 41 presents the results of the cost-benefit analysis.

Table 41. Results of Cost-Benefit Analysis		
Alternative	Present Value Cost at 2% Discount Rate ($ millions) [a]	Comparison to Baseline Alternative
CBA-1: Haiku groundwater (baseline)	$1,410	0%
CBA-2: Makawao, Waihee, and Haiku groundwater	$1,621	+15%
CBA-3: Wailoa ditch, high flows	$1,588	+13%
CBA-4: Wailoa ditch, reallocate ag water	$1,428	+1%
CBA-5: Makawao and Kamaʻole groundwater, lower Kula system expansion	$1,712	+21%
CBA-6: Waikapu and Waihee groundwater, reallocate ag water from Wailoa ditch	$1,538	+9%
CBA-7: Waikapu and Paia groundwater, reallocate ag water from Wailoa ditch	$1,555	+10%
CBA-8: Makawao and Paia groundwater, reallocate ag water from Wailoa ditch	$1,654	+17%
CBA-9: Makawao and Waihee groundwater, high flows from Wailoa ditch	$1,672	+19%

CBA-10: No action (lost economic benefits, partial)	**$30,995**	**+2,198%**
CBA-11 MDWS Identified Action	**$1,612**	**+14%**

Note:

a. 2% represents the real discount rate for long-term County projects funded with tax-exempt municipal bonds (4.2% bond rate – 2.2% inflation rate).

Table 41 shows that groundwater from the Haiku aquifer (CBA-1) and reallocation of agricultural water from Wailoa Ditch (CBA-4) have the lowest PV costs. Comparison of nine alternatives that would develop additional source water to support the growth of the community (CBA-1 through CBA-9) shows that the PV costs of all alternatives are within 21 percent of the baseline alternative (CBA-1).

The analysis shows that although relying on a single aquifer (Haʻikū), or a single surface water source (Wailoa Ditch), to meet future source needs has the lowest PV costs, diversification of source (e.g., multiple aquifers, or combination of groundwater and surface water) does not appear to incur unacceptably higher costs.

The high present cost of the “no action” alternative (CBA-10) in comparison to the rest of the alternatives shows that development of additional source water supplies to accommodate planned population and economic growth would provide substantial economic benefits to the community. These economic benefits would be lost under the “no action” alternative.

Based only on expenditures by MDWS, the alternative that would provide the lowest PV cost to MDWS and the lowest water rates is CBA-4. This finding ignores the future loss of farm-related economic benefits due to reallocating ditch water from future farming in Central Maui to the County water system.

With Alternative CBA-4, there is risk of not supplying projected water demand for two reasons. First, the planned use of ditch water may be subject to public opposition and legal challenges which, in turn, may delay development and/or reduce the planned flow of water to be reallocated. Second, once developed, the available flow of ditch water will be low during prolonged droughts, possibly resulting in the supply of water being insufficient to meet demand.

7.1.1 Groundwater

Based on analysis of the 12 aquifers included in the study area, the most attractive groundwater source options are within the Waiheʻe, Makawao, Waikapū, Haʻikū, Pāʻia, and Kamaʻole aquifers. From both a life-cycle cost and non-economic benefit perspective, the most attractive groundwater source option is the Haʻikū Aquifer. The Makawao and Waikapū aquifers also rank favorably in terms of life-cycle cost, with the Makawao Aquifer also ranking second only to Haʻikū in terms of benefit score.

Further studies will be required to implement source development projects. These studies may include hydrogeological studies, environmental reviews, and additional stakeholder engagement. Native Hawaiians consulted for the Ka Paʻakai analysis expressed concern about the impacts of groundwater source development on ecosystems and T&C uses. GDEs need to be considered, and continued opportunities should be explored to recharge aquifers.

7.1.2 Surface Water

While additional East Maui surface water supply from the Wailoa Ditch appears to be cost effective and (in the case of reallocation) beneficial, development of additional surface water source beyond existing agreements incurs substantial implementation risks, including community opposition, agricultural sector opposition, implementation delays to obtain approvals, and implementation delays due to potential legal actions. Furthermore, surface water sources are more vulnerable to climate change and drought conditions than groundwater sources. Increased storage capacity near Kamole WTF would improve drought resilience by allowing more surface water to be stored during times of high flow conditions, for use during drier periods.

Native Hawaiians consulted for the Ka Paʻakai analysis expressed concern about the impacts of surface water source development on ecosystems and T&C uses. Proposed surface water withdrawals will need to evaluate these potential impacts as it relates to future off-stream uses of water to meet projected demand. Opportunities to restore watershed areas that contribute to stream flow and recharge ground water aquifers should be pursued.

7.1.3 Alternative Water Sources

Surface water and groundwater are considered “traditional” water sources. While beyond the scope of this study to analyze alternative water sources, MDWS is separately evaluating alternative water source strategies such as desalination, stormwater capture for aquifer recharge, and reuse of treated wastewater. Future analyses may combine evaluation of traditional and alternative water sources, and more detailed considerations for flood control, water quality protection and climate resilience under a One Water framework. Collaboration across agencies with community input will be key to pursuing holistic solutions that create a resilient and equitable water future for Maui.

7.2 Recommended Approach

Based on this study, the most attractive groundwater source options are the Waiheʻe, Makawao, Waikapū, Haʻikū, Pāʻia, and Kamaʻole aquifers. Of these, only the Haʻikū Aquifer has remaining SY sufficient to supply the full 12 mgd demand shortage projected for 2040. The most attractive surface water source option is via the Wailoa Ditch.

Because of uncertainty associated with the use of East Maui surface water resources, if the increased supply from Wailoa Ditch water is pursued we recommend MDWS pursue a diversified water supply system that also incorporates groundwater from multiple aquifers to meet future needs. Interconnection of the Upcountry and Central Maui water systems would also allow greater flexibility in meeting demands for public water, providing more drought resilience for Upcountry Maui.

Native Hawaiians consulted through the Ka Paʻakai analysis for this study indicated that any development or extraction of groundwater should consider potential adverse impacts to stream flows and nearshore ecosystems to mitigate effects on areas of cultural significance and gathering rights. Participants also expressed a desire to keep water resources within their region of origin, and to prioritize the needs of Maui residents.

Building on public engagement from the WUDP, MDWS can continue conversations with Maui communities to review the potential water source strategy alternatives presented in this study. Further public outreach and Ka Paʻakai analyses for individual projects will help ensure successful implementation that is sensitive to the goals and needs of each community.

7.3 Implementation Plan

Following this feasibility study, additional actions needed to implement the preferred water source strategies include:

- Initiate hydrogeological studies

- Procure program manager
- Define well sites and infrastructure improvements
- Define project scopes and implementation priorities
- Conduct environmental reviews and other technical/environmental studies
- Site specific planning to identify required easements and land acquisitions
- Conduct stakeholder engagement including interagency collaboration and Ka Paʻakai analyses
- Procure design consultants
- Design, construct, and commission projects

Figure 57 shows an implementation schedule for planning, design, construction, and operation of water supply projects through a programmatic approach. Operations could begin in 2035, and construction could conclude in 2040.

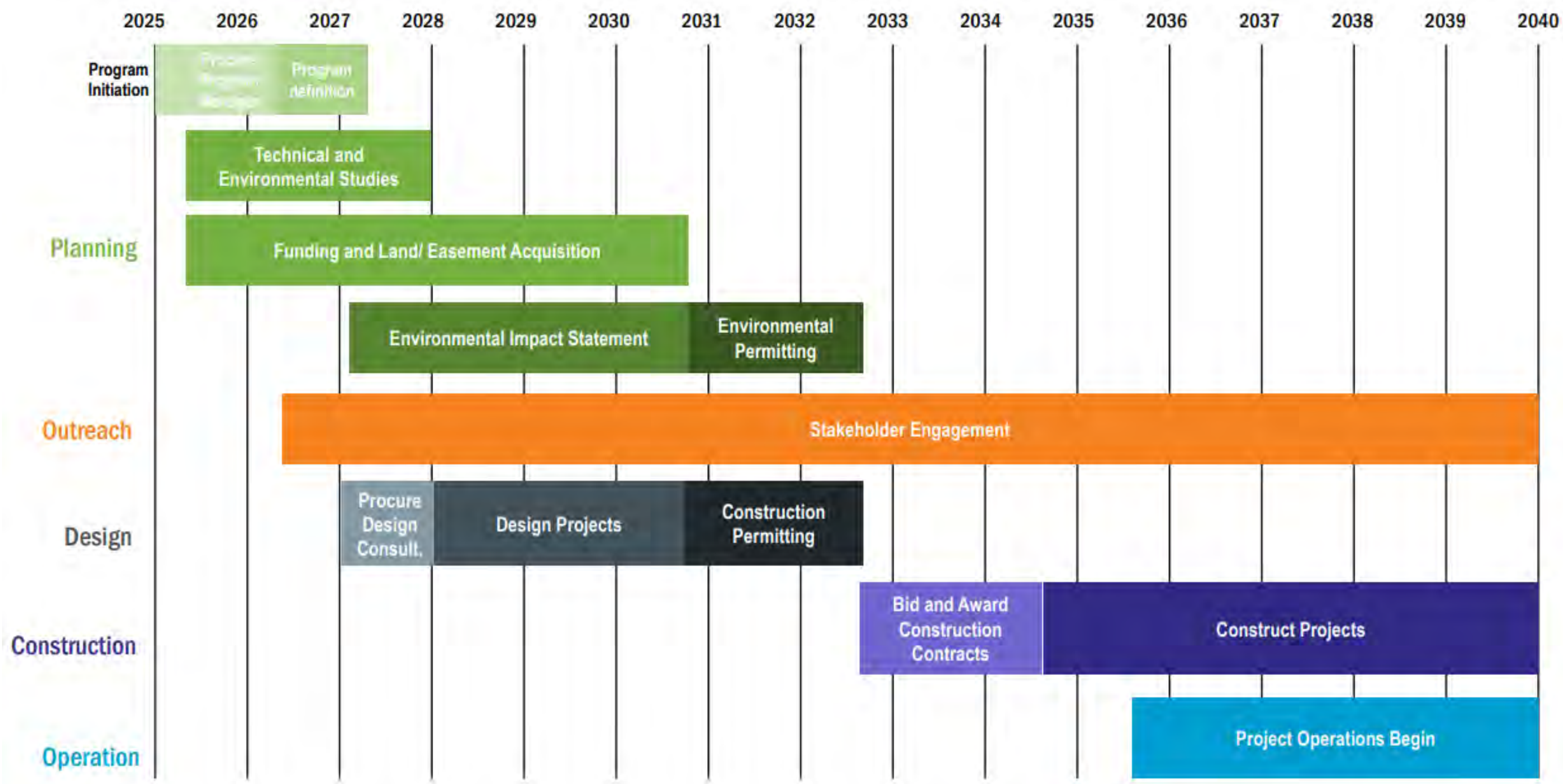

Figure 57. Implementation Schedule

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Appendix A: Non-economic Analysis

Table A-1. Groundwater Evaluation Criteria Definitions

Category	Criteria	Non-Economic Criteria Definitions			Fatal Flaw
		Favorable	Moderate	Least favorable	
Water Source	Quantity	> 20 mgd remaining aquifer sustainable yield (SY)	5 - 20 mgd remaining aquifer SY	0 - 5 mgd remaining aquifer SY	No remaining aquifer SY
	Groundwater sustainability	> 60% aquifer sustainable yield (SY) remaining	30 - 60% aquifer SY remaining	10 - 30% aquifer SY remaining	<10% aquifer SY remaining
	Saltwater intrusion risk	Low long-term risk of salinity reaching >250 ppm		High near-term risk of salinity reaching >250 ppm	
	Groundwater quality	0 - 2 contamination source categories identified. No additional treatment needed.	3 - 4 contamination source categories identified. Additional treatment may be needed.	5 -7 contamination source categories identified. GAC or other treatment needed.	Contamination not treatable to drinking water standards
Diversity and Supply-Demand Area	Source Location and Type Diversity	Located in area where County does not currently have source	Located in area where County has active source and would increase supply diversity	Located in area where County currently has source	
	Supply-Demand Area	Located in an aquifer system with current/future demand (Kamaʻole, Iao, Kahului, Haiku, or Makawao aquifer)	Located in an aquifer system with moderate demand (Waikapu, Waihee, Paia)	Located in aquifer system outside of Central/Upcountry system demand area	
Environmental	Groundwater Dependent Ecosystems (GDE)	≤ 1 GDE potentially impacted	2 GDEs potentially impacted	3 GDEs potentially impacted	
	Climate impacts	1 - 3% increase in groundwater recharge projected	1 - 30 % decrease in groundwater recharge projected	30 - 80% decrease in groundwater recharge projected	
	Drought resilience	Most resilient - groundwater	Less resilient - ditch water from multiple streams	Least resilient - stream water from an individual stream	
	Wildfire risk	Source area includes "Low" fire risk communities	Source area includes "Medium" fire risk communities	Source area includes "High" fire risk communities	
Permitting	Groundwater permitting complexity	Well Permit for new well outside Groundwater Management Area (GWMA), or increasing capacity of existing well outside of GWMA	Groundwater Use Permit Amendment for use of existing well within GWMA	Groundwater Use Permit and Well Permit for new well within GWMA, or for high-level groundwater potentially affecting surface water	
	Transmission permitting complexity	Makes use of existing easements (existing ditch or pipeline)	Modify existing easements or create new easements (new pipe to existing reservoir)	Condemnation of easements required (new pipe to new reservoir)	

Table A-1. Groundwater Evaluation Criteria Definitions					
Category	Criteria	Non-Economic Criteria Definitions			Fatal Flaw
		Favorable	Moderate	Least favorable	
Infrastructure	Well elevation	Max elevation < 500 ft above mean sea level (MSL)	Max elevation 501 – 1,500 ft above MSL	Max elevation 1,501 – 4,000 ft above MSL	Max elevation > 4001 ft above MSL
	Topography	Majority of area 0-10% slope	Majority of area 10-30% slope	Majority of area > 30% slope	
	Proximity to water system	< 1 mile to water system point of adequacy or existing ditch system	1-10 miles from water system point of adequacy or existing ditch system	> 10 miles from water system point of adequacy or existing ditch system	
	Treatment complexity	Groundwater treatment	Surface water from streams and ditches treatment	Stormwater treatment	
Energy	Energy grid accessibility	< 1 mile to electrical distribution system	1-10 miles to electrical distribution system	> 10 miles to electrical distribution system	
	Energy grid capacity	200% of expected electrical load available at connection point	100 - 200% of expected electrical load available at connection point	< 100% of expected electrical load available at connection point	
	Energy grid risk	Low risk of power outages, short duration	Medium risk of power outages, medium duration	High risk of power outages, longer duration	

Table A-2. Surface Water Evaluation Criteria Definitions

Category	Criteria	Non-Economic Criteria Definitions			Fatal Flaw (0)
		Favorable	Moderate	Least favorable	
Water Source	Quantity	> 10 mgd surface water flow	5 - 10 mgd surface water flow	1 - 5 mgd surface water flow	< 1 mgd surface water flow
	Surface water reliability	> 75% of days (diversion of low flows below Q75)	51 - 75% of days (diversion of flows from Q75 to Q50)	≤ 50% of days, or stormwater (diversion of high flows above Q50)	Intermittent/gulch
	Surface water quality	Less sediment and pollutants in base stream flows		More sediment and pollutants in high stream flows and stormwater	
Diversity and Supply-Demand Area	Source Location and Type Diversity	Located in area where County does not currently have source	Located in area where County has active source and would increase supply diversity	Located in area where County currently has source	
	Supply-Demand Area	Outlet/point of connection is in aquifer system with current/future demand (Kama‘ole, Iao, Kahului, Haiku, or Makawao aquifer)	Located in an aquifer system with moderate demand (Waikapu, Waihee, Paia)	Located in aquifer system outside of Central/Upcountry system demand area	
Environmental	Surface water ecosystems	Impact to ecosystems unknown - diversion of high flows above Q50	Potential impact to ecosystems - diversion of flows from Q75 to Q50	Likely impact to ecosystems - diversion of low flows below Q75	
	Climate impacts	1 - 3% increase in groundwater recharge projected	1 - 30 % decrease in groundwater recharge projected	30 - 80% decrease in groundwater recharge projected	
	Drought resilience	Most resilient - groundwater	Less resilient - ditch water from multiple streams, or high flows from individual stream	Least resilient - stream water from an individual stream, base flows or less	
	Wildfire risk	Source area includes "Low" fire risk communities	Source area includes "Medium" fire risk communities	Source area includes "High" fire risk communities	
Permitting	Surface water permitting complexity	Stream Diversion Works Permit (SDWP) for diversion outside a Surface Water Management Area (SWMA), or for stormwater	Surface Water Use Permit (SWUP) Amendment and SDWP for diversion of high flows above Q50 within a SWMA, or improve ditch	New SWUP and SDWP/ Modification for flows below Q50 for sources within a SWMA, or East Maui Water Authority for streams within East Maui region	Expressly disallowed in CWRM Decision & Order
	Transmission permitting complexity	Makes use of existing easements (existing ditch or pipeline)	Modify existing easements or create new easements (new pipe to existing reservoir)	New easements required (new pipe to new reservoir)	
Infrastructure	Raw surface water storage availability	Use existing reservoirs as-is	Modifications to existing reservoirs required	New reservoirs required	

Table A-2. Surface Water Evaluation Criteria Definitions

Category	Criteria	Non-Economic Criteria Definitions			Fatal Flaw (0)
		Favorable	Moderate	Least favorable	
	Proximity to water system	< 1 mile to water system point of adequacy or existing ditch system	1-10 miles from water system point of adequacy or existing ditch system	> 10 miles from water system point of adequacy or existing ditch system	
	Treatment complexity	Groundwater treatment	Surface water from streams and ditches treatment	Stormwater treatment	
Energy	Energy grid accessibility	< 1 mile to electrical distribution system	1-10 miles to electrical distribution system	> 10 miles to electrical distribution system	
	Energy grid risk	Low risk of power outages, short duration	Medium risk of power outages, medium duration	High risk of power outages, longer duration	

Table A-3. Groundwater Source Options Benefit Analysis

Potential Groundwater Sources (Id Number and Benefit Score)

Category	Criteria	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Water Source	Quantity	3	3	3	3	3	2	2	2	3	3	3	3	3	3	1	1	1	1	1	1	1	1	1
	Groundwater sustainability	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	2	2	2	1	1
	Saltwater intrusion risk	2	3	3	3	3	1	2	3	2	3	3	3	3	3	2	3	3	3	2	3	3	2	2
	Groundwater quality	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	1	2
	Total (max avail = 12)	10	11	11	11	12	9	10	11	11	12	12	12	12	12	9	10	10	9	8	9	9	5	6
Diversity and Supply-Demand Area	Source location and type diversity	3	2	3	2	2	3	2	2	3	2	2	2	2	2	3	3	3	3	1	3	3	1	1
	Supply-demand area	3	3	3	3	3	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	3	3
	Total (max avail = 6)	6	5	6	5	5	4	3	3	4	3	3	3	3	3	4	4	4	5	3	5	5	4	4
Environmental	Groundwater Dependent Ecosystems	2	2	2	2	2	2	2	1	2	1	1	2	1	1	2	2	1	2	2	2	2	1	1
	Climate impacts	2	2	2	2	2	3	3	3	3	3	3	2	2	2	2	2	2	2	2	2	2	2	2
	Drought resilience	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	Wildfire risk	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	2	2	2	2	2	2	1	1
	Total (max avail = 9)	10	10	10	10	10	11	11	10	11	10	10	10	9	9	9	9	8	9	9	9	9	7	7
Permitting	Groundwater permitting complexity	3	3	3	3	1	3	3	1	3	3	1	3	3	1	3	3	1	3	3	3	1	2	2
	Transmission permitting complexity	3	3	2	2	1	2	1	1	1	2	1	2	2	1	2	1	1	3	2	2	1	3	3
	Total (max avail = 6)	6	6	5	5	2	5	4	2	4	5	2	5	5	2	5	4	2	6	5	5	2	5	5
Infrastructure	Well elevation	3	2	3	2	1	3	2	1	3	2	1	3	2	1	3	2	1	2	3	2	1	3	2
	Proximity to water system	3	3	3	3	2	2	3	2	2	3	2	2	3	2	3	2	2	2	3	3	2	3	3
	Treatment complexity	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	Total (max avail = 9)	9	8	9	8	6	8	8	6	8	8	6	8	8	6	9	7	6	7	9	8	6	9	8
Energy	Energy grid accessibility	3	2	3	2	1	2	1	1	1	2	1	2	2	1	2	1	1	2	2	2	1	3	2
	Energy grid risk	3	2	3	2	1	2	2	1	2	2	1	2	2	1	2	1	1	2	2	2	1	3	3
	Total (max avail = 6)	6	4	6	4	2	4	3	2	3	4	2	4	4	2	4	2	2	4	4	4	2	6	5
	Water source option	Haʻikū aquifer existing wells < 500 ft	Haʻikū aquifer existing wells 500 - 1500 ft	Haʻikū aquifer new well(s) < 500 ft	Haʻikū aquifer new well(s) 500 - 1500 ft	Haʻikū aquifer new well(s) 1500 - 4000 ft	Honopou aquifer new well(s) < 500 ft	Honopou aquifer new well(s) 500 - 1500 ft	Honopou aquifer new well(s) 1500 - 4000 ft	Waikamoi aquifer new well(s) < 500 ft	Waikamoi aquifer new well(s) 500 - 1500 ft	Waikamoi aquifer new well(s) 1500 - 4000 ft	Keʻanae aquifer new well(s) < 500 ft	Keʻanae aquifer new well(s) 500 - 1500 ft	Keʻanae aquifer new well(s) 1500 - 4000 ft	Kahakuloa aquifer new well(s) < 500 ft	Kahakuloa aquifer new well(s) 500 - 1500 ft	Kahakuloa aquifer new well(s) 1500 - 4000 ft	Waiheʻe aquifer existing wells 500 - 1500 ft	Waiheʻe aquifer new well(s) < 500 ft	Waiheʻe aquifer new well(s) 500 - 1500 ft	Waiheʻe aquifer new well(s) 1500 - 4000 ft	ʻĪao aquifer existing wells < 500 ft	ʻĪao aquifer existing wells 500 - 1500 ft

Category	Criteria	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46
Water Source	Quantity	1	1	1	1	1	1	1	1	2	2	2	0	0	0	2	2	2	2	2	2	2	2	2
	Groundwater sustainability	1	1	1	3	3	3	3	3	3	3	3	0	0	0	3	3	3	3	3	3	3	3	3
	Saltwater intrusion risk	2	2	3	1	2	1	2	3	2	1	3	1	1	1	1	1	1	2	3	1	1	1	1
	Groundwater quality	1	2	3	2	2	2	2	3	2	2	3	1	1	1	2	2	2	2	3	1	1	1	1
	Total (max avail = 12)	5	6	8	7	8	7	8	10	9	8	11	2	2	2	8	8	8	9	11	7	7	7	7
Diversity and Supply-Demand Area	Source location and type diversity	1	2	3	3	3	3	3	3	2	3	2	1	1	1	3	3	3	3	3	2	2	3	2
	Supply-demand area	3	3	3	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	Total (max avail = 6)	4	5	6	5	5	5	5	5	5	6	5	4	4	4	6	6	6	6	6	5	5	6	5
Environmental	Groundwater Dependent Ecosystems	1	1	1	3	3	3	3	3	3	3	3	1	1	1	1	1	1	1	1	2	2	2	2
	Climate impacts	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Drought resilience	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	Wildfire risk	2	2	2	1	2	1	2	2	3	2	3	1	1	1	1	1	1	2	2	3	3	3	3
	Total (max avail = 9)	8	8	8	8	9	8	9	9	10	9	10	6	6	6	6	6	6	7	7	9	9	9	9
Permitting	Groundwater permitting complexity	1	1	1	3	3	3	3	1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	Transmission permitting complexity	3	2	1	3	3	3	2	1	3	3	3	3	3	3	3	3	3	1	2	3	3	3	2
	Total (max avail = 6)	4	3	2	6	6	6	5	2	6	6	6	6	6	6	6	6	6	4	5	6	6	6	5
Infrastructure	Well elevation	3	2	1	3	2	3	2	1	1	2	1	3	3	3	3	3	3	2	1	3	3	3	3
	Proximity to water system	3	3	2	3	2	3	2	2	3	3	2	3	3	3	3	3	3	2	2	2	2	3	2
	Treatment complexity	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	Total (max avail = 9)	9	8	6	9	7	9	7	6	7	8	6	9	9	9	9	9	9	7	6	8	8	9	8
Energy	Energy grid accessibility	3	2	1	3	2	3	2	1	3	3	3	3	3	3	3	3	3	1	2	2	2	3	2
	Energy grid risk	3	3	1	3	3	3	3	1	3	3	1	3	3	3	3	3	3	2	1	3	3	3	3
	Total (max avail = 6)	6	5	2	6	5	6	5	2	6	6	4	6	6	6	6	6	6	3	3	5	5	6	5
	Water source option	ʻĪao aquifer new well(s) < 500 ft	ʻĪao aquifer new well(s) 500 - 1500 ft	ʻĪao aquifer new well(s) 1500 - 4000 ft	Waikapū aquifer existing wells < 500 ft	Waikapū aquifer existing wells 500 - 1500 ft	Waikapū aquifer new well(s) < 500 ft	Waikapū aquifer new well(s) 500 - 1500 ft	Waikapū aquifer new well(s) 1500 - 4000 ft	Makawao aquifer existing wells 1500 - 4000 ft	Makawao aquifer new well(s) 1000 - 1500 ft	Makawao aquifer new well(s) 1500 - 4000 ft	Kahului aquifer existing wells < 500 ft	Kahului aquifer legacy wells < 500 ft	Kahului aquifer new well(s) < 500 ft	Kamaole aquifer existing wells < 500 ft	Kamaole aquifer legacy wells < 500 ft	Kamaole aquifer new well(s) < 500 ft	Kamaole aquifer new well(s) 500 - 1500 ft	Kamaole aquifer new well(s) 1500 - 4000 ft	Pāʻia aquifer existing wells 500 - 1000 ft	Pāʻia aquifer legacy wells 500 - 1000 ft	Pāʻia aquifer new well(s) < 500 ft	Pāʻia aquifer new well(s) 500 - 1000 ft

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Table A-4. Surface Water Options Benefits Analysis

	Criteria	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68
Water Source	Quantity	1	1	3	3	1	2	2	2	2	2	0	2	2	0	0	0	0	0	1	1	1	1
	Surface water reliability	2	2	3	1	2	2	3	1	2	2	3	1	2	2	3	1	2	2	3	1	1	1
	Surface water quality	3	3	3	1	3	3	3	1	3	3	3	1	3	3	3	1	3	3	3	1	1	1
	Total (max avail = 9)	6	6	9	5	6	7	8	4	7	7	6	4	7	5	6	2	5	5	7	3	3	3
Diversity and Supply-Demand Area	Source Location Diversity	1	1	1	1	1	2	2	2	2	1	1	1	2	3	3	3	3	2	2	2	3	2
	Supply-Demand Area	3	3	3	3	3	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3
	Total (max avail = 6)	4	4	4	4	4	4	4	4	4	4	4	4	5	6	6	6	6	5	5	5	6	5
Environmental	Surface water ecosystems	2	2	1	3	2	2	1	3	2	2	1	3	2	2	1	3	2	2	1	3	3	3
	Climate impacts	3	3	3	3	2	2	2	2	2	2	2	2	2	1	1	1	1	2	2	2	1	1
	Drought resilience	2	2	2	2	2	2	1	2	1	1	1	2	1	1	1	2	1	1	1	2	1	1
	Wildfire risk	3	3	3	3	2	2	2	2	2	1	1	1	1	1	1	1	1	2	2	2	1	3
	Total (max avail = 12)	10	10	9	11	8	8	6	9	7	6	5	8	6	5	4	7	5	7	6	9	6	8
Permitting	Surface water permitting complexity	0.5	1.0	0.5	1.0	0.5	0.5	1	2	2	1	1	2	2	1	1	0	2	1	1	2	3	3
	Transmission permitting complexity	3	3	2	3	2	2	3	3	2	3	3	2	2	3	1	2	2	3	1	2	1	1
	Total (max avail = 6)	4	4	3	4	3	3	4	5	4	4	4	4	4	4	2	2	4	4	2	4	4	4
Infrastructure	Raw surface water storage availability	3	2	3	1	3	3	3	2	2	3	3	1	2	3	3	1	2	3	3	1	1	1
	Proximity to water system	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	Treatment complexity	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1
	Total (max avail = 9)	8	7	8	6	8	8	8	7	7	8	8	6	7	8	8	6	7	8	8	6	5	5
Energy	Energy grid accessibility	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	Energy grid risk	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	2	2
	Total (max avail = 6)	5	5	5	5	5	5	5	5	5	6	6	6	6	6	6	6	6	6	6	6	5	5
	Water source option	East Maui available base flows in Wailoa Ditch	Improve Wailoa Ditch	East Maui reallocation of permitted uses from Wailoa Ditch	East Maui high flows from Wailoa Ditch	Lower Kula system expansion	Waihe'e River available base flows	Waihe'e River reallocate permitted uses	Waihe'e River high flows	Improve Waihe'e Ditch	Wailuku River available base flows	Wailuku River reallocate permitted uses	Wailuku River high flows	Improve Spreckels Ditch	Waikapū Stream available base flows	Waikapū Stream reallocate permitted uses	Waikapū Stream high flows	Improve Waikapū Ditch	Waiehu Stream available base flows	Waiehu Stream reallocate permitted uses	Waiehu Stream high flows	South Maui stormwater	Upcountry stormwater

Key
3 = Favorable
2 = Moderate
1 = Least favorable
0 = Fatal Flaw

Appendix B: Engineering Economic Analysis

County of Maui DWS
East Maui Feasibility Phase 3: Groundwater Strategies
Alternatives Net Present Value Analysis

Agency: County of Maui DWS

Project/Problem: East Maui Feasibility Phase 3: Groundwater Strategies

			Sensitivity Adjustments (%)			Results	
		Risk Premium	Benefits	Capital Costs	Other Costs	Capital Cost	30-year NPV
Alternative 1	No Action						
Alternative 2	A - Haiku aquifer groundwater					$972,400,000	($1,516,680,300)
Alternative 3	B - Makawao aquifer groundwater					$449,300,000	($693,380,181)
Alternative 4	C - Kamaole aquifer groundwater					$717,500,000	($1,014,686,533)
Alternative 5	D - Waikamoi aquifer groundwater					$1,987,300,000	($2,450,856,850)
Alternative 6	E - Paia aquifer groundwater					$451,800,000	($641,229,776)
Alternative 7	F - Waikapu aquifer groundwater					$226,800,000	($320,738,616)
Alternative 8	G - Keanae aquifer groundwater					$2,207,400,000	($2,620,056,226)
Alternative 9	H - Honopou aquifer groundwater					$1,670,800,000	($2,177,391,282)
Alternative 10	I - Waihee aquifer groundwater					$307,400,000	($397,318,181)
Alternative 11							
Alternative 12							

Year of analysis: 2025
Escalation rate: 2.20%
Discount rate: 4.20%

Select one
◉ All entries in dollars
○ All entries in thousands of dollars

Note: "Status quo" refers to Alternative 1

Make entries in yellow cells only

County of Maui DWS
East Maui Feasibility Phase 3: Surface Water Strategies
Alternatives Net Present Value Analysis

Agency: County of Maui DWS

Project/Problem: East Maui Feasibility Phase 3: Surface Water Strategies

			Sensitivity Adjustments (%)			Results	
		Risk Premium	Benefits	Capital Costs	Other Costs	Capital Cost	30-year NPV
Alternative 1	No Action						
Alternative 2	J - Capture Wailoa Ditch high flows					$871,400,000	($1,464,003,313)
Alternative 3	K - Reallocate Wailoa Ditch ag water					$694,900,000	($1,268,446,045)
Alternative 4	L - Lower Kula system expansion					$344,700,000	($498,283,339)
Alternative 5	M - Capture Waihee River high flows					$635,400,000	($903,497,245)
Alternative 6	N - Reallocate Wailuku Area ag water					$285,100,000	($399,068,011)
Alternative 7	O - Capture Wailuku River high flows					$580,000,000	($909,906,917)
Alternative 8							
Alternative 9							
Alternative 10							
Alternative 11							
Alternative 12							

Year of analysis:	2025
Escalation rate:	2.20%
Discount rate:	4.20%

Select one
- (●) All entries in dollars
- ( ) All entries in thousands of dollars

Note: "Status quo" refers to Alternative 1

Make entries in yellow cells only

East Maui Feasibility Study

Unit Costs

Engineering, Permitting, Admin & Legal	25%	
Contingency	30%	
ENR CCI	13,600	August, 2024

Phase 3: Capital Unit Costs	**Units**	**Unit Cost**
Water treatment facility	mgd	$12,000,000
Stream diversion	each	$5,000,000
New reservoir	mgal	$300,000
Improve reservoir	mgal	$100,000
Well (0 - 500 ft)	each	$8,000,000
Well (501 - 1500 ft)	each	$10,000,000
Well (1501 - 4000 ft)	each	$12,000,000
Well location(s) - extreme conditions	each	$10,000,000
GAC treatment process	each	$10,000,000
Transmission pump station	each	$23,000,000
Booster pump station	each	$3,000,000
Flume	LF	$3,500
Ditch improvement	LF	$2,000
Pipeline	in-ft	$50
Water tank	gal	$15
Access road - 12 ft wide (basic)	mi	$1,500,000
Access road - 12 ft wide (moderate)	mi	$2,500,000
Access road - 12 ft wide (complex)	mi	$10,000,000
Access road - 12 ft wide (extreme)	mi	$20,000,000
Power infrastructure (basic)	mi	$750,000
Power infrastructure (moderate)	mi	$1,000,000
Power infrastructure (complex)	mi	$1,500,000
Power infrastructure (extreme)	mi	$3,000,000
Environmental assessment (allowance)	LS	$4,000,000
Environmental & cultural mitigation measures (allowance)	LS	$6,000,000

Phase 3: Annual O&M Unit Costs	**Units**	**Unit Cost**
Water treatment facility inclusive	mgal	$4,000
Booster PS pumping	mgal	$530
Transmission PS pumping	mgal	$530
Transmission PS pumping variable (surface water)	mgal	$530
Transmission PS pumping fixed (surface water)	LS	$250,000
Stream diversion, pipelines, reservoir fixed	LS	$300,000
Labor (full time equivalent)	yr	$100,000
Access road maintenance	mi	$5,000
Electricity cost	kWh	$0.40
Hypochlorite	lb	$8
GAC replacement	lb	$4
GAC consumption	lbs/mgal	100
Hypochlorite consumption	lbs/mgal	16.7
Maintenance materials	R&R Cost	1%

Phase 3: East Maui Feasibility Study - Groundwater Strategy
A - Haiku aquifer groundwater

Capital Cost Estimate

Capital Cost Item Description	Units	Unit Cost	Quantity	Capital Cost
Lump Sum Allowance				
Environmental assessment (allowance)	LS	$4,000,000	1	$4,000,000
Environmental & cultural mitigation measures (allowance)	LS	$6,000,000	1	$6,000,000
			Lump Sum Allowance: Subtotal	$10,000,000
Low Elevation Band (0 - 500 ft) - 4 Wells				
Well (0 - 500 ft)	each	$8,000,000	4	$32,000,000
Transmission pump station	each	$23,000,000	1	$23,000,000
Booster pump station	each	$3,000,000	3	$9,000,000
Water tank (500,000 gal)	each	$7,500,000	4	$30,000,000
Pipeline (10 in)	ft	$500	6,000	$3,000,000
Pipeline (14 in)	ft	$700	6,000	$4,200,000
Pipeline (16 in)	ft	$800	6,000	$4,800,000
Pipeline (20 in)	ft	$1,000	27,000	$27,000,000
Access road - 12 ft wide (basic)	mi	$1,500,000	1.0	$1,500,000
Power infrastructure (basic)	mi	$750,000	1.0	$750,000
			Low Elevation Band (0 - 500 ft) - 4 Wells: Subtotal	$135,250,000
Medium Elevation Band (501 - 1500 ft) - 5 Wells				
Well (501 - 1500 ft)	each	$10,000,000	5	$50,000,000
GAC treatment process	each	$10,000,000	5	$50,000,000
Transmission pump station	each	$23,000,000	1	$23,000,000
Booster pump station	each	$3,000,000	4	$12,000,000
Water tank (500,000 gal)	each	$7,500,000	5	$37,500,000
Pipeline (10 in)	ft	$500	6,000	$3,000,000
Pipeline (14 in)	ft	$700	6,000	$4,200,000
Pipeline (16 in)	ft	$800	9,000	$7,200,000
Pipeline (20 in)	ft	$1,000	9,000	$9,000,000
Pipeline (24 in)	ft	$1,200	17,000	$20,400,000
Access road - 12 ft wide (moderate)	mi	$2,500,000	1.2	$3,000,000
Power infrastructure (moderate)	mi	$1,000,000	1.2	$1,200,000
			Medium Elevation Band (501 - 1500 ft) - 5 Wells: Subtotal	$220,500,000
High Elevation Band (1501 - 4000 ft) - 5 Wells				
Well (1501 - 4000 ft)	each	$12,000,000	5	$60,000,000
Transmission pump station	each	$23,000,000	1	$23,000,000
Booster pump station	each	$3,000,000	4	$12,000,000
Water tank (500,000 gal)	each	$7,500,000	5	$37,500,000
Pipeline (10 in)	ft	$500	13,000	$6,500,000
Pipeline (14 in)	ft	$700	9,500	$6,650,000
Pipeline (16 in)	ft	$800	9,500	$7,600,000
Pipeline (20 in)	ft	$1,000	13,000	$13,000,000
Pipeline (24 in)	ft	$1,200	17,000	$20,400,000
Access road - 12 ft wide (complex)	mi	$10,000,000	4.0	$40,000,000
Power infrastructure (complex)	mi	$1,500,000	4.0	$6,000,000
			High Elevation Band (1501 - 4000 ft) - 5 Wells: Subtotal	$232,650,000
			Subtotal	$598,400,000
			Contingency @ 30%	$179,520,000
			Subtotal	$777,920,000
			Eng, Permit, Admin, & Legal @ 25%	$194,480,000
			A - Haiku aquifer groundwater: Total	**$972,400,000**

Annual O&M Costs

O&M Cost Item Description	Units	Unit Cost	Quantity	Annual Cost
Well pumping	mgal	$2,600	4,380	$11,388,000
Booster PS pumping	mgal	$530	8,140	$4,314,200
Transmission PS pumping	mgal	$530	4,380	$2,321,400
Labor (full time equivalent)	yr	$100,000	9.9	$990,000
Access road maintenance	mi	$5,000	6.2	$31,000
Hypochlorite	lb	$8	73,100	$584,800
GAC replacement	lb	$4	169,000	$676,000
Maintenance materials	R&R Cost	1%	109,200,000	$1,092,000
			A - Haiku aquifer groundwater: Total	**$21,400,000**

Phase 3: East Maui Feasibility Study - Groundwater Strategy
B - Makawao aquifer groundwater

Capital Cost Estimate

Capital Cost Item Description	Units	Unit Cost	Quantity	Capital Cost
Lump Sum Allowance				
Environmental assessment (allowance)	LS	$4,000,000	1	$4,000,000
Environmental & cultural mitigation measures (allowance)	LS	$6,000,000	1	$6,000,000
			Lump Sum Allowance: Subtotal	$10,000,000
Medium Elevation Band (501 - 1500 ft) - 3 Wells				
Well (501 - 1500 ft)	each	$10,000,000	3	$30,000,000
Transmission pump station	each	$23,000,000	1	$23,000,000
Booster pump station	each	$3,000,000	2	$6,000,000
Water tank (400,000 gal)	each	$6,000,000	3	$18,000,000
Pipeline (8 in)	ft	$400	22,000	$8,800,000
Pipeline (12 in)	ft	$600	24,000	$14,400,000
Pipeline (14 in)	ft	$700	20,000	$14,000,000
Access road - 12 ft wide (moderate)	mi	$2,500,000	1.0	$2,500,000
Power infrastructure (moderate)	mi	$1,000,000	1.0	$1,000,000
			Medium Elevation Band (501 - 1500 ft) - 3 Wells: Subtotal	$117,700,000
High Elevation Band (1501 - 4000 ft) - 3 Wells				
Well (1501 - 4000 ft)	each	$12,000,000	3	$36,000,000
Transmission pump station	each	$23,000,000	1	$23,000,000
Booster pump station	each	$3,000,000	2	$6,000,000
Water tank (400,000 gal)	each	$6,000,000	3	$18,000,000
Pipeline (8 in)	ft	$400	31,000	$12,400,000
Pipeline (12 in)	ft	$600	24,000	$14,400,000
Pipeline (14 in)	ft	$700	31,000	$21,700,000
Access road - 12 ft wide (complex)	mi	$10,000,000	1.5	$15,000,000
Power infrastructure (complex)	mi	$1,500,000	1.5	$2,250,000
			High Elevation Band (1501 - 4000 ft) - 3 Wells: Subtotal	$148,750,000
			Subtotal	$276,450,000
			Contingency @ 30%	$82,940,000
			Subtotal	$359,390,000
			Eng, Permit, Admin, & Legal @ 25%	$89,850,000
			B - Makawao aquifer groundwater: Total	**$449,300,000**

Annual O&M Costs

O&M Cost Item Description	Units	Unit Cost	Quantity	Annual Cost
Well pumping	mgal	$3,300	1,980	$6,534,000
Booster PS pumping	mgal	$530	1,980	$1,049,400
Transmission PS pumping	mgal	$530	1,980	$1,049,400
Labor (full time equivalent)	yr	$100,000	3.6	$360,000
Access road maintenance	mi	$5,000	2.5	$12,500
Hypochlorite	lb	$8	32,900	$263,200
Maintenance materials	R&R Cost	1%	44,980,000	$449,800
			B - Makawao aquifer groundwater: Total	**$9,720,000**

Phase 3: East Maui Feasibility Study - Groundwater Strategy
C - Kamaole aquifer groundwater

Capital Cost Estimate

Capital Cost Item Description	Units	Unit Cost	Quantity	Capital Cost
Lump Sum Allowance				
Environmental assessment (allowance)	LS	$4,000,000	1	$4,000,000
Environmental & cultural mitigation measures (allowance)	LS	$6,000,000	1	$6,000,000
			Lump Sum Allowance: Subtotal	$10,000,000
Low Elevation Band (0 - 500 ft) - 7 Wells				
Well (0 - 500 ft)	each	$8,000,000	7	$56,000,000
Transmission pump station	each	$23,000,000	0	$0
Booster pump station	each	$3,000,000	7	$21,000,000
Water tank (200,000 gal)	each	$3,000,000	7	$21,000,000
Pipeline (6 in)	ft	$300	40,000	$12,000,000
Access road - 12 ft wide (basic)	mi	$1,500,000	5.0	$7,500,000
Power infrastructure (basic)	mi	$750,000	5.0	$3,750,000
			Low Elevation Band (0 - 500 ft) - 7 Wells: Subtotal	$121,250,000
High Elevation Band (1501 - 4000 ft) - 7 Wells				
Well (1501 - 4000 ft)	each	$12,000,000	7	$84,000,000
Transmission pump station	each	$23,000,000	1	$23,000,000
Booster pump station	each	$3,000,000	6	$18,000,000
Water tank (200,000 gal)	each	$3,000,000	7	$21,000,000
Pipeline (6 in)	ft	$300	46,000	$13,800,000
Pipeline (8 in)	ft	$400	39,000	$15,600,000
Pipeline (10 in)	ft	$500	20,000	$10,000,000
Pipeline (12 in)	ft	$600	21,000	$12,600,000
Pipeline (16 in)	ft	$800	90,000	$72,000,000
Access road - 12 ft wide (complex)	mi	$10,000,000	3.5	$35,000,000
Power infrastructure (complex)	mi	$1,500,000	3.5	$5,250,000
			High Elevation Band (1501 - 4000 ft) - 7 Wells: Subtotal	$310,250,000
			Subtotal	$441,500,000
			Contingency @ 30%	$132,450,000
			Subtotal	$573,950,000
			Eng, Permit, Admin, & Legal @ 25%	$143,490,000
			C - Kamaole aquifer groundwater: Total	**$717,500,000**

Annual O&M Costs

O&M Cost Item Description	Units	Unit Cost	Quantity	Annual Cost
Well pumping	mgal	$2,900	2,400	$6,960,000
Booster PS pumping	mgal	$530	3,420	$1,812,600
Transmission PS pumping	mgal	$530	1,200	$636,000
Labor (full time equivalent)	yr	$100,000	8.4	$840,000
Access road maintenance	mi	$5,000	8.5	$42,500
Hypochlorite	lb	$8	39,900	$319,200
Maintenance materials	R&R Cost	1%	71,110,000	$711,100
			C - Kamaole aquifer groundwater: Total	**$11,330,000**

Phase 3: East Maui Feasibility Study - Groundwater Strategy
D - Waikamoi aquifer groundwater

Capital Cost Estimate

Capital Cost Item Description	Units	Unit Cost	Quantity	Capital Cost
Lump Sum Allowance				
Environmental assessment (allowance)	LS	$4,000,000	1	$4,000,000
Environmental & cultural mitigation measures (allowance)	LS	$6,000,000	1	$6,000,000
			Lump Sum Allowance: Subtotal	$10,000,000
Low Elevation Band (0 - 500 ft) - 7 Wells				
Well (0 - 500 ft)	each	$8,000,000	7	$56,000,000
Well location(s) - extreme conditions	each	$10,000,000	7	$70,000,000
Transmission pump station	each	$23,000,000	0	$0
Booster pump station	each	$3,000,000	7	$21,000,000
Water tank (500,000 gal)	each	$7,500,000	7	$52,500,000
Pipeline (10 in)	ft	$500	9,000	$4,500,000
Pipeline (14 in)	ft	$700	9,000	$6,300,000
Pipeline (16 in)	ft	$800	18,000	$14,400,000
Pipeline (20 in)	ft	$1,000	18,000	$18,000,000
Pipeline (24 in)	ft	$1,200	56,000	$67,200,000
Access road - 12 ft wide (extreme)	mi	$20,000,000	2.0	$40,000,000
Power infrastructure (extreme)	mi	$3,000,000	10.5	$31,500,000
			Low Elevation Band (0 - 500 ft) - 7 Wells: Subtotal	$381,400,000
Medium Elevation Band (501 - 1500 ft) - 7 Wells				
Well (501 - 1500 ft)	each	$10,000,000	7	$70,000,000
Well location(s) - extreme conditions	each	$10,000,000	7	$70,000,000
Transmission pump station	each	$23,000,000	1	$23,000,000
Booster pump station	each	$3,000,000	6	$18,000,000
Water tank (500,000 gal)	each	$7,500,000	7	$52,500,000
Pipeline (10 in)	ft	$500	10,000	$5,000,000
Pipeline (14 in)	ft	$700	10,000	$7,000,000
Pipeline (16 in)	ft	$800	20,000	$16,000,000
Pipeline (20 in)	ft	$1,000	20,000	$20,000,000
Pipeline (24 in)	ft	$1,000	25,000	$25,000,000
Pipeline (36 in)	ft	$1,800	220,000	$396,000,000
Access road - 12 ft wide (extreme)	mi	$20,000,000	4.5	$90,000,000
Power infrastructure (extreme)	mi	$3,000,000	13.0	$39,000,000
			Medium Elevation Band (501 - 1500 ft) - 7 Wells: Subtotal	$831,500,000
			Subtotal	$1,222,900,000
			Contingency @ 30%	$366,870,000
			Subtotal	$1,589,770,000
			Eng, Permit, Admin, & Legal @ 25%	$397,450,000
			D - Waikamoi aquifer groundwater: Total	**$1,987,300,000**

Annual O&M Costs

O&M Cost Item Description	Units	Unit Cost	Quantity	Annual Cost
Well pumping	mgal	$1,400	4,380	$6,132,000
Booster PS pumping	mgal	$530	15,330	$8,124,900
Transmission PS pumping	mgal	$530	4,380	$2,321,400
Labor (full time equivalent)	yr	$100,000	8.4	$840,000
Access road maintenance	mi	$5,000	6.5	$32,500
Hypochlorite	lb	$8	73,100	$584,800
Maintenance materials	R&R Cost	1%	74,750,000	$747,500
			D - Waikamoi aquifer groundwater: Total	**$18,790,000**

Phase 3: East Maui Feasibility Study - Groundwater Strategy
E - Paia aquifer groundwater

Capital Cost Estimate

Capital Cost Item Description	Units	Unit Cost	Quantity	Capital Cost
Lump Sum Allowance				
Environmental assessment (allowance)	LS	$4,000,000	1	$4,000,000
Environmental & cultural mitigation measures (allowance)	LS	$6,000,000	1	$6,000,000
			Lump Sum Allowance: Subtotal	$10,000,000
Low Elevation Band (0 - 500 ft) - 7 Wells				
Well (0 - 500 ft)	each	$8,000,000	7	$56,000,000
GAC treatment process	each	$10,000,000	7	$70,000,000
Transmission pump station	each	$23,000,000	1	$23,000,000
Booster pump station	each	$3,000,000	6	$18,000,000
Water tank (250,000 gal)	each	$3,750,000	7	$26,250,000
Pipeline (8 in)	ft	$400	12,000	$4,800,000
Pipeline (10 in)	ft	$500	12,000	$6,000,000
Pipeline (12 in)	ft	$600	12,000	$7,200,000
Pipeline (14 in)	ft	$700	14,000	$9,800,000
Pipeline (16 in)	ft	$800	30,000	$24,000,000
Pipeline (18 in)	ft	$900	18,000	$16,200,000
Access road - 12 ft wide (basic)	mi	$1,500,000	3.0	$4,500,000
Power infrastructure (basic)	mi	$750,000	3.0	$2,250,000
			Low Elevation Band (0 - 500 ft) - 7 Wells: Subtotal	$268,000,000
			Subtotal	$278,000,000
			Contingency @ 30%	$83,400,000
			Subtotal	$361,400,000
			Eng, Permit, Admin, & Legal @ 25%	$90,350,000
			E - Paia aquifer groundwater: Total	**$451,800,000**

Annual O&M Costs

O&M Cost Item Description	Units	Unit Cost	Quantity	Annual Cost
Well pumping	mgal	$900	1,580	$1,422,000
Booster PS pumping	mgal	$530	4,740	$2,512,200
Transmission PS pumping	mgal	$530	1,580	$837,400
Labor (full time equivalent)	yr	$100,000	6.3	$630,000
Access road maintenance	mi	$5,000	3.0	$15,000
Hypochlorite	lb	$8	26,300	$210,400
GAC replacement	lb	$4	158,000	$632,000
Maintenance materials	R&R Cost	1%	57,688,000	$576,880
			E - Paia aquifer groundwater: Total	**$6,840,000**

Phase 3: East Maui Feasibility Study - Groundwater Strategy
F - Waikapu aquifer groundwater

Capital Cost Estimate

Capital Cost Item Description	Units	Unit Cost	Quantity	Capital Cost
Lump Sum Allowance				
Environmental assessment (allowance)	LS	$4,000,000	1	$4,000,000
Environmental & cultural mitigation measures (allowance)	LS	$6,000,000	1	$6,000,000
			Lump Sum Allowance: Subtotal	$10,000,000
Low Elevation Band (0 - 500 ft) - 6 Wells				
Well (0 - 500 ft)	each	$8,000,000	6	$48,000,000
Transmission pump station	each	$23,000,000	1	$23,000,000
Booster pump station	each	$3,000,000	5	$15,000,000
Water tank (200,000 gal)	each	$3,000,000	6	$18,000,000
Pipeline (6 in)	ft	$300	6,000	$1,800,000
Pipeline (8 in)	ft	$400	6,000	$2,400,000
Pipeline (10 in)	ft	$500	6,000	$3,000,000
Pipeline (12 in)	ft	$600	13,000	$7,800,000
Pipeline (14 in)	ft	$700	7,000	$4,900,000
Access road - 12 ft wide (basic)	mi	$1,500,000	2.5	$3,750,000
Power infrastructure (basic)	mi	$750,000	2.5	$1,875,000
			Low Elevation Band (0 - 500 ft) - 6 Wells: Subtotal	$129,525,000
			Subtotal	$139,525,000
			Contingency @ 30%	$41,860,000
			Subtotal	$181,385,000
			Eng, Permit, Admin, & Legal @ 25%	$45,350,000
			F - Waikapu aquifer groundwater: Total	**$226,800,000**

Annual O&M Costs

O&M Cost Item Description	Units	Unit Cost	Quantity	Annual Cost
Well pumping	mgal	$900	920	$828,000
Booster PS pumping	mgal	$530	2,300	$1,219,000
Transmission PS pumping	mgal	$530	920	$487,600
Labor (full time equivalent)	yr	$100,000	3.6	$360,000
Access road maintenance	mi	$5,000	2.5	$12,500
Hypochlorite	lb	$8	15,300	$122,400
Maintenance materials	R&R Cost	1%	30,290,000	$302,900
			F - Waikapu aquifer groundwater: Total	**$3,340,000**

Phase 3: East Maui Feasibility Study - Groundwater Strategy
G - Keanae aquifer groundwater

Capital Cost Estimate

Capital Cost Item Description	Units	Unit Cost	Quantity	Capital Cost
Lump Sum Allowance				
Environmental assessment (allowance)	LS	$4,000,000	1	$4,000,000
Environmental & cultural mitigation measures (allowance)	LS	$6,000,000	1	$6,000,000
			Lump Sum Allowance: Subtotal	$10,000,000
Low Elevation Band (0 - 500 ft) - 18 Wells				
Well (0 - 500 ft)	each	$8,000,000	18	$144,000,000
Well location(s) - extreme conditions	each	$10,000,000	18	$180,000,000
Transmission pump station	each	$23,000,000	1	$23,000,000
Booster pump station	each	$3,000,000	17	$51,000,000
Water tank (400,000 gal)	each	$6,000,000	18	$108,000,000
Pipeline (8 in)	ft	$400	36,000	$14,400,000
Pipeline (12 in)	ft	$600	38,000	$22,800,000
Pipeline (14 in)	ft	$700	22,000	$15,400,000
Pipeline (16 in)	ft	$800	15,000	$12,000,000
Pipeline (18 in)	ft	$900	11,000	$9,900,000
Pipeline (20 in)	ft	$1,000	7,000	$7,000,000
Pipeline (36 in)	ft	$1,800	338,000	$608,400,000
Access road - 12 ft wide (extreme)	mi	$20,000,000	5.0	$100,000,000
Power infrastructure (extreme)	mi	$3,000,000	17.5	$52,500,000
			Low Elevation Band (0 - 500 ft) - 18 Wells: Subtotal	$1,348,400,000
			Subtotal	$1,358,400,000
			Contingency @ 30%	$407,520,000
			Subtotal	$1,765,920,000
			Eng, Permit, Admin, & Legal @ 25%	$441,480,000
			G - Keanae aquifer groundwater: Total	**$2,207,400,000**

Annual O&M Costs

O&M Cost Item Description	Units	Unit Cost	Quantity	Annual Cost
Well pumping	mgal	$900	4,380	$3,942,000
Booster PS pumping	mgal	$530	13,870	$7,351,100
Transmission PS pumping	mgal	$530	4,380	$2,321,400
Labor (full time equivalent)	yr	$100,000	10.8	$1,080,000
Access road maintenance	mi	$5,000	5.0	$25,000
Hypochlorite	lb	$8	73,100	$584,800
Maintenance materials	R&R Cost	1%	84,890,000	$848,900
			G - Keanae aquifer groundwater: Total	**$16,160,000**

Phase 3: East Maui Feasibility Study - Groundwater Strategy
H - Honopou aquifer groundwater

Capital Cost Estimate

Capital Cost Item Description	Units	Unit Cost	Quantity	Capital Cost
Lump Sum Allowance				
Environmental assessment (allowance)	LS	$4,000,000	1	$4,000,000
Environmental & cultural mitigation measures (allowance)	LS	$6,000,000	1	$6,000,000
			Lump Sum Allowance: Subtotal	$10,000,000
Medium Elevation Band (501 - 1500 ft) - 21 Wells				
Well (501 - 1500 ft)	each	$10,000,000	21	$210,000,000
Transmission pump station	each	$23,000,000	1	$23,000,000
Booster pump station	each	$3,000,000	20	$60,000,000
Water tank (250,000 gal)	each	$3,750,000	21	$78,750,000
Pipeline (8 in)	ft	$400	56,000	$22,400,000
Pipeline (10 in)	ft	$500	52,000	$26,000,000
Pipeline (12 in)	ft	$600	51,000	$30,600,000
Pipeline (14 in)	ft	$700	44,000	$30,800,000
Pipeline (16 in)	ft	$800	42,000	$33,600,000
Pipeline (36 in)	ft	$1,800	150,000	$270,000,000
Access road - 12 ft wide (extreme)	mi	$20,000,000	10.0	$200,000,000
Power infrastructure (extreme)	mi	$3,000,000	11.0	$33,000,000
			Medium Elevation Band (501 - 1500 ft) - 21 Wells: Subtotal	$1,018,150,000
			Subtotal	$1,028,150,000
			Contingency @ 30%	$308,450,000
			Subtotal	$1,336,600,000
			Eng, Permit, Admin, & Legal @ 25%	$334,150,000
			H - Honopou aquifer groundwater: Total	**$1,670,800,000**

Annual O&M Costs

O&M Cost Item Description	Units	Unit Cost	Quantity	Annual Cost
Well pumping	mgal	$1,800	4,380	$7,884,000
Booster PS pumping	mgal	$530	12,520	$6,635,600
Transmission PS pumping	mgal	$530	4,380	$2,321,400
Labor (full time equivalent)	yr	$100,000	12.6	$1,260,000
Access road maintenance	mi	$5,000	10.0	$50,000
Hypochlorite	lb	$8	73,100	$584,800
Maintenance materials	R&R Cost	1%	105,463,000	$1,054,630
			H - Honopou aquifer groundwater: Total	**$19,800,000**

Phase 3: East Maui Feasibility Study - Groundwater Strategy
I - Waihee aquifer groundwater

Capital Cost Estimate

Capital Cost Item Description	Units	Unit Cost	Quantity	Capital Cost
Lump Sum Allowance				
Environmental assessment (allowance)	LS	$4,000,000	1	$4,000,000
Environmental & cultural mitigation measures (allowance)	LS	$6,000,000	1	$6,000,000
			Lump Sum Allowance: Subtotal	$10,000,000
Medium Elevation Band (501 - 1500 ft) - 3 Wells				
Well (501 - 1500 ft)	each	$10,000,000	3	$30,000,000
Transmission pump station	each	$23,000,000	1	$23,000,000
Booster pump station	each	$3,000,000	2	$6,000,000
Water tank (500,000 gal)	each	$7,500,000	3	$22,500,000
Pipeline (10 in)	ft	$500	15,000	$7,500,000
Pipeline (14 in)	ft	$700	15,000	$10,500,000
Pipeline (16 in)	ft	$800	78,000	$62,400,000
Access road - 12 ft wide (complex)	mi	$10,000,000	1.5	$15,000,000
Power infrastructure (complex)	mi	$1,500,000	1.5	$2,250,000
			Medium Elevation Band (501 - 1500 ft) - 3 Wells: Subtotal	$179,150,000
			Subtotal	$189,150,000
			Contingency @ 30%	$56,750,000
			Subtotal	$245,900,000
			Eng, Permit, Admin, & Legal @ 25%	$61,480,000
			I - Waihee aquifer groundwater: Total	**$307,400,000**

Annual O&M Costs

O&M Cost Item Description	Units	Unit Cost	Quantity	Annual Cost
Well pumping	mgal	$1,800	1,000	$1,800,000
Booster PS pumping	mgal	$530	1,000	$530,000
Transmission PS pumping	mgal	$530	1,000	$530,000
Labor (full time equivalent)	yr	$100,000	1.8	$180,000
Access road maintenance	mi	$5,000	1.5	$7,500
Hypochlorite	lb	$8	16,700	$133,600
Maintenance materials	R&R Cost	1%	22,100,000	$221,000
			I - Waihee aquifer groundwater: Total	**$3,410,000**

Phase 3: East Maui Feasibility Study - Surface Water Strategy
J - Capture Wailoa Ditch high flows

Capital Cost Estimate

Capital Cost Item Description	Units	Unit Cost	Quantity	Capital Cost
Lump Sum Allowance				
Environmental assessment (allowance)	LS	$4,000,000	1	$4,000,000
Environmental & cultural mitigation measures (allowance)	LS	$6,000,000	1	$6,000,000
			Lump Sum Allowance: Subtotal	$10,000,000
J - Capture Wailoa Ditch high flows				
Water treatment facility	mgd	$12,000,000	18	$216,000,000
Improve stream diversion	each	$5,000,000	1	$5,000,000
New reservoir	mgal	$300,000	540	$162,000,000
Raw water transmission pump station	each	$23,000,000	1	$23,000,000
Finished water transmission pump station	each	$23,000,000	1	$23,000,000
Finished water storage tank (5 mgal)	each	$75,000,000	1	$75,000,000
Finished water pipeline (36 in)	ft	$1,800	10,000	$18,000,000
Raw water pipeline (42 in)	ft	$2,100	2,000	$4,200,000
			J - Capture Wailoa Ditch high flows: Subtotal	$526,200,000
			Subtotal	$536,200,000
			Contingency @ 30%	$160,860,000
			Subtotal	$697,060,000
			Eng, Permit, Admin, & Legal @ 25%	$174,270,000
			J - Capture Wailoa Ditch high flows: Total	**$871,400,000**

Annual O&M Costs

O&M Cost Item Description	Units	Unit Cost	Quantity	Annual Cost
Water treatment facility inclusive	mgal	$4,000	4,380	$17,520,000
Transmission PS pumping variable (surface water)	mgal	$530	8,760	$4,642,800
Transmission PS pumping fixed (surface water)	LS	$250,000	1	$250,000
Stream diversion, pipelines, reservoir fixed	LS	$300,000	1	$300,000
			J - Capture Wailoa Ditch high flows: Total	**$22,720,000**

Phase 3: East Maui Feasibility Study - Surface Water Strategy
K - Reallocate Wailoa Ditch ag water

Capital Cost Estimate

Capital Cost Item Description	Units	Unit Cost	Quantity	Capital Cost
Lump Sum Allowance				
Environmental assessment (allowance)	LS	$4,000,000	1	$4,000,000
Environmental & cultural mitigation measures (allowance)	LS	$6,000,000	1	$6,000,000
			Lump Sum Allowance: Subtotal	$10,000,000
K - Reallocate Wailoa Ditch ag water				
Water treatment facility	mgd	$12,000,000	18	$216,000,000
New stream diversion	each	$5,000,000	1	$5,000,000
New reservoir	mgal	$300,000	180	$54,000,000
Raw water transmission pump station	each	$23,000,000	1	$23,000,000
Finished water transmission pump station	each	$23,000,000	1	$23,000,000
Finished water storage tank (5 mgal)	each	$75,000,000	1	$75,000,000
Finished water pipeline (36 in)	ft	$1,800	10,000	$18,000,000
Raw water pipeline (36 in)	ft	$1,800	2,000	$3,600,000
			K - Reallocate Wailoa Ditch ag water: Subtotal	$417,600,000
			Subtotal	$427,600,000
			Contingency @ 30%	$128,280,000
			Subtotal	$555,880,000
			Eng, Permit, Admin, & Legal @ 25%	$138,970,000
			K - Reallocate Wailoa Ditch ag water: Total	**$694,900,000**

Annual O&M Costs

O&M Cost Item Description	Units	Unit Cost	Quantity	Annual Cost
Water treatment facility inclusive	mgal	$4,000	4,380	$17,520,000
Transmission PS pumping variable (surface water)	mgal	$530	8,760	$4,642,800
Transmission PS pumping fixed (surface water)	LS	$250,000	1	$250,000
Stream diversion, pipelines, reservoir fixed	LS	$300,000	1	$300,000
			K - Reallocate Wailoa Ditch ag water: Total	**$22,720,000**

Phase 3: East Maui Feasibility Study - Surface Water Strategy
L - Lower Kula system expansion

Capital Cost Estimate

Capital Cost Item Description	Units	Unit Cost	Quantity	Capital Cost
Lump Sum Allowance				
Environmental assessment (allowance)	LS	$4,000,000	1	$4,000,000
Environmental & cultural mitigation measures (allowance)	LS	$6,000,000	1	$6,000,000
			Lump Sum Allowance: Subtotal	$10,000,000
L - Lower Kula system expansion				
Water treatment facility	mgd	$12,000,000	4.8	$57,600,000
New stream diversion	each	$5,000,000	1	$5,000,000
New reservoir	mgal	$300,000	75	$22,500,000
Finished water transmission pump station	each	$23,000,000	1	$23,000,000
Finished water storage tank (2 mgal)	each	$30,000,000	1	$30,000,000
Finished water pipeline (20 in)	ft	$1,000	10,000	$10,000,000
Raw water pipeline (24 in)	ft	$1,200	45,000	$54,000,000
			L - Lower Kula system expansion: Subtotal	$202,100,000
			Subtotal	$212,100,000
			Contingency @ 30%	$63,630,000
			Subtotal	$275,730,000
			Eng, Permit, Admin, & Legal @ 25%	$68,940,000
			L - Lower Kula system expansion: Total	**$344,700,000**

Annual O&M Costs

O&M Cost Item Description	Units	Unit Cost	Quantity	Annual Cost
Water treatment facility inclusive	mgal	$4,000	1,170	$4,680,000
Transmission PS pumping variable (surface water)	mgal	$530	1,170	$620,100
Transmission PS pumping fixed (surface water)	LS	$250,000	1	$250,000
Stream diversion, pipelines, reservoir fixed	LS	$300,000	1	$300,000
			L - Lower Kula system expansion: Total	**$5,860,000**

Phase 3: East Maui Feasibility Study - Surface Water Strategy
M - Capture Waihee River high flows

Capital Cost Estimate

Capital Cost Item Description	Units	Unit Cost	Quantity	Capital Cost
Lump Sum Allowance				
Environmental assessment (allowance)	LS	$4,000,000	1	$4,000,000
Environmental & cultural mitigation measures (allowance)	LS	$6,000,000	1	$6,000,000
			Lump Sum Allowance: Subtotal	$10,000,000
M - Capture Waihee River high flows				
Water treatment facility	mgd	$12,000,000	7.7	$92,400,000
New stream diversion	each	$5,000,000	1	$5,000,000
New reservoir	mgal	$300,000	250	$75,000,000
Raw water transmission pump station	each	$23,000,000	1	$23,000,000
Finished water transmission pump station	each	$23,000,000	1	$23,000,000
Finished water storage tank (3 mgal)	each	$45,000,000	1	$45,000,000
Finished water pipeline (24 in)	ft	$1,200	10,000	$12,000,000
Raw water pipeline (48 in)	ft	$2,400	44,000	$105,600,000
			M - Capture Waihee River high flows: Subtotal	$381,000,000
			Subtotal	$391,000,000
			Contingency @ 30%	$117,300,000
			Subtotal	$508,300,000
			Eng, Permit, Admin, & Legal @ 25%	$127,080,000
			M - Capture Waihee River high flows: Total	**$635,400,000**

Annual O&M Costs

O&M Cost Item Description	Units	Unit Cost	Quantity	Annual Cost
Water treatment facility inclusive	mgal	$4,000	1,870	$7,480,000
Transmission PS pumping variable (surface water)	mgal	$530	3,730	$1,976,900
Transmission PS pumping fixed (surface water)	LS	$250,000	1	$250,000
Stream diversion, pipelines, reservoir fixed	LS	$300,000	1	$300,000
			M - Capture Waihee River high flows: Total	**$10,010,000**

Phase 3: East Maui Feasibility Study - Surface Water Strategy
N - Reallocate Wailuku Area ag water

Capital Cost Estimate

Capital Cost Item Description	Units	Unit Cost	Quantity	Capital Cost
Lump Sum Allowance				
Environmental assessment (allowance)	LS	$4,000,000	1	$4,000,000
Environmental & cultural mitigation measures (allowance)	LS	$6,000,000	1	$6,000,000
			Lump Sum Allowance: Subtotal	$10,000,000
N - Reallocate Wailuku Area ag water				
Water treatment facility	mgd	$12,000,000	2.9	$34,800,000
Improve stream diversion	each	$5,000,000	1	$5,000,000
Improve reservoir	mgal	$100,000	145	$14,500,000
Raw water transmission pump station	each	$23,000,000	1	$23,000,000
Finished water transmission pump station	each	$23,000,000	1	$23,000,000
Finished water storage tank (2 mgal)	each	$30,000,000	1	$30,000,000
Finished water pipeline (18 in)	ft	$900	10,000	$9,000,000
Raw water pipeline (18 in)	ft	$900	29,000	$26,100,000
			N - Reallocate Wailuku Area ag water: Subtotal	$165,400,000
			Subtotal	$175,400,000
			Contingency @ 30%	$52,620,000
			Subtotal	$228,020,000
			Eng, Permit, Admin, & Legal @ 25%	$57,010,000
			N - Reallocate Wailuku Area ag water: Total	**$285,100,000**

Annual O&M Costs

O&M Cost Item Description	Units	Unit Cost	Quantity	Annual Cost
Water treatment facility inclusive	mgal	$4,000	700	$2,800,000
Transmission PS pumping variable (surface water)	mgal	$530	1,390	$736,700
Transmission PS pumping fixed (surface water)	LS	$250,000	1	$250,000
Stream diversion, pipelines, reservoir fixed	LS	$300,000	1	$300,000
			N - Reallocate Wailuku Area ag water: Total	**$4,090,000**

Phase 3: East Maui Feasibility Study - Surface Water Strategy
O - Capture Wailuku River high flows

Capital Cost Estimate

Capital Cost Item Description	Units	Unit Cost	Quantity	Capital Cost
Lump Sum Allowance				
Environmental assessment (allowance)	LS	$4,000,000	1	$4,000,000
Environmental & cultural mitigation measures (allowance)	LS	$6,000,000	1	$6,000,000
			Lump Sum Allowance: Subtotal	$10,000,000
O - Capture Wailuku River high flows				
Water treatment facility	mgd	$12,000,000	9.9	$118,800,000
New stream diversion	each	$5,000,000	1	$5,000,000
New reservoir	mgal	$300,000	110	$33,000,000
Improve reservoir	mgal	$100,000	145	$14,500,000
Raw water transmission pump station	each	$23,000,000	1	$23,000,000
Finished water transmission pump station	each	$23,000,000	1	$23,000,000
Finished water storage tank (3 mgal)	each	$45,000,000	1	$45,000,000
Finished water pipeline (30 in)	ft	$1,500	10,000	$15,000,000
Raw water pipeline (48 in)	ft	$2,400	29,000	$69,600,000
			O - Capture Wailuku River high flows: Subtotal	$346,900,000
			Subtotal	$356,900,000
			Contingency @ 30%	$107,070,000
			Subtotal	$463,970,000
			Eng, Permit, Admin, & Legal @ 25%	$116,000,000
			O - Capture Wailuku River high flows: Total	**$580,000,000**

Annual O&M Costs

O&M Cost Item Description	Units	Unit Cost	Quantity	Annual Cost
Water treatment facility inclusive	mgal	$4,000	2,410	$9,640,000
Transmission PS pumping variable (surface water)	mgal	$530	4,820	$2,554,600
Transmission PS pumping fixed (surface water)	LS	$250,000	1	$250,000
Stream diversion, pipelines, reservoir fixed	LS	$300,000	1	$300,000
			O - Capture Wailuku River high flows: Total	**$12,750,000**

East Maui Feasibility Study
O&M Unit Costs and Quantities

Phase 3: Alternative A - Haiku aquifer groundwater
O&M Unit Cost Reference

Electricity cost:	0.40	/kWh
Num elevation bands:	3	count
Num wells (main):	13	count
Num wells (standby):	1	
Total Flow:	12	mgd
Max flow per well:	1000	gpm
	1.44	mgd

Qty Summary Table

	Units	Quantity
Well pumping	mgal	4,380
Booster PS pumping	mgal	8,134
Transmission PS pumping	mgal	4,380
Labor (full time equivalent)	FTE	9.9
Access road maintenance	mi	6.2
Hypochlorite	lb	73,058
GAC replacement	lb	168,462

Wells - Low Elevation Band (0-500 ft)

Assumed TDH:	500	ft MSL
Num wells:	4	
Well flow:	0.92	mgd
	641	gpm
	1.43	cfs
Pump efficiency:	80%	
Brake HP:	101	
Motor efficiency:	90%	
Draw:	113	hp
	84	kW
Unit pump time:	26.0	hours/mgal
Power use:	2,182	kWh/mgal
Power cost:	$873	/mgal
0 - 500 ft pumping cost:	$1,176,013	/yr

Wells - Medium Elevation Band (501 - 1500 ft)

Assumed TDH:	1,000	ft MSL
Num wells:	5	
Well flow:	0.92	mgd
	641	gpm
	1.43	cfs
Pump efficiency:	80%	
Brake HP:	203	
Motor efficiency:	90%	
Draw:	225	hp
	168	kW
Unit pump time:	26.0	hours/mgal
Power use:	4,363	kWh/mgal
Power cost:	$1,745	/mgal
501 - 1500 ft pumping cost:	$2,940,033	/yr

Wells - High Elevation Band (1501 - 4000 ft)

Assumed TDH:	2,750	ft MSL
Num wells:	5	
Well flow:	0.92	mgd
	641	gpm
	1.43	cfs
Pump efficiency:	80%	
Brake HP:	557	
Motor efficiency:	90%	
Draw:	619	hp
	461	kW
Unit pump time:	26.0	hours/mgal
Power use:	11,998	kWh/mgal
Power cost:	$4,799	/mgal
1501 - 4000 ft pumping cost:	$8,085,090	/yr

Well pumping power cost (including standby):	$12,201,135	/yr	*14 wells (total)*
Total well pumping power cost (mains only):	$11,329,626	/yr	*13 main wells / 14 total wells*
	$2,587	/mgal	

Transmission PS Pumping

Assumed TDH:	300	ft MSL	
Total flow:	12	mgd	
	8,333	gpm	
	18.57	cfs	
Pump efficiency:	80%		
Brake HP:	790		
Motor efficiency:	90%		
Draw:	878	hp	
	654	kW	
Unit pump time:	2.0	hours/mgal	
Power use:	1,309	kWh/mgal	
Power cost:		$524	/mgal

Booster PS Pumping

Assumed TDH:	300	ft MSL	
Num Booster PS:	11	count	
Total booster flow:	10.2	mgd	
	7051	gpm	
	15.71	cfs	
Pump efficiency:	80%		
Brake HP:	668		
Motor efficiency:	90%		
Draw:	743	hp	
	554	kW	
Unit pump time:	2.4	hours/mgal	
Power use:	1309	kWh/mgal	
Power cost:		$524	/mgal

Chlorine Treatment

Chlorine dose:	2	mg/L	
Total flow:	12	mgd	
Hypochlorite cost:	$8.00	/lb	
Chlorine use:	200	lbs/day	
Chlorine consumption:	16.7	lbs/mgal	
Annual consumption:	73,058	lbs of Hypochlorite	
Total hypochlorite cost:		$584,467	/yr

GAC Treatment

GAC material cost:	$4.00	/lb	
GAC consumption:	100	lbs/mgal	
	168,462	lbs of GAC	*medium elevation wells only*
Total GAC replacement cost:		$673,846	/yr

Fixed Labor - 10 well operation at 3 elevation bands

Labor (FTE) demand	0.3	FTE per well/PS/GAC	
Num wells/PS/GAC	33	count	
Total labor (FTE):	9.9	FTE	
Labor cost:	$100,000	/yr/FTE loaded	
Total labor cost:		$990,000	/yr

Access Road BMP Maintenance

Access rd total	6.2	mi	
Maintenance Cost	$5,000	/mi	
Total access road BMP maintenance cost:		$31,000	/yr

East Maui Feasibility Study
O&M Unit Costs and Quantities

Phase 3: Alternative B - Makawao aquifer groundwater
O&M Unit Cost Reference

Electricity cost:	0.40	/kWh
Num elevation bands:	2	count
Num wells (main):	5	count
Num wells (standby):	1	
Total Flow:	5.4	mgd
Max flow per well:	750	gpm
	1.08	mgd

Qty Summary Table

	Units	Quantity
Well pumping	mgal	1,971
Booster PS pumping	mgal	1,971
Transmission PS pumping	mgal	1,971
Labor (full time equivalent)	FTE	3.6
Access road maintenance	mi	2.5
Hypochlorite	lb	32,876
GAC replacement	lb	-

Wells - Low Elevation Band (0-500 ft)

Assumed TDH:	500	ft MSL
Num wells:	0	
Well flow:	1.08	mgd
	750	gpm
	1.67	cfs
Pump efficiency:	80%	
Brake HP:	118	
Motor efficiency:	90%	
Draw:	132	hp
	98	kW
Unit pump time:	22.2	hours/mgal
Power use:	2,182	kWh/mgal
Power cost:	$873	/mgal
0 - 500 ft pumping cost:	$0	/yr

Wells - Medium Elevation Band (501 - 1500 ft)

Assumed TDH:	1,000	ft MSL
Num wells:	3	
Well flow:	1.08	mgd
	750	gpm
	1.67	cfs
Pump efficiency:	80%	
Brake HP:	237	
Motor efficiency:	90%	
Draw:	263	hp
	196	kW
Unit pump time:	22.2	hours/mgal
Power use:	4,363	kWh/mgal
Power cost:	$1,745	/mgal
501 - 1500 ft pumping cost:	$2,063,903	/yr

Wells - High Elevation Band (1501 - 4000 ft)

Assumed TDH:	2,750	ft MSL
Num wells:	3	
Well flow:	1.08	mgd
	750	gpm
	1.67	cfs
Pump efficiency:	80%	
Brake HP:	652	
Motor efficiency:	90%	
Draw:	724	hp
	540	kW
Unit pump time:	22.2	hours/mgal
Power use:	11,998	kWh/mgal
Power cost:	$4,799	/mgal
1501 - 4000 ft pumping cost:	$5,675,733	/yr

Well pumping power cost (including standby):	$7,739,636	/yr	*6 wells (total)*
Total well pumping power cost (mains only):	$6,449,697	/yr	*5 main wells / 6 total wells*
	$3,272	/mgal	

Transmission PS Pumping

Assumed TDH:	300	ft MSL	
Total flow:	5.4	mgd	
	3,750	gpm	
	8.35	cfs	
Pump efficiency:	80%		
Brake HP:	355		
Motor efficiency:	90%		
Draw:	395	hp	
	295	kW	
Unit pump time:	4.4	hours/mgal	
Power use:	1,309	kWh/mgal	
Power cost:		$524	/mgal

Booster PS Pumping

Assumed TDH:	300	ft MSL	
Num Booster PS:	4	count	
Total booster flow:	4.3	mgd	
	3000	gpm	
	6.68	cfs	
Pump efficiency:	80%		
Brake HP:	284		
Motor efficiency:	90%		
Draw:	316	hp	
	236	kW	
Unit pump time:	5.6	hours/mgal	
Power use:	1309	kWh/mgal	
Power cost:		$524	/mgal

Chlorine Treatment

Chlorine dose:	2	mg/L	
Total flow:	5.4	mgd	
Hypochlorite cost:	$8.00	/lb	
Chlorine use:	90	lbs/day	
Chlorine consumption:	16.7	lbs/mgal	
Annual consumption:	32,876	lbs of Hypochlorite	
Total hypochlorite cost:		$263,010	/yr

GAC Treatment (Not Required)

GAC material cost:	$4.00	/lb	
GAC consumption:	0	lbs/mgal	
	-	lbs of GAC	
Total GAC replacement cost:		$0	/yr

Fixed Labor - 10 well operation at 3 elevation bands

Labor (FTE) demand	0.3	FTE per well/PS/GAC	
Num wells/PS/GAC	12	count	
Total labor (FTE):	3.6	FTE	
Labor cost:	$100,000	/yr/FTE loaded	
Total labor cost:		$360,000	/yr

Access Road BMP Maintenance

Access rd total	2.5	mi	
Maintenance Cost	$5,000	/mi	
Total access road BMP maintenance cost:		$12,500	/yr

Phase 3: Alternative C - Kamaole aquifer groundwater

O&M Unit Cost Reference

Electricity cost:	0.40	/kWh
Num elevation bands:	2	count
Num wells (main):	13	count
Num wells (standby):	1	
Total Flow:	6.55	mgd
Max flow per well:	350	gpm
	0.504	mgd

Qty Summary Table

	Units	Quantity
Well pumping	mgal	2,391
Booster PS pumping	mgal	3,415
Transmission PS pumping	mgal	1,195
Labor (full time equivalent)	FTE	8.4
Access road maintenance	mi	8.5
Hypochlorite	lb	39,878
GAC replacement	lb	-

Wells - Low Elevation Band (0-500 ft)

Assumed TDH:	500	ft MSL
Num wells:	7	
Well flow:	0.50	mgd
	350	gpm
	0.78	cfs
Pump efficiency:	80%	
Brake HP:	55	
Motor efficiency:	90%	
Draw:	61	hp
	46	kW
Unit pump time:	47.6	hours/mgal
Power use:	2,182	kWh/mgal
Power cost:	$873	/mgal
0 - 500 ft pumping cost:	$1,123,680	/yr

Wells - Medium Elevation Band (501 - 1500 ft)

Assumed TDH:	1,000	ft MSL
Num wells:	0	
Well flow:	0.50	mgd
	350	gpm
	0.78	cfs
Pump efficiency:	80%	
Brake HP:	111	
Motor efficiency:	90%	
Draw:	123	hp
	92	kW
Unit pump time:	47.6	hours/mgal
Power use:	4,363	kWh/mgal
Power cost:	$1,745	/mgal
501 - 1500 ft pumping cost:	$0	/yr

Wells - High Elevation Band (1501 - 4000 ft)

Assumed TDH:	2,750	ft MSL
Num wells:	7	
Well flow:	0.50	mgd
	350	gpm
	0.78	cfs
Pump efficiency:	80%	
Brake HP:	304	
Motor efficiency:	90%	
Draw:	338	hp
	252	kW
Unit pump time:	47.6	hours/mgal
Power use:	11,998	kWh/mgal
Power cost:	$4,799	/mgal
1501 - 4000 ft pumping cost:	$6,180,243	/yr

Well pumping power cost (including standby):	$7,303,923	/yr	*14 wells (total)*
Total well pumping power cost (mains only):	$6,782,214	/yr	*13 main wells / 14 total wells*
	$2,837	/mgal	

Transmission PS Pumping

Assumed TDH:	300	ft MSL
Total flow:	6.6	mgd
	4,549	gpm
	10.13	cfs
Pump efficiency:	80%	
Brake HP:	431	
Motor efficiency:	90%	
Draw:	479	hp
	357	kW
Unit pump time:	3.7	hours/mgal
Power use:	1,309	kWh/mgal
Power cost:	$524	/mgal

Booster PS Pumping

Assumed TDH:	300	ft MSL
Num Booster PS:	13	count
Total booster flow:	6.6	mgd
	4550	gpm
	10.14	cfs
Pump efficiency:	80%	
Brake HP:	431	
Motor efficiency:	90%	
Draw:	479	hp
	357	kW
Unit pump time:	3.7	hours/mgal
Power use:	1309	kWh/mgal
Power cost:	$524	/mgal

Chlorine Treatment

Chlorine dose:	2	mg/L
Total flow:	6.6	mgd
Hypochlorite cost:	$8.00	/lb
Chlorine use:	109	lbs/day
Chlorine consumption:	16.7	lbs/mgal
Annual consumption:	39,878	lbs of Hypochlorite
Total hypochlorite cost:	$319,022	/yr

GAC Treatment (Not Required)

GAC material cost:	$4.00	/lb
GAC consumption:	0	lbs/mgal
	-	lbs of GAC
Total GAC replacement cost:	$0	/yr

Fixed Labor - 10 well operation at 3 elevation bands

Labor (FTE) demand	0.3	FTE per well/PS/GAC
Num wells/PS/GAC	28	count
Total labor (FTE):	8.4	FTE
Labor cost:	$100,000	/yr/FTE loaded
Total labor cost:	$840,000	/yr

Access Road BMP Maintenance

Access rd total	8.5	mi
Maintenance Cost	$5,000	/mi
Total access road BMP maintenance cost:	$42,500	/yr

East Maui Feasibility Study
O&M Unit Costs and Quantities

Phase 3: Alternative D - Waikamoi aquifer groundwater
O&M Unit Cost Reference

Electricity cost:	0.40	/kWh
Num elevation bands:	2	count
Num wells (main):	13	count
Num wells (standby):	1	
Total Flow:	12	mgd
Max flow per well:	1000	gpm
	1.44	mgd

Qty Summary Table

	Units	Quantity
Well pumping	mgal	4,380
Booster PS pumping	mgal	15,330
Transmission PS pumping	mgal	4,380
Labor (full time equivalent)	FTE	8.4
Access road maintenance	mi	6.5
Hypochlorite	lb	73,058
GAC replacement	lb	-

Wells - Low Elevation Band (0-500 ft)

Assumed TDH:	500	ft MSL
Num wells:	7	
Well flow:	0.92	mgd
	641	gpm
	1.43	cfs
Pump efficiency:	80%	
Brake HP:	101	
Motor efficiency:	90%	
Draw:	113	hp
	84	kW
Unit pump time:	26.0	hours/mgal
Power use:	2,182	kWh/mgal
Power cost:	$873	/mgal
0 - 500 ft pumping cost:	$2,058,023	/yr

Wells - Medium Elevation Band (501 - 1500 ft)

Assumed TDH:	1,000	ft MSL
Num wells:	7	
Well flow:	0.92	mgd
	641	gpm
	1.43	cfs
Pump efficiency:	80%	
Brake HP:	203	
Motor efficiency:	90%	
Draw:	225	hp
	168	kW
Unit pump time:	26.0	hours/mgal
Power use:	4,363	kWh/mgal
Power cost:	$1,745	/mgal
501 - 1500 ft pumping cost:	$4,116,046	/yr

Wells - High Elevation Band (1501 - 4000 ft)

Assumed TDH:	2,750	ft MSL
Num wells:	0	
Well flow:	0.92	mgd
	641	gpm
	1.43	cfs
Pump efficiency:	80%	
Brake HP:	557	
Motor efficiency:	90%	
Draw:	619	hp
	461	kW
Unit pump time:	26.0	hours/mgal
Power use:	11,998	kWh/mgal
Power cost:	$4,799	/mgal
1501 - 4000 ft pumping cost:	$0	/yr

Well pumping power cost (including standby):	$6,174,068	/yr	*14 wells (total)*
Total well pumping power cost (mains only):	$5,733,064	/yr	*13 main wells / 14 total wells*
	$1,309	/mgal	

Transmission PS Pumping

Assumed TDH:	300	ft MSL
Total flow:	12	mgd
	8,333	gpm
	18.57	cfs
Pump efficiency:	80%	
Brake HP:	790	
Motor efficiency:	90%	
Draw:	878	hp
	654	kW
Unit pump time:	2.0	hours/mgal
Power use:	1,309	kWh/mgal
Power cost:	$524	/mgal

Booster PS Pumping

Assumed TDH:	300	ft MSL
Num Booster PS:	13	count
Total booster flow:	12.0	mgd
	8333	gpm
	18.57	cfs
Pump efficiency:	80%	
Brake HP:	790	
Motor efficiency:	90%	
Draw:	878	hp
	654	kW
Unit pump time:	2.0	hours/mgal
Power use:	1309	kWh/mgal
Power cost:	$524	/mgal

Chlorine Treatment

Chlorine dose:	2	mg/L
Total flow:	12	mgd
Hypochlorite cost:	$8.00	/lb
Chlorine use:	200	lbs/day
Chlorine consumption:	16.7	lbs/mgal
Annual consumption:	73,058	lbs of Hypochlorite
Total hypochlorite cost:	$584,467	/yr

GAC Treatment (Not Required)

GAC material cost:	$4.00	/lb
GAC consumption:	0	lbs/mgal
	-	lbs of GAC
Total GAC replacement cost:	$0	/yr

Fixed Labor - 10 well operation at 3 elevation bands

Labor (FTE) demand	0.3	FTE per well/PS/GAC
Num wells/PS/GAC	28	count
Total labor (FTE):	8.4	FTE
Labor cost:	$100,000	/yr/FTE loaded
Total labor cost:	$840,000	/yr

Access Road BMP Maintenance

Access rd total	6.5	mi
Maintenance Cost	$5,000	/mi
Total access road BMP maintenance cost:	$32,500	/yr

Phase 3: Alternative E - Paia aquifer groundwater

O&M Unit Cost Reference

Electricity cost:	0.40	/kWh
Num elevation bands:	1	count
Num wells (main):	6	count
Num wells (standby):	1	
Total Flow:	4.32	mgd
Max flow per well:	500	gpm
	0.72	mgd

Qty Summary Table

	Units	Quantity
Well pumping	mgal	1,577
Booster PS pumping	mgal	4,730
Transmission PS pumping	mgal	1,577
Labor (full time equivalent)	FTE	6.3
Access road maintenance	mi	3.0
Hypochlorite	lb	26,301
GAC replacement	lb	157,680

Wells - Low Elevation Band (0-500 ft)

Assumed TDH:	500	ft MSL
Num wells:	7	
Well flow:	0.72	mgd
	500	gpm
	1.11	cfs
Pump efficiency:	80%	
Brake HP:	79	
Motor efficiency:	90%	
Draw:	88	hp
	65	kW
Unit pump time:	33.3	hours/mgal
Power use:	2,182	kWh/mgal
Power cost:	$873	/mgal
0 - 500 ft pumping cost:	$1,605,258	/yr

Wells - Medium Elevation Band (501 - 1500 ft)

Assumed TDH:	1,000	ft MSL
Num wells:	0	
Well flow:	0.72	mgd
	500	gpm
	1.11	cfs
Pump efficiency:	80%	
Brake HP:	158	
Motor efficiency:	90%	
Draw:	176	hp
	131	kW
Unit pump time:	33.3	hours/mgal
Power use:	4,363	kWh/mgal
Power cost:	$1,745	/mgal
501 - 1500 ft pumping cost:	$0	/yr

Wells - High Elevation Band (1501 - 4000 ft)

Assumed TDH:	2,750	ft MSL
Num wells:	0	
Well flow:	0.72	mgd
	500	gpm
	1.11	cfs
Pump efficiency:	80%	
Brake HP:	434	
Motor efficiency:	90%	
Draw:	483	hp
	360	kW
Unit pump time:	33.3	hours/mgal
Power use:	11,998	kWh/mgal
Power cost:	$4,799	/mgal
1501 - 4000 ft pumping cost:	$0	/yr

Well pumping power cost (including standby):	$1,605,258	/yr	*7 wells (total)*
Total well pumping power cost (mains only):	$1,375,935	/yr	*6 main wells / 7 total wells*
	$873	/mgal	

Transmission PS Pumping

Assumed TDH:	300	ft MSL	
Total flow:	4.3	mgd	
	3,000	gpm	
	6.68	cfs	
Pump efficiency:	80%		
Brake HP:	284		
Motor efficiency:	90%		
Draw:	316	hp	
	236	kW	
Unit pump time:	5.6	hours/mgal	
Power use:	1,309	kWh/mgal	
Power cost:		$524	/mgal

Booster PS Pumping

Assumed TDH:	300	ft MSL	
Num Booster PS:	6	count	
Total booster flow:	4.3	mgd	
	3000	gpm	
	6.68	cfs	
Pump efficiency:	80%		
Brake HP:	284		
Motor efficiency:	90%		
Draw:	316	hp	
	236	kW	
Unit pump time:	5.6	hours/mgal	
Power use:	1309	kWh/mgal	
Power cost:		$524	/mgal

Chlorine Treatment

Chlorine dose:	2	mg/L	
Total flow:	4.3	mgd	
Hypochlorite cost:	$8.00	/lb	
Chlorine use:	72	lbs/day	
Chlorine consumption:	16.7	lbs/mgal	
Annual consumption:	26,301	lbs of Hypochlorite	
Total hypochlorite cost:		$210,408	/yr

GAC Treatment (Not Required)

GAC material cost:	$4.00	/lb	
GAC consumption:	100	lbs/mgal	
	157,680	lbs of GAC	
Total GAC replacement cost:		$630,720	/yr

Fixed Labor - 10 well operation at 3 elevation bands

Labor (FTE) demand	0.3	FTE per well/PS/GAC	
Num wells/PS/GAC	21	count	
Total labor (FTE):	6.3	FTE	
Labor cost:	$100,000	/yr/FTE loaded	
Total labor cost:		$630,000	/yr

Access Road BMP Maintenance

Access rd total	3	mi	
Maintenance Cost	$5,000	/mi	
Total access road BMP maintenance cost:		$15,000	/yr

East Maui Feasibility Study
O&M Unit Costs and Quantities

Phase 3: Alternative F - Waikapu aquifer groundwater

O&M Unit Cost Reference

Electricity cost:	0.40	/kWh
Num elevation bands:	1	count
Num wells (main):	5	count
Num wells (standby):	1	
Total Flow:	2.52	mgd
Max flow per well:	350	gpm
	0.504	mgd

Qty Summary Table

	Units	Quantity
Well pumping	mgal	920
Booster PS pumping	mgal	2,300
Transmission PS pumping	mgal	920
Labor (full time equivalent)	FTE	3.6
Access road maintenance	mi	2.5
Hypochlorite	lb	15,342
GAC replacement	lb	-

Wells - Low Elevation Band (0-500 ft)

Assumed TDH:	500	ft MSL
Num wells:	6	
Well flow:	0.50	mgd
	350	gpm
	0.78	cfs
Pump efficiency:	80%	
Brake HP:	55	
Motor efficiency:	90%	
Draw:	61	hp
	46	kW
Unit pump time:	47.6	hours/mgal
Power use:	2,182	kWh/mgal
Power cost:	$873	/mgal
0 - 500 ft pumping cost:	$963,155	/yr

Wells - Medium Elevation Band (501 - 1500 ft)

Assumed TDH:	1,000	ft MSL
Num wells:	0	
Well flow:	0.50	mgd
	350	gpm
	0.78	cfs
Pump efficiency:	80%	
Brake HP:	111	
Motor efficiency:	90%	
Draw:	123	hp
	92	kW
Unit pump time:	47.6	hours/mgal
Power use:	4,363	kWh/mgal
Power cost:	$1,745	/mgal
501 - 1500 ft pumping cost:	$0	/yr

Wells - High Elevation Band (1501 - 4000 ft)

Assumed TDH:	2,750	ft MSL
Num wells:	0	
Well flow:	0.50	mgd
	350	gpm
	0.78	cfs
Pump efficiency:	80%	
Brake HP:	304	
Motor efficiency:	90%	
Draw:	338	hp
	252	kW
Unit pump time:	47.6	hours/mgal
Power use:	11,998	kWh/mgal
Power cost:	$4,799	/mgal
1501 - 4000 ft pumping cost:	$0	/yr

Well pumping power cost (including standby):	$963,155	/yr	*6 wells (total)*
Total well pumping power cost (mains only):	$802,629	/yr	*5 main wells / 6 total wells*
	$873	/mgal	

Transmission PS Pumping

Assumed TDH:	300	ft MSL	
Total flow:	2.5	mgd	
	1,750	gpm	
	3.90	cfs	
Pump efficiency:	80%		
Brake HP:	166		
Motor efficiency:	90%		
Draw:	184	hp	
	137	kW	
Unit pump time:	9.5	hours/mgal	
Power use:	1,309	kWh/mgal	
Power cost:		$524	/mgal

Booster PS Pumping

Assumed TDH:	300	ft MSL	
Num Booster PS:	5	count	
Total booster flow:	2.5	mgd	
	1750	gpm	
	3.90	cfs	
Pump efficiency:	80%		
Brake HP:	166		
Motor efficiency:	90%		
Draw:	184	hp	
	137	kW	
Unit pump time:	9.5	hours/mgal	
Power use:	1309	kWh/mgal	
Power cost:		$524	/mgal

Chlorine Treatment

Chlorine dose:	2	mg/L	
Total flow:	2.5	mgd	
Hypochlorite cost:	$8.00	/lb	
Chlorine use:	42	lbs/day	
Chlorine consumption:	16.7	lbs/mgal	
Annual consumption:	15,342	lbs of Hypochlorite	
Total hypochlorite cost:		$122,738	/yr

GAC Treatment (Not Required)

GAC material cost:	$4.00	/lb	
GAC consumption:	0	lbs/mgal	
	-	lbs of GAC	
Total GAC replacement cost:		$0	/yr

Fixed Labor - 10 well operation at 3 elevation bands

Labor (FTE) demand	0.3	FTE per well/PS/GAC	
Num wells/PS/GAC	12	count	
Total labor (FTE):	3.6	FTE	
Labor cost:	$100,000	/yr/FTE loaded	
Total labor cost:		$360,000	/yr

Access Road BMP Maintenance

Access rd total	2.5	mi	
Maintenance Cost	$5,000	/mi	
Total access road BMP maintenance cost:		$12,500	/yr

East Maui Feasibility Study
O&M Unit Costs and Quantities

Phase 3: Alternative G - Keanae aquifer groundwater
O&M Unit Cost Reference

Electricity cost:	0.40	/kWh
Num elevation bands:	1	count
Num wells (main):	17	count
Num wells (standby):	1	
Total Flow:	12	mgd
Max flow per well:	750	gpm
	1.08	mgd

Qty Summary Table

	Units	Quantity
Well pumping	mgal	4,380
Booster PS pumping	mgal	13,870
Transmission PS pumping	mgal	4,380
Labor (full time equivalent)	FTE	10.8
Access road maintenance	mi	5.0
Hypochlorite	lb	73,058
GAC replacement	lb	-

Wells - Low Elevation Band (0-500 ft)

Assumed TDH:	500	ft MSL
Num wells:	18	
Well flow:	0.71	mgd
	490	gpm
	1.09	cfs
Pump efficiency:	80%	
Brake HP:	77	
Motor efficiency:	90%	
Draw:	86	hp
	64	kW
Unit pump time:	34.0	hours/mgal
Power use:	2,182	kWh/mgal
Power cost:	$873	/mgal
0 - 500 ft pumping cost:	$4,046,868	/yr

Wells - Medium Elevation Band (501 - 1500 ft)

Assumed TDH:	1,000	ft MSL
Num wells:	0	
Well flow:	0.71	mgd
	490	gpm
	1.09	cfs
Pump efficiency:	80%	
Brake HP:	155	
Motor efficiency:	90%	
Draw:	172	hp
	128	kW
Unit pump time:	34.0	hours/mgal
Power use:	4,363	kWh/mgal
Power cost:	$1,745	/mgal
501 - 1500 ft pumping cost:	$0	/yr

Wells - High Elevation Band (1501 - 4000 ft)

Assumed TDH:	2,750	ft MSL
Num wells:	0	
Well flow:	0.71	mgd
	490	gpm
	1.09	cfs
Pump efficiency:	80%	
Brake HP:	426	
Motor efficiency:	90%	
Draw:	473	hp
	353	kW
Unit pump time:	34.0	hours/mgal
Power use:	11,998	kWh/mgal
Power cost:	$4,799	/mgal
1501 - 4000 ft pumping cost:	$0	/yr

Well pumping power cost (including standby):	$4,046,868	/yr	*18 wells (total)*
Total well pumping power cost (mains only):	$3,822,042	/yr	*17 main wells / 18 total wells*
	$873	/mgal	

Transmission PS Pumping

Assumed TDH:	300	ft MSL
Total flow:	12.0	mgd
	8,333	gpm
	18.57	cfs
Pump efficiency:	80%	
Brake HP:	790	
Motor efficiency:	90%	
Draw:	878	hp
	654	kW
Unit pump time:	2.0	hours/mgal
Power use:	1,309	kWh/mgal
Power cost:	$524	/mgal

Booster PS Pumping

Assumed TDH:	300	ft MSL
Num Booster PS:	17	count
Total booster flow:	12.0	mgd
	8333	gpm
	18.57	cfs
Pump efficiency:	80%	
Brake HP:	790	
Motor efficiency:	90%	
Draw:	878	hp
	654	kW
Unit pump time:	2.0	hours/mgal
Power use:	1309	kWh/mgal
Power cost:	$524	/mgal

Chlorine Treatment

Chlorine dose:	2	mg/L
Total flow:	12	mgd
Hypochlorite cost:	$8.00	/lb
Chlorine use:	200	lbs/day
Chlorine consumption:	16.7	lbs/mgal
Annual consumption:	73,058	lbs of Hypochlorite
Total hypochlorite cost:	$584,467	/yr

GAC Treatment (Not Required)

GAC material cost:	$4.00	/lb
GAC consumption:	0	lbs/mgal
	-	lbs of GAC
Total GAC replacement cost:	$0	/yr

Fixed Labor - 10 well operation at 3 elevation bands

Labor (FTE) demand	0.3	FTE per well/PS/GAC
Num wells/PS/GAC	36	count
Total labor (FTE):	10.8	FTE
Labor cost:	$100,000	/yr/FTE loaded
Total labor cost:	$1,080,000	/yr

Access Road BMP Maintenance

Access rd total	5.0	mi
Maintenance Cost	$5,000	/mi
Total access road BMP maintenance cost:	$25,000	/yr

East Maui Feasibility Study
O&M Unit Costs and Quantities

Phase 3: Alternative H - Honopou aquifer groundwater
O&M Unit Cost Reference

Electricity cost:	0.40	/kWh
Num elevation bands:	1	count
Num wells (main):	20	count
Num wells (standby):	1	
Total Flow:	12	mgd
Max flow per well:	500	gpm
	0.72	mgd

Qty Summary Table

	Units	Quantity
Well pumping	mgal	4,380
Booster PS pumping	mgal	12,514
Transmission PS pumping	mgal	4,380
Labor (full time equivalent)	FTE	12.6
Access road maintenance	mi	10.0
Hypochlorite	lb	73,058
GAC replacement	lb	-

Wells - Low Elevation Band (0-500 ft)

Assumed TDH:	500	ft MSL
Num wells:	0	
Well flow:	0.60	mgd
	417	gpm
	0.93	cfs
Pump efficiency:	80%	
Brake HP:	66	
Motor efficiency:	90%	
Draw:	73	hp
	55	kW
Unit pump time:	40.0	hours/mgal
Power use:	2,182	kWh/mgal
Power cost:	$873	/mgal
0 - 500 ft pumping cost:	$0	/yr

Wells - Medium Elevation Band (501 - 1500 ft)

Assumed TDH:	1,000	ft MSL
Num wells:	21	
Well flow:	0.60	mgd
	417	gpm
	0.93	cfs
Pump efficiency:	80%	
Brake HP:	132	
Motor efficiency:	90%	
Draw:	146	hp
	109	kW
Unit pump time:	40.0	hours/mgal
Power use:	4,363	kWh/mgal
Power cost:	$1,745	/mgal
501 - 1500 ft pumping cost:	$8,026,289	/yr

Wells - High Elevation Band (1501 - 4000 ft)

Assumed TDH:	2,750	ft MSL
Num wells:	0	
Well flow:	0.60	mgd
	417	gpm
	0.93	cfs
Pump efficiency:	80%	
Brake HP:	362	
Motor efficiency:	90%	
Draw:	402	hp
	300	kW
Unit pump time:	40.0	hours/mgal
Power use:	11,998	kWh/mgal
Power cost:	$4,799	/mgal
1501 - 4000 ft pumping cost:	$0	/yr

Well pumping power cost (including standby):	$8,026,289	/yr	*21 wells (total)*
Total well pumping power cost (mains only):	$7,644,085	/yr	*20 main wells / 21 total wells*
	$1,745	/mgal	

Transmission PS Pumping

Assumed TDH:	300	ft MSL
Total flow:	12	mgd
	8,333	gpm
	18.57	cfs
Pump efficiency:	80%	
Brake HP:	790	
Motor efficiency:	90%	
Draw:	878	hp
	654	kW
Unit pump time:	2.0	hours/mgal
Power use:	1,309	kWh/mgal
Power cost:	$524	/mgal

Booster PS Pumping

Assumed TDH:	300	ft MSL
Num Booster PS:	20	count
Total booster flow:	12.0	mgd
	8333	gpm
	18.57	cfs
Pump efficiency:	80%	
Brake HP:	790	
Motor efficiency:	90%	
Draw:	878	hp
	654	kW
Unit pump time:	2.0	hours/mgal
Power use:	1309	kWh/mgal
Power cost:	$524	/mgal

Chlorine Treatment

Chlorine dose:	2	mg/L
Total flow:	12	mgd
Hypochlorite cost:	$8.00	/lb
Chlorine use:	200	lbs/day
Chlorine consumption:	16.7	lbs/mgal
Annual consumption:	73,058	lbs of Hypochlorite
Total hypochlorite cost:	$584,467	/yr

GAC Treatment (Not Required)

GAC material cost:	$4.00	/lb
GAC consumption:	0	lbs/mgal
	-	lbs of GAC
Total GAC replacement cost:	$0	/yr

Fixed Labor - 10 well operation at 3 elevation bands

Labor (FTE) demand	0.3	FTE per well/PS/GAC
Num wells/PS/GAC	42	count
Total labor (FTE):	12.6	FTE
Labor cost:	$100,000	/yr/FTE loaded
Total labor cost:	$1,260,000	/yr

Access Road BMP Maintenance

Access rd total	10.0	mi
Maintenance Cost	$5,000	/mi
Total access road BMP maintenance cost:	$50,000	/yr

East Maui Feasibility Study
O&M Unit Costs and Quantities

Phase 3: Alternative I - Waihee aquifer groundwater
O&M Unit Cost Reference

Electricity cost:	0.40	/kWh
Num elevation bands:	1	count
Num wells (main):	2	count
Num wells (standby):	1	
Total Flow:	2.74	mgd
Max flow per well:	1000	gpm
	1.44	mgd

Qty Summary Table

	Units	Quantity
Well pumping	mgal	1,000
Booster PS pumping	mgal	1,000
Transmission PS pumping	mgal	1,000
Labor (full time equivalent)	FTE	1.8
Access road maintenance	mi	1.5
Hypochlorite	lb	16,682
GAC replacement	lb	-

Wells - Low Elevation Band (0-500 ft)

Assumed TDH:	500	ft MSL
Num wells:	0	
Well flow:	1.37	mgd
	951	gpm
	2.12	cfs
Pump efficiency:	80%	
Brake HP:	150	
Motor efficiency:	90%	
Draw:	167	hp
	125	kW
Unit pump time:	17.5	hours/mgal
Power use:	2,182	kWh/mgal
Power cost:	$873	/mgal
0 - 500 ft pumping cost:	$0	/yr

Wells - Medium Elevation Band (501 - 1500 ft)

Assumed TDH:	1,000	ft MSL
Num wells:	3	
Well flow:	1.37	mgd
	951	gpm
	2.12	cfs
Pump efficiency:	80%	
Brake HP:	301	
Motor efficiency:	90%	
Draw:	334	hp
	249	kW
Unit pump time:	17.5	hours/mgal
Power use:	4,363	kWh/mgal
Power cost:	$1,745	/mgal
501 - 1500 ft pumping cost:	$2,618,099	/yr

Wells - High Elevation Band (1501 - 4000 ft)

Assumed TDH:	2,750	ft MSL
Num wells:	0	
Well flow:	1.37	mgd
	951	gpm
	2.12	cfs
Pump efficiency:	80%	
Brake HP:	827	
Motor efficiency:	90%	
Draw:	918	hp
	685	kW
Unit pump time:	17.5	hours/mgal
Power use:	11,998	kWh/mgal
Power cost:	$4,799	/mgal
1501 - 4000 ft pumping cost:	$0	/yr

Well pumping power cost (including standby):	$2,618,099	/yr	*3 wells (total)*
Total well pumping power cost (mains only):	$1,745,399	/yr	*2 main wells / 3 total wells*
	$1,745	/mgal	

Transmission PS Pumping

Assumed TDH:	300	ft MSL
Total flow:	2.7	mgd
	1,903	gpm
	4.24	cfs
Pump efficiency:	80%	
Brake HP:	180	
Motor efficiency:	90%	
Draw:	200	hp
	149	kW
Unit pump time:	8.8	hours/mgal
Power use:	1,309	kWh/mgal
Power cost:	$524	/mgal

Booster PS Pumping

Assumed TDH:	300	ft MSL
Num Booster PS:	2	count
Total booster flow:	2.7	mgd
	1903	gpm
	4.24	cfs
Pump efficiency:	80%	
Brake HP:	180	
Motor efficiency:	90%	
Draw:	200	hp
	149	kW
Unit pump time:	8.8	hours/mgal
Power use:	1309	kWh/mgal
Power cost:	$524	/mgal

Chlorine Treatment

Chlorine dose:	2	mg/L
Total flow:	2.7	mgd
Hypochlorite cost:	$8.00	/lb
Chlorine use:	46	lbs/day
Chlorine consumption:	16.7	lbs/mgal
Annual consumption:	16,682	lbs of Hypochlorite
Total hypochlorite cost:	$133,453	/yr

GAC Treatment (Not Required)

GAC material cost:	$4.00	/lb
GAC consumption:	0	lbs/mgal
	-	lbs of GAC
Total GAC replacement cost:	$0	/yr

Fixed Labor - 10 well operation at 3 elevation bands

Labor (FTE) demand	0.3	FTE per well/PS/GAC
Num wells/PS/GAC	6	count
Total labor (FTE):	1.8	FTE
Labor cost:	$100,000	/yr/FTE loaded
Total labor cost:	$180,000	/yr

Access Road BMP Maintenance

Access rd total	1.5	mi
Maintenance Cost	$5,000	/mi
Total access road BMP maintenance cost:	$7,500	/yr

East Maui Feasibility Study
O&M Unit Costs and Quantities

Phase 3: Alternatives J - O: Surface Water Strategies
O&M Unit Cost Reference

Current CPI:	300	
Electricity cost:	$0.40	/kWh
Labor cost:	100,000	/yr/FTE loaded

Water Treatment Facility O&M

Exclude Piiholo, assume MF

MF WTF	2020 O&M ($/kgal)	
Iao	2.43	
Kamole	3.78	
Olinda	4.32	
Average:	3.51	
2020 CPI:	259	
Adjusted:	4.07	
WTF O&M inclusive:	$4,066	/mgal

Transmission Pumping

Variable

Assumed TDH:	300	ft
Flow:	1	mgd
	694	gpm
	1.55	cfs
Pump efficiency:	80%	
Brake HP:	66	
Motor efficiency:	90%	
Draw:	73	hp
	55	kW
Unit pump time:	24	hours/mgal
Power use:	1309	kWh/mgal
Power cost (variable):	$524	/mgal

Fixed

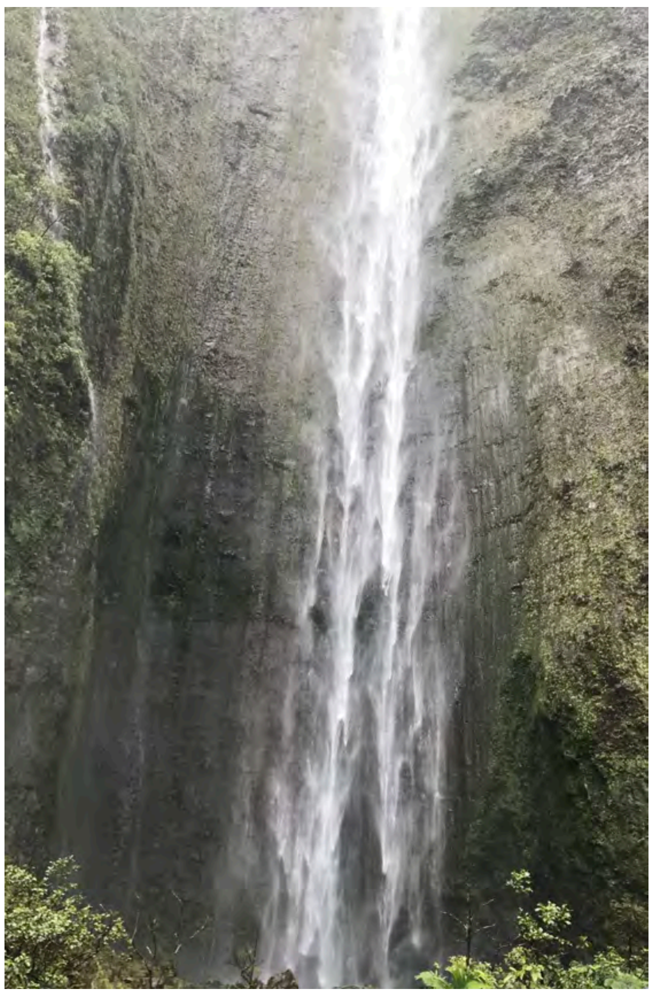
Labor:	1	FTE	$100,000	/yr
MX materials:	$150,000		$150,000	/yr
Total fixed costs:			$250,000	/yr

Diversion, Pipelines, Reservoirs

Labor:	2	FTE	$200,000	/yr
Expenses:	$100,000		$100,000	/yr
Total fixed costs:			$300,000	/yr

Appendix C: Cost-Benefit Analysis

EAST MAUI WATER-SOURCE DEVELOPMENT: COST -BENEFIT ANALYSIS



Source: Maui Department of Water Supply
(https://waterresources.mauicounty.gov/31/Watershed-Protection)

EAST MAUI WATER-SOURCE DEVELOPMENT: COST -BENEFIT ANALYSIS

PREPARED FOR:
Brown and Caldwell

PREPARED BY:
Plasch Econ Pacific LLC

October 2024

Contents

ACRONYMS AND ABBREVIATIONS

A&B	Alexander & Baldwin, Inc.
AV	Annualized Value
B&C	Brown and Caldwell
BLNR	Board of Land and Natural Resources, State of Hawai‘i
C-B	cost-benefit
CBA	Cost-Benefit Alternative
CDP	census designated place
County	County of Maui
CPI	Consumer Price Index
CWRM	Commission on Water Resource Management
D&O	Decision and Order by CWRM
EMI Co.	East Maui Irrigation Company, LLC
EMI System	East Maui Irrigation System
HC&S	Hawaiian Commercial and Sugar Co.
IIFS	Interim Instream Flow Standards
Kula Ag Park	Kula Agricultural Park
lb	pound
Mahi Pono	Mahi Pono LLC and its affiliated companies
MDWS	Maui Department of Water Supply
mgd	million gallons per day
O&M	operations and maintenance
OMB	Office of Management and Budget
PEP	Plasch Econ Pacific LLC
PV	Present Value
R&R	repair and restoration
State	State of Hawai‘i
yr	year

EXECUTIVE SUMMARY

The County of Maui (**County**) is considering various alternatives for supplying water to accommodate population and economic growth in Central and Upcountry Maui. The alternatives include various combinations of groundwater and surface water.

Development of the County water system to accommodate planned population and economic growth would provide substantial economic benefits to the community at large. These economic benefits would be lost under the No Action Alternative.

The alternative with the lowest Present Value (**PV**) cost is Haʻikū Groundwater (CBA-1, the Baseline Alternative) with Alternative CBA-4 (Wailoa Ditch, Reallocate Ag Water) a close second. These two alternatives remain the lowest cost even with reasonable changes in the discount rate.

Based only on expenditures by the Maui Department of Water Supply (**MDWS**), the alternative that would provide the lowest PV cost to the MDWS and the lowest water rates is CBA-4 (Wailoa Ditch, Reallocate Ag Water). This finding ignores the future loss of farm-related economic benefits due to reallocating ditch water from future farming in Central Maui to the County water system. It would result in a change in the farm plan for Central Maui to decrease irrigated crop farming by about 2,280 acres and increase unirrigated pasture land by the same amount. An estimated 114 future farm jobs would be lost. Increasing the amount of unirrigated pasture land in windy Central Maui is likely to increase wind-blown dust, increase the risk of wildfires, and require an increase in fire-control services. With Alternative CBA-4, there is risk of not supplying projected water demand for two reasons. First, the planned use of ditch water may be subject to public opposition and legal challenges which, in turn, may delay development and/or reduce the planned flow of water to be reallocated. Second, once developed, the available flow of ditch water will be low during prolonged droughts, possibly resulting in the supply of water being insufficient to meet demand.

EAST MAUI WATER-SOURCE DEVELOPMENT: COST-BENEFIT ANALYSIS

1. INTRODUCTION

a. Content and Purpose

To accommodate planned economic and population growth for Central Maui, Upcountry Maui, and South Maui, the Maui Department of Water Supply (**MDWS**) plants to increase the supply of water delivered to the affected communities (the **Project**). This may entail improving existing water supply systems and/or developing new ones. Since many water-supply options are available, a rigorous cost-benefit (**C-B**) analysis was conducted of the more promising alternatives. The purpose of the analysis was to identify those alternatives which will provide the greatest net benefit to Maui residents.

b. Consultants

The **C-B** analysis was performed for the MDWS by Plasch Econ Pacific LLC (**PEP**) under subcontract to Brown and Caldwell (**B&C**). B&C provided cost information, anticipated development schedules, and a preliminary assessment of various impacts related to development and operations.

c. Organization of the Report

Section 2 provides information on Consent Decree that mandates a **C-B** analysis.

Section 3 defines the Project Area and Project Communities.

Section 4 provides information on the Socio-Economic Conditions of the Project Communities.

Section 5 provides information about the East Maui Irrigation System (**EMI System**) and agricultural plans for Central Maui. Details are provided because many of the alternatives would use surface water from the EMI System and thus could affect future agricultural activity in Central Maui.

Sections 6 provides information on water-supply options for developing the County water system to supply the Project Communities.

Section 7 provides information on the methodology used for the **C-B** analysis, including various assumptions and calculations.

Section 8 presents the findings.

Section 9 lists references that were used.

Tables are at the end of the report.

2. CONSENT DECREE

Consent Decree Civil No. 03-1-0008(3)—dated December 2, 2003 and filed with the the Circuit Court of the Second Circuit, State of Hawai‘i—calls for a rigorous cost-benefit analysis for developing and transmitting “the surface and groundwater resources available in the Central Maui Region, Upcountry Maui Region, and East Maui Region.” This decree is between (1) Hawaiian and environmental community groups, and (2) Maui County, the Maui Board of Water Supply, the MDWS, and County officials.

3. PROJECT AREA AND COMMUNITIES

The **Project Area** includes twelve aquifers within the Wailuku, Central and Ko‘olau Aquifer sectors (see Figure 1). The **Project Communities** are those served by the MDWS Central, Makawao, Lower Kula and Upper Kula Water Systems (see Figure 2). The latter three systems form the Upcountry Water District.

The Central Water District serves the following Census Designated Places (**CDPs**): Mākena, Wailea, Kīhei, Mā‘alaea, Waikapū, Kahului, Wailuku and Waihe‘e-Waiehu. The Upcountry Water District serves the following CDPs: Makawao, Pukalani, Hāli‘imaile, Ha‘ikū-Pa‘uwela, Olinda, Kēōkea and Kula.

4. SOCIO-ECONOMIC CONDITIONS

For context, the socio-economic conditions of the Project Communities, as provided by the U.S. Census Bureau, are summarized in Tables 1 to 4:

— Table 1: Demographic Characteristics (2020 and 2018-2022)

- Population by sex, age and race
- Household by size, tenure, and type
- Housing units

— Table 2: Income and Education (2020 and 2018-2022)

- Median annual income
- Educational Attainment
- Language spoken

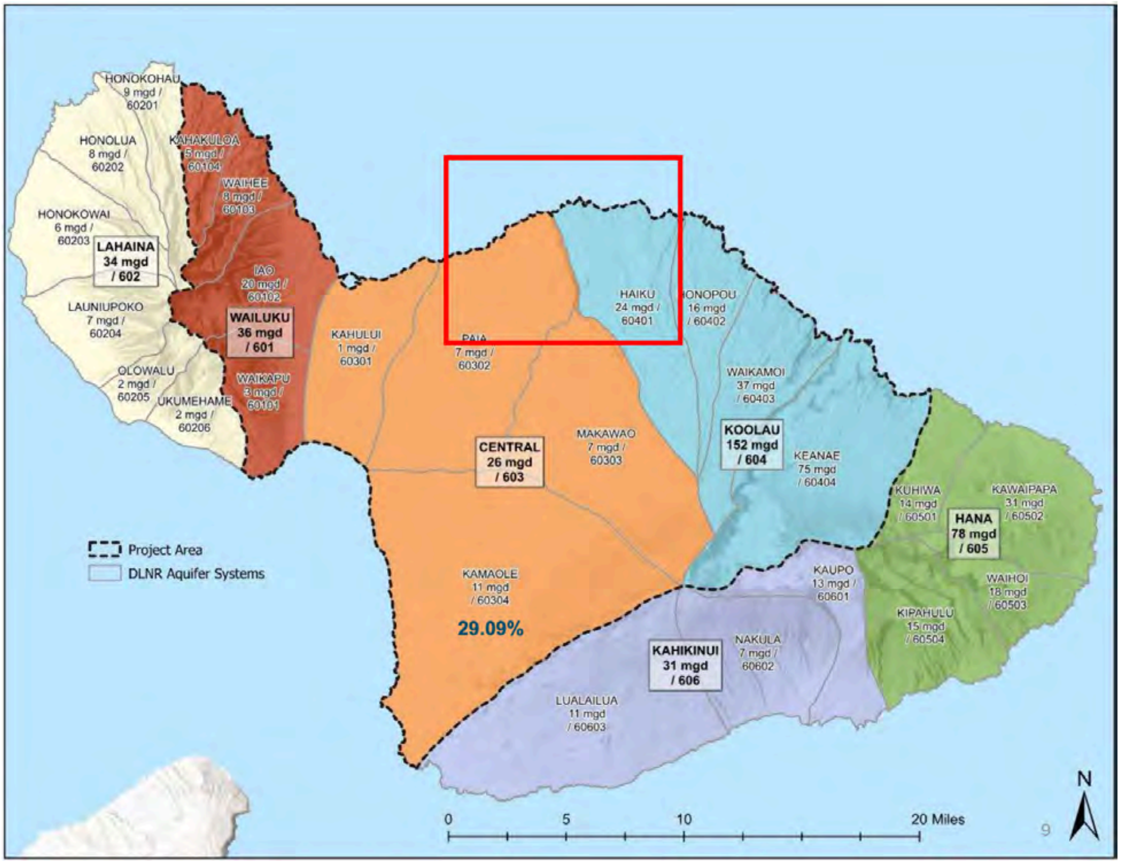


Figure 1. Wailuku, Central and Ko'olau Aquifer Sectors

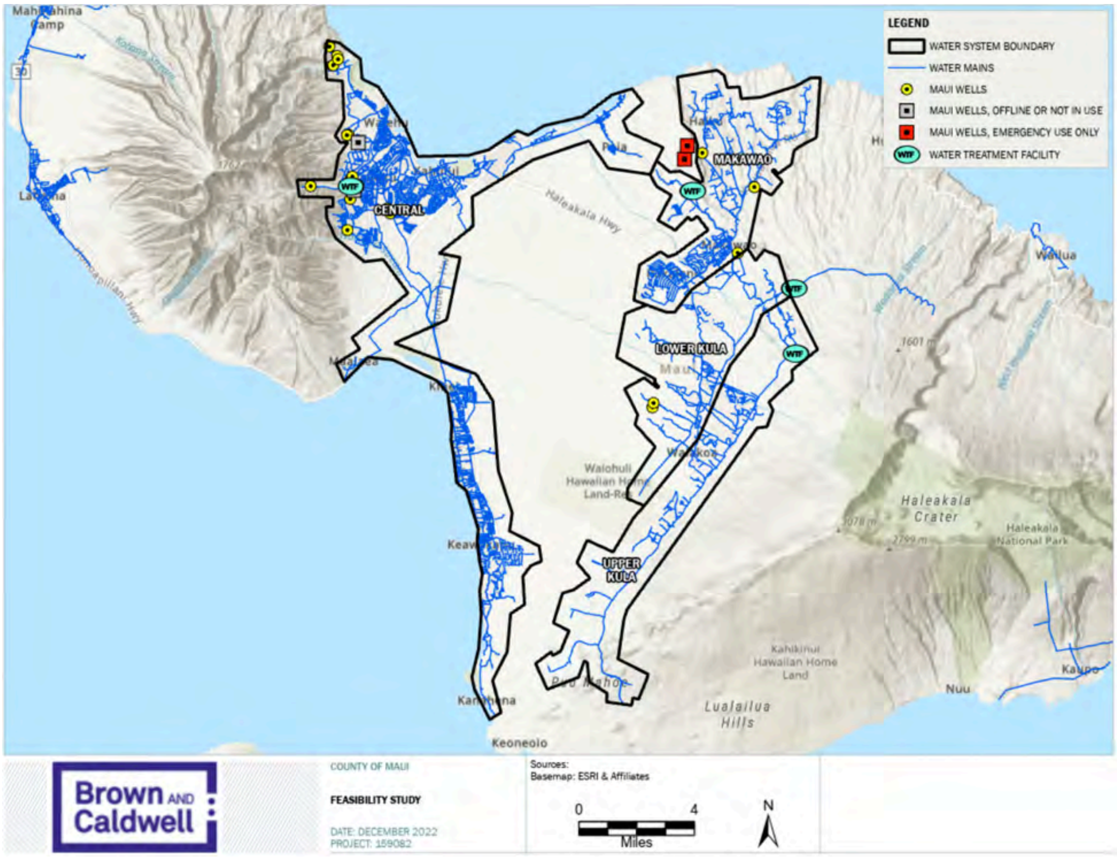


Figure 2. Central, Makawao, Lower Kula and Upper Kula Water Systems

— Table 3: Economic Indicators (partial) (2017)

- Number of establishments by sector
- Sales, value of shipments, or revenue by sector
- Annual payroll by sector

— Table 4: Number of Employees by Sector (2016--2020 and 2018-2022)

Note that the figures in Table 3 are low because data for Hali'imaile, Kēōkea, Makena, Ma'alaea, and Olinda CDPs are excluded in order to avoid revealing information about individual companies.

5. EMI SYSTEM AND AGRICULTURAL PLANS FOR CENTRAL MAUI

The EMI System, which is managed by the East Maui Irrigation Company, LLC (**EMI Co.**), delivers surface water from East Maui to Central Maui for irrigating crops. Since many of the alternatives for expanding the County water system would divert water from the EMI System, agricultural activity could be affected. Accordingly, the EMI System and the planned agricultural use of water from this system are summarized below. Most of the material is from the report, "East Maui Water Lease: Agricultural and Related Economic Impacts," Plasch Econ Pacific LLC, June 2019.

a. EMI System

The EMI System, which was completed in 1923, is an integrated system of diversions, intakes, ditches (about 24 miles), and tunnels (about 50 miles) which collect surface water from streams located on the rainy windward slopes of East Maui and transport the water by gravity to the comparatively dry agricultural fields in Central Maui. Four parallel levels of water ditches run from east to west across the East Maui mountains. Wailoa is the highest elevation ditch, thus has access to large and reliable sources of water and runs year round. Many of the alternatives for expanding the County water system would divert water from Wailoa Ditch for use by the MDWS.

The watersheds from which the EMI System collects water total about 50,000 acres on the north slope of Haleakala, of which about 17,000 acres are privately owned, and about 33,000 acres are owned by the State. It has been recognized that 70% of the EMI System flow east of Honopou Stream comes from State lands, and 30% comes from private lands [Commission on Water Resource Management (**CWRM**) Decision and Order (**D&O**), June 20, 2018, p. 14]. Between Honopou Stream and Maliko Gulch, all of the additional water flow comes from private lands.

Historically, the right to collect water from State lands has been leased to Alexander & Baldwin, Inc. (**A&B**) and its subsidiary EMI Co. for growing sugarcane at the Hawaiian Commercial and Sugar Co. (**HC&S**) plantation.

In 2006, the EMI system delivered 156.5 million gallons per day (**mgd**) of water to Central Maui, with nearly all of the water used by HC&S. The year 2006 is regarded as typical when rainfall was normal and restoration of stream flows was insignificant. In the five years prior to closing the HC&S plantation (2008 to 2013), water delivered to Central Maui had dropped to about 113.7 mgd (a decrease of about 43 mgd). During this period, rainfall was below normal and significant water had been returned to East Maui streams.

b. Restoration of Stream Flows

Since the 2003 Consent Decree (see Section 3), the volume of surface water that was diverted from East Maui streams to irrigate crops in Central Maui—and which could be diverted in the future to supply water to Central Maui and Upcountry Maui for agriculture, domestic or business use—has been greatly reduced.

On May 24, 2001, the Native Hawaiian Legal Corporation filed petitions with the CWRM to Amend the Interim Instream Flow Standards (**IIFS**) for 27 East Maui streams. In 2007, A&B ceased diversions on Waiokamilo Stream, fully restoring flows to the stream, in response to an interim order by the Board of Land and Natural Resources (**BLNR**). In June 2018, the CWRM amended the IIFS for East Maui streams. In its D&O, CWRM fully or partially restored stream flows for most of the petitioned East Maui streams and limited the volume of water which can be diverted from East Maui streams. Further, the D&O "will return free flowing water, with no upstream diversions, to all streams which have historically supported significant kalo cultivation (Honopou, Huelo, Hanehoi, Pi‘ina‘au, Palauhulu, Ohia (Waianui), Waiokamilo, Kualani, Wailuanui, Makapipi)."

c. Revocable Water Permits

Since 1986, the BLNR has issued to A&B one-year revocable permits for four license areas in East Maui. The permits have allowed A&B to divert surface water via the the EMI System to (1) irrigate fields in Central Maui and (2) supply water to the MDWS for domestic and agricultural water needs for portions of Upcountry Maui, including the Kula Agricultural Park and communities served with water from the EMI System. Since 2022, BLNR permits have allocated water to EMI Co. and other users (e.g., MDWS) in single overall decisions (BLNR 2022).

As of December 2023, the maximum volume of water which can be diverted from East Maui is 38.25 mgd averaged annually, with 31.25 mgd granted to the permittee for agricultural use, 6 mgd to the County for Kamole Treatment Center, and 1 mgd for the Kula Agricultural Park (**Kula Ag Park**) (EMI Water Delivery Agreement 2018).

d. Agreements to Supply Water to the County

Subject to various agreements and amendments, A&B/EMI Co. agreed to supply water from the EMI System to the County:

— The 1973 Agreement/memorandum-of-understanding permits the MDWS to withdraw 12 mgd per 24 hours and an additional 4 mgd upon one year written notice by MDWS to the EMI Co.

— The 4th amendment allocation was 8.5 mgd per 24 hours, with 7 mgd at Kamole Weir and 1.5 mgd to the Kula Ag Park.

— The 5th amendment (1998) is the last one that addresses the allocation of water: EMI Co. will make available to the MDWS up to 8.675 mgd per 24-hour period, with 7.175 mgd at Kamole Weir and up to 1.5 mgd per 24-hour period from Hamakua Ditch to the Kula Ag Park.

— The 6th to 8th amendments do not change the allocation. Therefore, the 5th amendment allocation of 7.175 mgd at Kāmole, with no option to increase, still applies.

e. Proposed Water Lease

In 2001, A&B requested that the BLNR offer a long-term East Maui Water Lease at public auction for the right, privilege and authority to enter and go upon State-owned lands in East Maui for the purposes of developing, diverting, transporting and using government-owned waters. BLNR action on issuing a Water Lease has been delayed for various reasons.

Under the proposed Water Lease, the State of Hawaiʻi would allow the continued diversion of East Maui surface water for delivery to Central Maui and Upcountry Maui. The Central Maui agricultural lands, as well as other lands formerly owned by A&B, are now owned by MP Central A, LLC, MP Central B, LLC, MP CPR, LLC, MP East A, LLC, MP East B, LLC, and MP West, LLC (individually or collectively, "**Mahi Pono**"), which acquired these lands from A&B in December 2018. In addition, since early 2019, MP EMI, LLC owns 50% of the EMI Co. and is the managing member of the company; A&B is the other member.

The request submitted to BLNR was for a long-term 30-year Water Lease. A long term is needed to provide sufficient time for Mahi Pono to implement its farm plan and earn a return on its investment. Many of the fields will be planted in orchard trees which take years to mature and which will yield fruit and other crops for decades.

Under the proposed lease, and consistent with the CWRM D&O, the EMI System would deliver about 92.3 mgd from State and private lands in East Maui to Central Maui (a reduction of about 64 mgd from the typical sugar diversions). About 85.2 mgd would be used for farming in Central Maui, and about 7.1 mgd would be used by the MDWS for domestic and agricultural water needs.

In September 2024 the Maui Mayor Richard Bissen, Jr. convinced the BLNR chair to defer the decision on the water lease in order to allow the newly formed County of Maui East Maui Regional Community Board and the East Maui Water Authority to "… pursue the County's control and management of the East Maui Water License," and "… allow the

County of Maui and other interested parties to explore possible long-term partnership opportunities that will address the water needs of both public and private entities that depend on this important water resource."

f. Agricultural Water Supply, Central Maui

The surface water from the EMI System is supplemented with brackish groundwater to further increase the supply of water for irrigating crops in Central Maui. For the assumed 85.2 mgd of surface water, about 21.3 mgd of brackish groundwater would be used. This is based on a split of 80% surface water and 20% brackish groundwater (i.e., a 4-to-1 mix; 85.2 mgd of surface water ÷ 4 = 21.3 mgd). This 80%/20% split applies to the farm as a whole. However, all of the groundwater is applied to the lower fields, and none to the upper fields which are irrigated only with surface water. The resulting water mix that is applied to the lower fields is about 70% surface water and 30% brackish groundwater. This mixture is consistent with safe use of brackish groundwater on diversified crops.

The resulting water supply for farming in Central Maui would total about 106.5 mgd, including both surface water and brackish groundwater.

g. Farm Plan

Central Maui has some of the best agricultural conditions in the State for farming, including a large area in a compact configuration, high-quality soils, high solar radiation, a location near markets and shipping terminals, potentially ample water at low delivery costs (assuming a new Water Lease at a reasonable use fee).

Mahi Pono's plans for Central Maui envision cultivating a broad range of food and non-food crops for local consumption and export, including orchard crops (citrus, macadamia nuts, coffee, avocado, etc.), tropical fruits, vegetables and melons, row crops, annual crops, energy crops, and grass-fed cattle. In addition, the company plans to lease some of its land to other farmers. For the proposed water lease, about 15,950 acres would be used for growing crops, including 12,850 acres for orchard crops and 3,100 acres for other crops. About 13,800 acres would be used for pasture, of which about 4,700 acres would be irrigated. About 250 acres would be used for green energy, such as solar farms. These acreages indicate a major expansion in crop farming in Hawai‘i.

As indicated, the predominant crops will be various types of orchard trees, which reflect a long-term commitment to farming. About 5 years or more will be required for citrus, coffee, and avocado trees to reach full maturity, and 12 years or more for macadamia nuts. After reaching maturity, macadamia nuts trees will provide yields for 35 years or more, citrus and coffee for 50 years or more, and avocado for over 100 years.

The Mahi Pono farm plan was designed to match water requirements for farming with the available water supply. If less water is provided than what is planned, then the agricultural plan will have to be changed to reduce acreage in crops and increase acreage used for unirrigated pasture.

6. COUNTY WATER-SUPPLY OPTIONS

a. Planned Develoment of the County Water System

Planned water development is based on the "Most Likely" 2040 water demand provided in Table 3 of the report, "Phase 1: Central and Upcountry Demand and Capacity Analysis," B&C, July 13, 2023:

— **2020 Actual Water Demand**

- Central District: 24.033 million gallons per day (**mgd**)
- Upcountry District: 7.55 mgd
- **Total: 31.583 mgd**

— **Planned 2020-to-2040 Water Development to Meet Future Demand**

- Central District: 9 mgd increase
- Upcountry District: 3 mgd increase
- **Total: 12 mgd increase (38%)**

The same planned growth is assumed for all alternatives except for the No Action Alternative. In other words, all water-supply alternatives except for the No Action Alternative were designed by B&C to supply sufficient water to accommodate planned economic and population growth for the Project Communities.

b. Water-Supply Strategies

B&C identified 15 promising water-supply strategies that could supply future water needs to the Project Communities, either in full or in part. For details, see B&C, "Phase 3: Cost-Benefit Study for Central Maui, Upcountry and East Maui Regions," November 2024. These strategies and their potential yields are as follows:

	mgd
— A: Haʻikū aquifer groundwater	12
— B: Makawao aquifer groundwater	5.4
— C: Kamaʻole aquifer groundwater	6.6
— D: Waikamoi aquifer groundwater	12
— E: Pāʻia aquifer groundwater	4.3
— F: Waikapū aquifer groundwater	2.5
— G: Keʻanae aquifer groundwater	12

— H: Honopou aquifer groundwater	12
— I: Waihe‘e aquifer groundwater	2.7
— J: Capture Wailoa Ditch high flows	12
— K: Reallocate agricultural water from Wailoa Ditch	12
— L: Lower Kula system expansion	3.2
— M: Capture Waihe‘e River high flows	5.1
— N: Reallocate agricultural water from Waihe‘e River	1.9
— O: Capture Wailuku River high flows	6.6

All of the proposed water supply strategies are consistent with CWRM's 2018 D&O for East Maui streams and the 2021 D&Os for the Na Wai ‘Eha streams (Waihe‘e River, Waiehu Stream, Wailuku River, and Waikapū Stream). Also, proposed surface water diversions, if any, will be subject to CWRM approvals.

c. Water-Supply Alternatives

From these Strategies, B&C identified nine promising Strategy Combination Alternatives/Cost-Benefit Alternatives (**CBAs or alternatives**) which could fully supply future water needs to the Project Communities (9 mgd for the Central Water District + 3 mgd for the Upcountry Water District = a total of 12 mgd.). These CBAs plus the No Action alternative are as follows:

— CBA-1: Ha‘ikū Groundwater (Baseline, A)

— CBA-2: Makawao, Waihee and Ha‘ikū Groundwater (B+I+A)

— CBA-3: Wailoa Ditch, High Flows (J)

— CBA-4: Wailoa Ditch, Reallocate Ag Water (K)

— CBA-5: Makawao and Kama‘ole Groundwater, Lower Kula System Expansion (B+L+C)

— CBA-6: Waikapu and Waihee Groundwater, Reallocate Ag Water from Wailoa Ditch (F+I+K)

— CBA-7: Waikapu and Pā‘ia Groundwater, Reallocate Ag Water from Wailoa Ditch (F+K+B)

— CBA-8: Makawao and Pā‘ia Groundwater, Reallocate Ag Water from Wailoa Ditch (B+K+E)

— CBA-9: Makawao and Waihee Groundwater, High Flows from Wailoa Ditch (B+I+J)

— CBA-10: No Action

Each alternative may include many but not all of the following components: wells, booster pump stations, transmission pump stations, pipelines, water tanks, access road improvements, power infrastructure improvements, one or more storage reservoir, and an expanded Kāmole Water Treatment Facility. None of the alternatives would require new stream diversions, although two (CBA-3 and CBA-9) would capture high flows from Wailoa Ditch. During periods of high water flows in the Ditch, these two alternatives would divert a portion of the water subject to meeting (1) stream requirements as established by CWRM and (2) allowed water uses for farms in Central Maui, the Kula Agricultural Park, and the County for use in Upcountry Maui.

These ten alternatives were subject to the **C-B** analysis. Depending on the water source or sources and on specific components, each alternative will have economic, environmental and social impacts.

d. Baseline and No Action Alternatives

Two of the alternatives were treated differently than the others.

Baseline Alternative (CBA-1)

To simplify the comparison among the strategy combinations, CBA-1 (Ha'ikū Groundwater) was arbitrarily chosen as the Baseline Alternative. This alternative was chosen as the baseline because it is based on typical incremental improvements designed to meet the projected water demand, while assuming no new stream diversions nor changes in existing stream diversions. This Baseline simplifies the comparison among alternatives because it allows a focus on only those impacts of an alternative that differ from the Baseline Alternative. Impacts of an alternative that are the same as those for the Baseline Alternative need not be explored since only differences matter when comparing alternatives.

For example, economic benefits related to future water use is not required for any of the alternatives other than the No Action Alternative since these benefits will be the same as those for the Baseline Alternative. This is because all these alternatives will be based on the same economic/population and water-demand assumptions as used for the Baseline Alternative. However, impacts of the various CBAs will differ due to different assumptions regarding water sources and delivery systems. Similarly, impacts related to surface water will be limited to those combinations that change existing steam flows or the use of surface water since the Baseline Alternative will not change stream flows or the use of surface water.

No Action Alternative (CBA-10)

For the No Action Alternative, no significant improvements to the existing water system nor a significant increase in operations and maintenance (**O&M**) expenditures are assumed. However, this alternative will capture the lost economic and social benefits of not meeting the projected demand for water.

7. METHODOLOGY

a. Overview

For each CBA, the discounted present value (**PV**) of the future time-stream of monetized benefits and costs was calculated. The PV is similar to the value of a loan for a specified time-stream of irregular loan payments. For this analysis, costs are positive numbers while benefits are negative numbers. With this accounting, the objective is to identify those alternatives which have a low PV cost.

b. Guidelines for Cost-Benefit Analysis

The C-B analysis adhered to the guidelines set forth in the following documents:

- The U.S. Whitehouse Council on Environmental Quality, "Updated Principles, Requirements and Guidelines for Water and Land Related Resources Implementation Studies," December 2014.
- The U.S. Whitehouse Office of Management and Budget (**OMB**) Circular No. A-94, Revised , Nov. 9, 2023, "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs," including the latest versions of Appendix C, "Discount Rates for Cost-Effectiveness, Lease Purchase, and Related Analyses."

In the United States, the terms cost-benefit analysis and benefit-cost analysis are used interchangeably, and refer to the same analysis. The main differences between the two are where they are used. Benefit-cost analysis is common when evaluating Federal projects and in academia. Cost-benefit analysis is more common outside of these sectors. In this report, cost-benefit is used in order to to be consistent with the terminology used in the Consent Decree (Section 2).

c. Analysis Assumptions

The following assumptions were used for calculating PVs:

— <u>Time horizon</u>: 2090. All capital improvements are scheduled for installation by 2040 and are expected to remain functional to 2090 with proper maintenance, repair, and rehabilitation.

— <u>"Real" 2025 values and prices</u>: monetary values and prices are expressed in terms of the purchasing power of a dollar in 2025 ("**real**" dollars). Past and future "**nominal**" values and prices (i.e., values and prices existing at the time) were converted to "real" 2025 values and prices based on adjustments for inflation.

— <u>Past inflation</u>: past inflation was based on (1) the Engineering News Record Construction Cost Index (ENRCCI) for capital costs, and (2) annual changes of the Honolulu Consumer Price Index for O&M costs.

— <u>Future inflation</u>: 2.2% per year over the life of the Project. Future inflation was derived from the latest version of OMB Circular No. A-94, Appendix C, revised

December 28, 2023 (i.e., the 4.7% 30-year Nominal Interest Rate on U.S. Treasury Notes and Bonds (with inflation) – the corresponding 2.5% Real Interest Rate (without inflation) = the 2.2% future inflation rate).

— Real discount rate: 2% for Maui. This is based on the 2.5% real interest rate of 30-year U.S. Treasury Notes and Bonds (OMB Circular No. A-94, Appendix C, revised December 28, 2023) minus 0.5% for high quality municipal bonds. High-quality municipal bonds have lower interest rates than Treasury bonds because the interest on municipal bonds is generally not subject to income taxes, while the interest on Treasury bonds is taxed.

— Other discount rates: 1% to 4%. PVs are sensitive to the assumed discount rate. Accordingly, a sensitivity analysis was performed to determine if the findings are sensitive to the assumed discount rate. The assumed discount rates are as follows:

- 1%: a low discount rate that is consistent with future inflation of construction and O&M costs exceeding general inflation by about 1% per year (2% real discount rate – 1% faster inflation = 1% adjusted discount rate)
- 2%: the real discount rate for long-term Maui County projects
- 2.5%: the real discount rate for long-term Federal projects
- 4%: a high discount rate that is consistent with uncertainty over costs and impacts far into the future

— Discount factor: $1/(1.02)^n$ for future year "n" (i.e., n years from 2025) and a 2% discount rate. Multiplying a future value in year n × the discount factor for year n gives the value in 2025. Discounting adjusts for the time-value of monetary amounts: a dollar amount received in the distant future has a lower current value than the same dollar amount received in the immediate future, largely because an amount received in the near term can be invested to earn interest.

d. Development and Operating Costs

For each alternative, B&C provided expenditures over time for (1) planning, design, construction, etc. (capital costs); (2) repair and rehabilitation (**R&R**) of capital improvements, and (3) O&M. The last capital expenditures are projected to occur in 2040, followed by R&R expenditures from 2060 to 2065 which will extend the life of the capital expenditures to about 2090. O&M expenditures are projected to increase linearly from 2035 to 2041, then remain stable until 2090.

The projected expansion of the County water system is designed to accommodate projected population and economic growth in the Project Communities until the demand for water in the Project Area exceeds the added 12 mgd. Water demand beyond the additional 12 mgd would require even more improvements to the County water system.

e. Salvage Values and Rehabilitation Costs

By 2090, after 50 or more years of use, improvements are assumed to have negligible values (salvage values). Similarly, the cost to close wells, remove old equipment and structures, etc. (rehabilitation costs) is expected to be relatively small.

f. Economic Benefits

Wages, profits and taxes are generally categorized as benefits in a **C-B** analysis. In this report, gross (not net) wages are used. Correspondingly, income taxes on wages and profits are excluded from the analysis in order to avoid double counting of benefits.

The development of the water system will generate wages to construction employees and profits to construction companies. Similarly, operation of the water system will generate wages to County workers. These wages and profits are both benefits and costs of developing and operating the Maui water system. However, these wages and profits are not counted as benefits under the standard assumption that these employees and companies would otherwise be employed.

During development of the water system, construction companies and their employees will purchase goods and services, thereby generating indirect sales and employment along with related wages and profits (indirect benefits). Similarly, the purchase of goods and services by employees engaged in operations will generate indirect wages and profits. These indirect benefits are not counted in the **C-B** analysis under the standard assumption that the suppliers of the goods and services would otherwise be employed.

g. Value of Non-Economic Impacts

Each alternative could generate various economic, environmental and social impacts. Before an alternative is implemented, an Environmental Impact Statement will be required to comply with Chapter 343 of Hawai‘i Revised Statutes, along with related studies of impacts of construction and operations. Such studies may include, but will not be limited to, impacts on: groundwater, stream flows, animal and plant life, floods and drainage, soil and pesticide runoff, air quality, noise, agriculture, historic and archeological sites, cultural resources and practices, recreation (hiking swimming, fishing, hunting, etc.), views, utilities, roads and traffic, government finances and services, etc.

The purposes of the studies will be to ensure compliance with various legal requirements, rules and regulations, standards, and best management practices. It is anticipated that the studies will help steer development so as to avoid, minimize and mitigate nearly all potentially adverse impacts. Groundwater withdrawal rates will comply with safe yields; sensitive sites and practices will be avoided; construction activity will be timed to avoid peak commute times; submersible pump motors and noise suppression measures will be used to reduce noise in sensitive areas; plants, walls, fences and/or berms will be used to hide views of facilities where needed; etc. The capital cost of each alternative includes a $10 million allowance to mitigate adverse impacts. In any case, it is assumed that mitigating measures will be fully implemented. However, a few of the alternatives will have a significant adverse impact on agricultural activity in Central Maui.

Similar to the above, it is anticipated that there will be few beneficial impacts beyond those associated with supplying water to accommodate projected growth.

h. Agricultural Impacts

Six alternatives (CBA-3, CBA-4, CBA-6, CBA-7, CBA-8 and CBA-9) would divert water from Wailoa Ditch to the County water system, thereby reducing the potential future flow of ditch water for farming in Central Maui. This would cause a change in the farm plan to reduce planned crop farming and increase unirrigated pastures for cattle grazing. An orchard crop is assumed because it is the predominate crop being planned by Mahi Pono in Central Maui.

The economic impacts of this change in agricultural use are based on the multipliers included in the report "East Maui Water Lease: Agricultural and Related Economic Impacts," by Plasch Econ Pacific LLC, June 2019. However, prices and wages were adjusted to 2025 values based on the Honolulu consumer price index. The agricultural impacts and lost benefits per 1 mgd of reallocated ditch water is based on the following assumptions and calculations:

— Water (reduction)

• Reallocated ditch water	1	mgd
• Brackish water mixed with ditch water to extend supply	0.25	mgd
• Subtotal	1.25	mgd
• Less system losses (22.7%)	- 0.28	mgd
• Useable water	0.97	mgd

— Orchard crops (reduction)

• Planted area (5,089 gallons per acre per day)	190	acres
• Production (25,000 lbs/acre)	4,750,000	lbs/yr
• Revenues (50¢/lb)	$ 2,375,000	per yr
• Profits (10%)	$ 237,500	per yr
• Excise taxes (0.5% of revenues)	$ 11,900	per yr
• Jobs (20 acres per job)	9.5	jobs
• Payroll ($43,800 per job)	$ 416,100	per yr

— Cattle Grazing (gain)			
• Grazed area, unirrigated		190	acres
• Economic impacts		negligible	
— Property value and taxes (reduction)			
• Change in assessed value ($1,010 per acre)	$	191,900	
• Property taxes ($5.74 per $1,000 acres)	$	1,100	per yr
— Benefits (reduction)			
• Profits	$	237,500	per yr
• Payroll	$	416,100	per yr
• Excise taxes (State)	$	11,900	per yr
• Property Taxes (County)	$	1,100	per yr
• **Total Benefits** (per 1 mgd of ditch water)	**$**	**666,600**	**per yr**

The change from irrigated crop farming to cattle grazing on unirrigated pastures may increase the wind-blown dust, the risk of wildfires, and the costs of fire-control services. These impacts were not quantified nor monetized.

Assuming the BLNR decides to increase the diversion of water from the EMI System to the MDWS—either for the Wailoa Ditch reallocation strategy or the Wailoa Ditch high-flow strategy—it is further assumed that this would be achieved with an increase in the flow of surface water from East Maui and not a reallocation of the existing flow of ditch water. That is, it is assumed that the Board would provide sufficient water (at least the current 31.25 mgd) to existing farm operations in Central Maui to prevent a forced fallowing of farmland now used for growing crops in Central Maui. However, future increases in the allocation of water for farms in Central Maui may be affected if more water from the EMI System is allocated to the MDWS. For example, if an addition 50 mgd of water from the EMI System were to be allocated to expand crop farming in Central Maui under the assumption that no additional water will flow to the County for future use, this 50 mgd increase for Central Maui farms could be reduced to a 40 mgd increase if 10 mgd were to be allocated to the MDWS for future County use. This allocation of more water to the County from the EMI System (i.e., the assumed 10 mgd increase for future use) would result in a smaller increase (i.e., 40 mgd instead of 50 mgd) in the flow of water for farming in Central Maui. In turn, the growth of farming in Central Maui would be reduced due to less growth in the supply of water for farming.

It is assumed that a decision to increase future flows of water from the EMI System to the MDWS would result in decreased plantings of orchard starting soon after the decision is made, and reduced planting would continue for a few years. If planted, it is assumed that the affected fields would have produced crops starting as early 2030, and production would have grown linearly and reached maximum production by 2040. This future increased production of crops and the resulting economic benefits would be lost.

i. No Action Alternative

Approach for Estimating Lost Economic Benefits

As mentioned in Subsection 9.b, and as the name of this alternative implies, the No Action Alternative would entail no improvements to the existing water system nor significant changes in operations and maintenance to the existing water system serving the Project Communities. Normally, no new benefits or costs would be calculated for the No Action Alternative given the lack of changes. However, the analysis in this report is structured to include lost economic benefits that would otherwise occur if the demand for water were to be met.

As noted in Subsection 9, estimating economic benefits related to future water use is not required for alternatives CBA-1 through CBA-9 since these benefits will be the same as those for the Baseline Alternative (CBA-1). This is because all these alternatives will be based on the same economic/population and water-demand assumptions as used for the Baseline Alternative. Impacts of an alternative that are the same as those for the Baseline Alternative need not be explored since only differences matter when comparing alternatives. Mathematically, this is equivalent to subtracting the same economic benefits related to future water use from the benefits and costs for alternatives CBA-1 to CBA-9.

For consistency and valid comparison among alternatives, the same economic benefits should be subtracted from the No Action Alternative (CBA-10). This results in the No Action Alternative including the economic benefits that would otherwise occur if the demand for water were to be met (i.e., lost benefits).

The advantage of this approach is twofold. First, it simplifies the analysis since only one alternative (instead of nine) includes future economic benefits related to future water use. Second, the cost of each alternative to meet the water demand is clearly presented and separated from the economic benefits of satisfying the demand for water.

Lost Economic Benefits Compared to 2020 Benefits

The planned improvements will increase the supply of water to the Central Maui Water District and the Upcountry Water District by about 12 mgd for an increase of about 38% above the 31.583 mgd delivered to these two Districts in 2020. Without the additional water supply (No Action Alternative), the economic benefits that will be lost in the future will total approximately 38% of the economic benefits occurring in the Project Area in 2020.

Calculation of Lost Economic Activity and Related Impacts

Compared to what would otherwise occur if the demand for water would be met in the Project Area, the No Action Alternative leads to the following estimates of lost economic activity (2025 dollars) and related socio-economic impacts:

— Revenues: $3,440 million per year (low estimate)

Total revenues (sales, value of shipments, etc.) of businesses in the Project Area exceeded $7,090 million in 2017 (see Table 3). This estimate is low because revenues of businesses in Halimaile, Kēōkea, Kakena, Māʻalaea and Olinda are excluded to avoid revealing information about individual companies. No adjustment was make in these figures to adjust for these omissions or for economic growth from 2017 to 2020.

Adjusting for 2017-to-2025 inflation, the revenues increase to about $9,054 million (27.7% increase).

Under the No Action Alternative, the lost revenues in the Project Area are expected to eventually exceed $3,440 million per year (38% of $9,052 million). Based on Table 3, the sectors generating the greatest revenues would be Retail, Health Care, and Accommodation and Food Services.

— Excise Taxes: $119 million per year (low estimate)

Based on State tax collections in 2023, about 74% of business revenues were taxed at the final-sales rate of 4.5% (including County surcharges), and 24% of revenues were taxed at the intermediate-sales rate of 0.5% (Data Book 2023, Table 9.38). These percentages and rates provide estimated excises taxes of $119 million per year [(revenues of $3,440 million × 74% x 4.5%) + (revenues of $3,440 million 26% x 0.5%) = $119 million].

— Profits: $340 million per year (low estimate)

Profits were estimated at 10% of Revenue.

— Payroll: $860 million (low estimate)

Total payroll of businesses in the Project Area exceeded $1,773 million in 2017 (see Table 3). This estimate is low because payroll paid by businesses in Halimaile, Kēōkea, Kakena, Māʻalaea and Olinda are excluded to avoid revealing information about individual companies. No adjustment was make in these figures to adjust for these omissions or for economic growth from 2017 to 2020.

Adjusting for 2017-to-2025 inflation, the payroll increases to about $2,264 million (27.7% increase).

Under the No Action Alternative, the lost revenues in the Project Area are expected to eventually exceed $860 million (38% of $2,264 million). Based on Table 3, the sectors generating the greatest payroll would be Retail, Health Care, and Accommodation and Food Services.

— Employees: 23,810

About 62,666 employees lived in the Project Area during the 2018-to-2022 period (see Table 4).

Under the No Action Alternative, about 23,810 fewer employees eventually would live in the Project Area than would otherwise be the case (38% of 62,666 employees). The distribution of lost employment by sector would be similar to that shown in Table 4 for the 2018-to-2022 period.

— Population: 47,350

About 124,607 people lived in the Project Area in 2020 (see Table 1).

Under the No Action Alternative, about 47,350 fewer people eventually would live in the Project Area than would otherwise be the case (38% of 124,607 people).

— Households: 16,110

About 42,384 households lived in the Project Area during in 2020 (see Table 1).

Under the No Action Alternative, about 16,110 fewer households eventually would live in the Project Area than would otherwise be the case (38% of 42,384 households).

For these calculations, it is assumed that the future economic benefits that would be lost under the No Action Alternative would be lost to the entire island and would not simply relocate to other communities on Maui. Relocation of future residents and businesses to other communities is regarded as unlikely because of a lack of sufficient water development in these other communities to accommodate growth beyond what is already planned.

Calculation of Lost Property Taxes

Based on 2024 property assessments and 2024/2025 tax rates, the Project Area will generate more than $158 billion in 2025:

Classification	Assessment	Tax Rate per $1,000	Tax
Owner-occupied (1)	$ 13,448,527,900	*$ 1.80*	$ 24,207,350
Non owner-occupied (1)	$ 9,114,669,300	*$ 5.87*	$ 53,503,109
Apartment	$ 435,152,700	$ 3.50	$ 1,523,034
Hotel/Resort	$ 1,729,455,700	$ 11.75	$ 20,321,104
Timeshare	$ 159,763,900	$ 14.60	$ 2,332,553
Transient/short-term rental (1)	$ 712,275,000	*$ 12.50*	$ 8,903,438
Long Term Rental (1)	$ 1,431,167,200	$ 3.00	$ 4,293,502
Agricultural	$ 922,769,300	$ 5.74	$ 5,296,696
Conservation	$ 36,856,500	$ 6.43	$ 236,987
Commercial	$ 1,216,217,800	$ 6.05	$ 7,358,118
Industrial	$ 2,058,389,400	$ 7.05	$ 14,511,645
Commercialized residential (1)	$ 193,833,600	*$ 4.00*	$ 775,334
Multiple classes (2)	$ 2,922,887,900	$ 5.00	$ 14,614,440
Total	**$ 34,381,966,200**		**$ 157,877,310**

(1) The calculation of taxes is based on the tax rate for the lowest tier (i.e., below $1 million in assessed value).

(2) The calculation of taxes is based on an estimated average tax rate of $5 per $1,000.

The analysis of lost benefits is based on 2020 conditions but expressed in 2025 dollars. Thus, the above assessment is high in that it includes the value of upzoning and improvements that occurred after 2020. Also, it includes some large parcels that extend outside the Project Area. However, the estimate of property taxes is low since, as indicated, the calculations use the tax rates for the lowest tier of residential properties (i.e., the tax rates for Tier 1 properties which have a value of less than $1 million dollars). Tier 2 ($1million to $3 million) and Tier 3 (over $3 million) residential properties are taxed at significantly higher rates. No adjustment was made to convert 2024 assessed values to 2025 values since the increase in value would be small.

Under the No Action Alternative, about $60 million less in property taxes eventually would be collected annually than would otherwise be the case (38% of $157,877,310).

Calculation of Lost Economic Benefits

Compared to what would otherwise occur if the demand for water would be met in the Project Area, the No Action Alternative leads to the following low estimates of lost economic benefits (2025 dollars):

Profits	$ 344 million per year	
Payroll	$ 860 million per year	
Excise Taxes	$ 119 million	
Property taxes	$ 60 million per year	
Total	$ 1,383 million per year	(low)

The estimates of profits, excise taxes and payroll are low because the source data excludes many business in the Project Area (see above). Also, the property taxes are low because the lowest tier tax rates are used in the calculations. Even so, the eventually lost economic benefits would be substantial.

The lost benefits are projected to start in 2035 when delivery of water would begin from the water improvements that would otherwise be the case, grow linearly for about 15 years, then level off when the additional supply of water would otherwise be fully utilized.

j. Time-Stream of Monetized Benefits and Costs

For each alternative, a table was constructed showing the annual time-stream of (1) capital expenditures,(2) R&R expenditure, (3) O&M expenditures, (4) monetized benefit-cost impacts that deviate from the Baseline Alternative, and (5) annual sum of these items.

k. Calculation of Present and Annual Values

Present Values

For each alternative, the annual sums of benefits and costs were discounted to convert them to 2025 values using the real 2% discount rate appropriate for Maui, then these discounted amounts were summed to calculate the PV of the time-stream of benefits and costs. To simplify comparisons, the PV of each alternative was then compared to that of the Baseline Alternative (CBA-1).

The least expensive options for expanding the County water system are the ones with low PV costs.

Annualized Values

A PV of a long time-stream of monetary amounts can be very large. However, a PV can be translated to Annualized Value (**AV**) which is easier to comprehend. The two are similar to a mortgage amount and its corresponding monthly mortgage payments at a specified interest rate and duration. The PVs and AVs will provide the same ranking of alternatives.

For the four discount rates and the 2025-to-2090 period specified above, the conversions are as follows:

— 1% discount rate: AV = 2.056% × PV

— 2% discount rate: AV = 2.688% × PV

— 2.5% discount rate: AV = 3.034% × PV

— 4% discount rate: AV = 4.159% × PV

For example, at the 2% discount rate, a PV of $1 billion translates to a AV of $26.88 million (2.688% × $1 billion). In other words, an expenditure of $26.88 million per year from 2025 to 2090 results in a PV of $1 billion.

l. Sensitivity Analysis

A sensitivity analysis was conducted to determine how the PVs may change due to reasonable changes in the discount rate. The purpose was to identify the options that are "robust" (i.e., they have low PV costs relative to the other alternatives even when assumptions are changed).

m. Lowest Water Rates

The alternative that would provide the lowest water rates on Maui is the one that provides the lowest PV cost based only on expenditures by the MDWS. County expenditures on capital, R&R and O&M would be included in the analysis, but other benefits and costs would be excluded (e.g. lost benefits due to a reduction in crop farming).

n. Adjustments for Non-Monetized Impacts

The ranking of alternatives was revisited taking into account impacts that were not monetized and possible risks (e.g. prolonged droughts).

8. FINDINGS

Calculations of PV for the 10 alternatives are summarized in Table 5, and the calculations for each alternative are given in Tables 6 through 15. The upper part of Table 5 shows the PV findings, and the lower part shows the cost savings relative to the Baseline Alternative (CBA-1). The calculations for the Baseline Alternative are shown in *black italics*. The calculations using the 2% discount rate, which is the appropriate rate for Maui, is shown in **bold**. PVs that are lower than that for the Baseline are shown in **green**. PVs that are higher than that for the Baseline are shown in red. Parentheses "( )" indicate a negative number.

a. Economic Benefits of Accommodating Growth

As indicated in Table 5, the No Action Alternative (CBA-10) has a very high PV and AV costs due to the loss of future economic benefits (a PV of nearly $31 billion at the 2% discount rate and an AV exceeding $830 million per year). These lost benefits include future profits, excise taxes, payroll and property taxes. However, this estimate is low because estimates of profits, excise taxes and payroll exclude many business in the Project Area (see Subsection 10.h). Also, the property taxes are low because the lowest tier tax rates are used in the calculations.

The very substantial loss of future economic benefits under the No Action Alternative (CBA-10) indicates that the development of the County water system to accommodate planned population and economic growth would be beneficial.

Additional benefits would be lost due to not accommodating population and economic growth, including but not limited to a wider selection of goods, services and employment opportunities. At the same time additional crowding, congestion, changes in the character of the communities, etc. would be avoided. There are varying opinions on these additional benefits and costs related to growth . Valuing them is beyond the scope of this report.

b. Alternatives with Low PV Costs

The alternative with the lowest PV cost is Ha‘ikū Groundwater (CBA-1, the Baseline Alternative, A). At the 2% discount rate the estimated PV and AV cost are $1,410 million $37.9 million per year, respectively (AV = 2.688% × PV). Alternative CBA-4, Reallocate Ag Water (K), is a close second with a PV cost of $ 1,428 million and a AV $38.4 million per year at the 2% discount rate, or $18 million ($0.5 million per year) higher than that for the Baseline Alternative. At higher discount rates, the CBA-4 becomes slightly less expensive than the Baseline Alternative.

These findings are robust: all other alternatives are much more expensive.

c. Alternative Providing the Lowest Water Rates

The alternative with the lowest PV of expenditures by the MDWS will result in the lowest County water rates. This alternative is found by recalculating the PV costs using just the expenditures by the MDWS while ignoring the future loss of farm-related economic benefits due to reallocating ditch water from future farming in Central Maui to the County water system. The affected alternatives are CBA-3, CBA-4, CBA-6, CBA-7, CBA-8 and CBA-9.

The recalculated PV costs are as follows:

	PV ($ millions)	PV Relative to Baseline
CBA-1: Ha'ikū Groundwater (Baseline, A)	***$ 1,410***	***$ -***
CBA-2: Makawao, Waihee and Ha'ikū Groundwater (B+I+A)	$ 1,621	$ (211)
CBA-3: Wailoa Ditch, High Flows (J)	$ 1,373	$ 36
CBA-4: Wailoa Ditch, Reallocate Ag Water (K)	$ 1,214	$ 196
CBA-5: Makawao and Kama'ole Groundwater, Lower Kula System Expansion (B+L+C)	$ 1,712	$ (303)
CBA-6: Waikapu and Waihee Groundwater, Reallocate Ag Water from Wailoa Ditch (F+I+K)	$ 1,416	$ (7)
CBA-7: Waikapu and Pā'ia Groundwater, Reallocate Ag Water from Wailoa Ditch (F+K+B)	$ 1,465	$ (56)
CBA-8: Makawao and Pā'ia Groundwater, Reallocate Ag Water from Wailoa Ditch (B+K+E)	$ 1,582	$ (173)
CBA-9: Makawao and Waihee Groundwater, High Flows from Wailoa Ditch (B+I+J)	$ 1,595	$ (185)

As indicated above, Alternative CBA-4 (Wailoa Ditch, Reallocate Ag Water) would provide the lowest PV and AV costs to the MDWS: $1,214 million and $32.6 million per year (2.688% × PV). Consequently, this alternative would result in the lowest County water rates.

d. Agricultural Impacts

As mentioned, six alternatives would require reallocating ditch water from future farm operations in Central Maui to the County water system. The impact on agriculture is an important consideration when choosing a water alternative given the importance of farming in Hawai'i for food production, contribution to food self-sufficiency, green open space, a farming lifestyle, etc.

At full development of the water system, the adverse impacts on agricultural are as follows:

	CBA-3	CBA-4	CBA-6	CBA-7	CBA-8	CBA-9
Reallocated water (mgd)	12	12	6.8	5	4	4.3
Farmed acreage	2,280	2,280	1,290	950	760	820
Production (million lbs)	57.0	57.0	32.3	23.7	19.0	20.4
Revenues ($ million)	$28.5	$28.5	$16.1	$11.9	$9.5	10.2
Farm jobs	114	114	65	47	38	41
Farm payroll ($ million)	$5.0	$5.0	$2.8	$2.1	$1.7	$1.8

The alternatives with the greatest adverse impacts are CBA-3 (Wailoa Ditch, High Flows) and CBA-4 (Wailoa Ditch, Reallocate Ag Water).

In addition to the above, the reduction in the area farmed will result in a corresponding increase in unirrigated pastures in dry and windy Central Maui. This may increase wind blown dust in Central Maui, increase the risk of wildfire, and require an increase in fire-control services.

e. Risks of Using Surface Water

The alternatives that depend on surface (ditch) water are at somewhat greater risk of not supplying projected water demand for two reasons. First, the planned use of ditch water may be subject to public opposition and legal challenges which, in turn, may delay development and/or reduced the planned flow of water to be reallocated. Second, once developed, the available flow of ditch water will be low during prolonged droughts, possibly resulting in the supply of water being insufficient to meet demand.

f. Summary of Findings

Development of the County water system to accommodate planned population and economic growth would provide substantial economic benefits.

The alternative with the lowest PV cost is Haʻikū Groundwater (CBA-1, the Baseline Alternative) with Alternative CBA-4 (Wailoa Ditch, Reallocate Ag Water) a close second. These two alternatives remain the least expensive even with reasonable changes in the discount rate.

The alternative that would provide the lowest water rates is CBA-4 (Wailoa Ditch, Reallocate Ag Water). However, Alternative CBA-4 would have an adverse impact on agriculture, pose a somewhat greater risk of not supplying projected demand, and would increase wind-blown dust and wildfire risks in Central Maui.

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U.S. Census Bureau. American Community Survey 5 Year Estimate, 2016-2020.

U.S. Census Bureau. American Community Survey 5 Year Estimate, 2018-2022.

U.S. Census Bureau. Economic Census, 2017.

Table 1. Demographic Characteristics: Central and Upcountry Maui Water System Areas, 2020 and 2018–2022 Estimates

Item	Water System Area Total			Central Water System Area			Upcountry Water System Area		
	2020	2018-2022	Disparity	2020	2018-2022	Disparity	2020	2018-2022	Disparity
Population (residents)	124,607	126,510	1.53%	89,013	90,086	1.21%	35,594	36,424	2.33%
Male	61,941	62,907	1.56%	44,377	44,810	0.98%	17,564	18,097	3.03%
Female	62,666	63,603	1.50%	44,636	45,276	1.43%	18,030	18,327	1.65%
Distribution									
Male	49.71%	49.72%		49.85%	49.74%		49.35%	49.68%	
Female	50.29%	50.28%		50.15%	50.26%		50.65%	50.32%	
Population by Age									
Pre-school Age, 4 and Under	6,487	6,848	5.56%	4,658	4,636	-0.47%	1,829	2,212	20.94%
School Age, 5 to 19	22,472	22,780	1.37%	16,212	16,720	3.13%	6,260	6,060	-3.19%
Working Age, 20 to 64	71,720	72,835	1.55%	51,484	51,765	0.55%	20,236	21,070	4.12%
Retirement Age, 65 and Over	23,928	24,047	0.50%	16,659	16,965	1.84%	7,269	7,082	-2.57%
Distribution									
Pre-school Age, 4 and Under	5.21%	5.41%		5.23%	5.15%		5.14%	6.07%	
School Age, 5 to 17	18.03%	18.01%		18.21%	18.56%		17.59%	16.64%	
Working Age, 18 to 64	57.56%	57.57%		57.84%	57.46%		56.85%	57.85%	
Retirement Age, 65 and Over	19.20%	19.01%		18.72%	18.83%		20.42%	19.44%	
Median Age	42	43	2.38%	42	42	0.00%	42	44	4.76%
Race									
White alone	40,668	39,876	-1.95%	25,068	24,449	-2.47%	15,600	15,427	-1.11%
Black or African American alone	797	1,139	42.91%	610	1,013	66.07%	187	126	-32.62%
American Indian and Alaska Native alone	573	459	-19.90%	403	237	-41.19%	170	222	30.59%
Asian alone	34,788	37,492	7.77%	29,834	31,468	5.48%	4,954	6,024	21.60%
Native Hawaiian and Other Pacific Islander alone	13,729	11,783	-14.17%	10,295	8,501	-17.43%	3,434	3,282	-4.43%
Some Other Race alone	2,662	2,800	5.18%	1,953	1,880	-3.74%	709	920	29.76%
Two or More Races	31,390	32,961	5.00%	20,850	22,538	8.10%	10,540	10,423	-1.11%
Distribution									
White alone	32.64%	31.52%		28.16%	27.14%		43.83%	42.35%	
Black or African American alone	0.64%	0.90%		0.69%	1.12%		0.53%	0.35%	
American Indian and Alaska Native alone	0.46%	0.36%		0.45%	0.26%		0.48%	0.61%	
Asian alone	27.92%	29.64%		33.52%	34.93%		13.92%	16.54%	
Native Hawaiian and Other Pacific Islander alone	11.02%	9.31%		11.57%	9.44%		9.65%	9.01%	
Some Other Race alone	2.14%	2.21%		2.19%	2.09%		1.99%	2.53%	
Two or More Races	25.19%	26.05%		23.42%	25.02%		29.61%	28.62%	

Table 1. Demographic Characteristics: Central and Upcountry Maui Water System Areas: 2020 and 2018–2022 Estimates (continued)

Item	Water System Areas Total			Central Water System Area			Upcountry Water System Area		
	2020	2018-2022	Disparity	2020	2018-2022	Disparity	2020	2018-2022	Disparity
Households	42,384	42,323	-0.14%	29,566	29,615	0.17%	12,818	12,708	-0.86%
Average Size	2.90	2.94	1.38%	2.95	2.97	0.68%	2.77	2.86	3.25%
Tenure									
Owner-occupied households	25,104	28294	12.71%	17,422	19,714	13.16%	7,682	8,580	11.69%
Renter-occupied households	17,280	14029	-18.81%	12,144	9,901	-18.47%	5,136	4,128	-19.63%
Distribution									
Homeowners	59.23%	66.85%		58.93%	66.57%		59.93%	67.52%	
Renters	40.77%	33.15%		41.07%	33.43%		40.07%	32.48%	
Household Type									
Households with householder's own children	10,585	11,294	6.70%	7,473	8,007	7.15%	3,112	3,287	5.62%
Households without householder's own children	31,799	31,029	-2.42%	22,093	21,608	-2.20%	9,706	9,421	-2.94%
Single householder with no partner present	18,543	17,423	-6.04%	12,980	12,590	-3.00%	5,563	4,833	-13.12%
Householder with other adult present	23,841	24,900	4.44%	16,586	17,025	2.65%	7,255	7,875	8.55%
Distribution									
Households with householder's own children	24.97%	26.69%		25.28%	27.04%		24.28%	25.87%	
Households without householder's own children	75.03%	73.31%		74.72%	72.96%		75.72%	74.13%	
Single householder with no partner present	43.75%	41.17%		43.90%	42.51%		43.40%	38.03%	
Householder with other adult present	56.25%	58.83%		56.10%	57.49%		56.60%	61.97%	
Housing Units	51,469	52,718	2.43%	37,626	39,135	4.01%	13,843	13,583	-1.88%
Occupied	42,384	42,323	-0.14%	29,566	29,615	0.17%	12,818	12,708	-0.86%
Vacant	9,085	10,395	14.42%	8,060	9,520	18.11%	1,025	875	-14.63%
For seasonal, recreational, or occasional use	5,287	4,317	-18.35%	4,931	4,035	-18.17%	356	282	-20.79%
Distribution									
Occupied	82.35%	80.28%		78.58%	75.67%		92.60%	93.56%	
Vacant	17.65%	19.72%		21.42%	24.33%		7.40%	6.44%	
For seasonal, recreational, or occasional use	10.27%	8.19%		13.11%	10.31%		2.57%	2.08%	

Sources:

U.S. Census Bureau. Decennial Census. 2020.

U.S. Census Bureau. American Community Survey 5 Year Estimate, 2018-2022.

Table 2. Income and Education: Central and Upcountry Maui Water System Areas, 2016–2020 and 2018–2022 Estimates

Item	Water System Area Total			Central Water System Area			Upcountry Water System Area		
	2016-2020	2018-2022	Disparity	2016-2020	2018-2022	Disparity	2016-2020	2018-2022	Disparity
Median Annual Income									
Individuals 25 Years and over with Earnings	$ 45,171.50	$ 52,002.00	15.12%	$ 44,311.00	$ 52,235.00	17.88%	$ 47,667.00	$ 51,769.00	8.61%
Educational Attainment, 25 Years and Older									
Less than 9th Grade	3,168	3,167	-0.03%	2,660	2,619	-1.54%	508	548	7.87%
Grades 9 to 12, No Diploma	3,911	3,815	-2.45%	2,509	2,470	-1.55%	1,402	1,345	-4.07%
High School Graduate (no college, includes equivalency)	27,655	26,077	-5.71%	20,320	18,983	-6.58%	7,335	7,094	-3.29%
Some College, No Degree	21,341	20,566	-3.63%	15,581	14,277	-8.37%	5,760	6,289	9.18%
Associate Degree	9,217	8,725	-5.34%	6,482	6,282	-3.09%	2,735	2,443	-10.68%
College, Bachelor's Degree	17,695	18,658	5.44%	11,775	13,268	12.68%	5,920	5,390	-8.95%
Graduate or Professional Degree	9,067	9,385	3.51%	6,103	5,833	-4.42%	2,964	3,552	19.84%
Total Population, Age 25 and Older	92,054	90,393	-1.80%	65,430	63,732	-2.60%	26,624	26,661	0.14%
Distrbution									
Less than 9th Grade	3.44%	3.50%		4.07%	4.11%		1.91%	2.06%	
Grades 9 to 12, No Diploma	4.25%	4.22%		3.83%	3.88%		5.27%	5.04%	
High School Graduate, No College	30.04%	28.85%		31.06%	29.79%		27.55%	26.61%	
Some College, No Degree	23.18%	22.75%		23.81%	22.40%		21.63%	23.59%	
Associate Degree	10.01%	9.65%		9.91%	9.86%		10.27%	9.16%	
College, Bachelor's Degree	19.22%	20.64%		18.00%	20.82%		22.24%	20.22%	
Graduate or Professional Degree	9.85%	10.38%		9.33%	9.15%		11.13%	13.32%	
Language Spoken (5 years and older)									
English Only	95,831	94,554	-1.33%	66,492	64,624	-2.81%	29,339	29,930	2.01%
Spanish	3,579	2,933	-18.05%	2,633	2,161	-17.93%	946	772	-18.39%
Other Indo-European	1,522	1,733	13.86%	971	1,100	13.29%	551	633	14.88%
Asian and Pacific Island languages	20,861	20,009	-4.08%	18,074	17,332	-4.11%	2,787	2,677	-3.95%
Others	364	433	18.96%	226	233	3.10%	138	200	44.93%
Total Population, Age 5 and Older	122,157	119,662	-2.04%	88,396	85,450	-3.33%	33,761	34,212	1.34%
Distribution									
English Only	78.45%	79.02%		75.22%	75.63%		86.90%	87.48%	
Spanish	2.93%	2.45%		2.98%	2.53%		2.80%	2.26%	
Other Indo-European	1.25%	1.45%		1.10%	1.29%		1.63%	1.85%	
Asian and Pacific Island languages	17.08%	16.72%		20.45%	20.28%		8.26%	7.82%	
Others	0.30%	0.36%		0.26%	0.27%		0.41%	0.58%	

Sources:

U.S. Census Bureau. American Community Survey 5 Year Estimate, 2016-2020.

U.S. Census Bureau. American Community Survey 5 Year Estimate, 2018-2022.

Table 3. Economic Indicators: Central and Upcountry Maui Water Systems, 2017 Estimates

Sector	Water System Area Totals			Central Water System Area			Upcountry Water System Area		
	Number of establish-ments	Sales, Value of Shipments, or Revenue ($1000)	Annual Payroll ($1000)	Number of establish-ments	Sales, Value of Shipments, or Revenue ($1000)	Annual Payroll ($1000)	Number of establish-ments	Sales, Value of Shipments, or Revenue ($1000)	Annual Payroll ($1000)
Wholesale	123	$ 778,405	$ 58,169	100	$ 755,467	$ 54,580	23	$ 22,938	$ 3,589
Retail	478	$ 2,282,282	$ 229,717	414	$ 2,144,708	$ 215,352	64	$ 137,574	$ 14,365
Transport and Warehouse	77	$ 419,483	$ 88,117	71	$ 416,570	$ 87,245	6	$ 2,913	$ 872
Information	44	$ -	$ 31,535	41	$ -	$ 30,404	3	$ -	$ 1,131
Real Estate and Rentals	167	$ 193,542	$ 32,260	152	$ 188,146	$ 31,290	15	$ 5,396	$ 970
Services	577	$ 302,880	$ 111,466	424	$ 266,121	$ 98,731	153	$ 36,759	$ 12,735
Health Care	597	$ 1,567,335	$ 684,502	564	$ 1,552,968	$ 678,106	33	$ 14,367	$ 6,396
Arts, Entertainment, and Recreation	101	$ 105,138	$ 29,754	61	$ 80,696	$ 23,276	40	$ 24,442	$ 6,478
Accomodation and Food Service	227	$ 1,120,289	$ 309,364	210	$ 1,103,274	$ 304,619	17	$ 17,015	$ 4,745
Finance and Insurance	115	$ -	$ 36,459	105	$ -	$ 34,318	10	$ -	$ 2,141
Education	26	$ 7,681	$ 2,141	17	$ 3,928	$ 1,050	9	$ 3,753	$ 1,091
Management and Remediation	228	$ 312,498	$ 159,937	181	$ 279,489	$ 146,145	47	$ 33,009	$ 13,792
Totals:	2760	$ 7,089,533	$ 1,773,421	2340	$ 6,791,367	$ 1,705,116	420	$ 298,166	$ 68,305

Sources:

U.S. Census Bureau. Economic Census, 2017.

Notes:

2017 data not available for Hali'imaile, Keokea, Makena, Ma'alaea, or Olinda CDPs

Some regions do not provide data to avoid revealing information about individual companies

Table 4. Number of Employees by Sector: Central and Upcountry Maui Water Systems, 2016-2020 and 2018-2022 Estimates

Sector	Water System Area Totals			Central Water System Area			Upcountry Water System Area		
	2016-2020	2018-2022	Disparity	2016-2020	2018-2022	Disparity	2016-2020	2018-2022	Disparity
Agriculture, forestry, fishing and hunting, and mining	780	985	26.28%	290	245	-15.52%	490	740	51.02%
Construction	5,034	5,105	1.41%	3113	3,243	4.18%	1,921	1,862	-3.07%
Manufacturing	1,736	1,500	-13.59%	1063	862	-18.91%	673	638	-5.20%
Wholesale trade	1,706	1,151	-32.53%	1273	848	-33.39%	433	303	-30.02%
Retail trade	7,502	7,844	4.56%	5588	6,012	7.59%	1,914	1,832	-4.28%
Transportation and warehousing, and utilities	3,800	3,890	2.37%	2780	2,977	7.09%	1,020	913	-10.49%
Information	962	804	-16.42%	647	505	-21.95%	315	299	-5.08%
Finance and insurance, and real estate and rental and leasing	5,245	4,096	-21.91%	3821	2,901	-24.08%	1,424	1,195	-16.08%
Professional, scientific, and management, and administrative and waste management services	6,208	6,490	4.54%	4358	4,623	6.08%	1,850	1,867	0.92%
Educational services, and health care and social assistance	12,224	12,150	-0.61%	8505	8,517	0.14%	3,719	3,633	-2.31%
Arts, entertainment, and recreation, and accommodation and food services	12,730	12,252	-3.75%	10293	9,426	-8.42%	2,437	2,826	15.96%
Other services, except public administration	3,213	3,074	-4.33%	2579	2,368	-8.18%	634	706	11.36%
Public administration	3,997	3,325	-16.81%	2746	2,467	-10.16%	1,251	858	-31.41%
Totals:	65,137	62,666		47,056	44,994		18,081	17,672	

Sources:

U.S. Census Bureau. American Community Survey 5 Year Estimate, 2016-2020.

U.S. Census Bureau. American Community Survey 5 Year Estimate, 2018-2022.

Table 5. Summary of Present Values and Cost Savings

($ millions)

Present Values

Alternataive	Discount Rates 1.0%	2.0%	2.5%	4.0%
CBA-1: Haiku Groundwater (Baseline, A)	*$ 1,739*	***$ 1,410***	*$ 1,282*	*$ 998*
CBA-2: Makawao, Waihee and Haiku Groundwater (B+I+A)	$ 1,961	**$ 1,621**	$ 1,487	$ 1,184
CBA-3: Wailoa Ditch, High Flows (J)	$ 2,017	**$ 1,588**	$ 1,425	$ 1,070
CBA-4: Wailoa Ditch, Reallocate Ag Water (K)	$ 1,837	**$ 1,428**	$ 1,274	$ 940
CBA-5: Makawao and Kamaole Groundwater, Lower Kula System Expansion (B+L+C)	$ 2,073	**$ 1,712**	$ 1,571	$ 1,250
CBA-6: Waikapu and Waihee Groundwater, Reallocate Ag Water from Wailoa Ditch (F+I+K)	$ 1,906	**$ 1,538**	$ 1,396	$ 1,081
CBA-7: Waikapu and Paia Groundwater, Reallocate Ag Water from Wailoa Ditch (F+K+B)	$ 1,926	**$ 1,555**	$ 1,412	$ 1,094
CBA-8: Makawao and Paia Groundwater, Reallocate Ag Water from Wailoa Ditch (B+K+E)	$ 2,033	**$ 1,654**	$ 1,507	$ 1,178
CBA-9: Makawao and Waihee Groundwater, High Flows from Wailoa Ditch (B+I+J)	$ 2,048	**$ 1,672**	$ 1,526	$ 1,198
CBA-10: No Action (lost economic benefits, partial)	$ 45,051	**$ 30,995**	$ 25,934	$ 15,697

Cost Savings Relative to Baseline (CBA-1)

Alternataive	Discount Rates 1.0%	2.0%	2.5%	4.0%
CBA-1: Haiku Groundwater (Baseline, A)	*$ -*	***$ -***	*$ -*	*$ -*
CBA-2: Makawao, Waihee and Haiku Groundwater (B+I+A)	$ (222)	**$ (211)**	$ (205)	$ (185)
CBA-3: Wailoa Ditch, High Flows (J)	$ (278)	$ (178)	$ (143)	$ (71)
CBA-4: Wailoa Ditch, Reallocate Ag Water (K)	$ (98)	**$ (18)**	$ 9	$ 58
CBA-5: Makawao and Kamaole Groundwater, Lower Kula System Expansion (B+L+C)	$ (334)	**$ (303)**	$ (288)	$ (251)
CBA-6: Waikapu and Waihee Groundwater, Reallocate Ag Water from Wailoa Ditch (F+I+K)	$ (166)	**$ (128)**	$ (114)	$ (83)
CBA-7: Waikapu and Paia Groundwater, Reallocate Ag Water from Wailoa Ditch (F+K+B)	$ (187)	**$ (145)**	$ (129)	$ (95)
CBA-8: Makawao and Paia Groundwater, Reallocate Ag Water from Wailoa Ditch (B+K+E)	$ (294)	**$ (244)**	$ (224)	$ (179)
CBA-9: Makawao and Waihee Groundwater, High Flows from Wailoa Ditch (B+I+J)	$ (308)	**$ (262)**	$ (243)	$ (200)
CBA-10: No Action (lost economic benefits, partial)	$ (43,312)	**$ (29,585)**	$ (24,651)	$ (14,699)

Discount Rates

1%: a low rate consistent with future inflation of construction and O&M costs exceeding general inflation by about 1% per year

2%: the real discount rate for long-term Maui County projects

2.5%: the real discount rate for long-term Federal projects

4%: a high rate consistent with uncertainty over costs and impacts far into the future

Formating

Black italics: calculations for the Baseline Alternative

Bold: calculations for the 2% discount rate, which is appropriate for Maui

Bold green: PVs that are lower than that for the Baseline

Red: PVs that are greater than that for the Baseline

( ): negative numbers

Table 6. CBA-1: Haiku Groundwater (Baseline, A)

Costs		
Capital	$	972.0
R&R	$	109.0
O&M	$	21.4

Discount Rate	2.0%
Total PV	**$ 1,409.8**
Baseline PV	$ 1,409.8
Cost Savings	$ -

Year	Discount Factor	Costs ($ millions)				
		Capital and R&R	O&M	Impacts vs. Baseline	Total	PV
2025	1.000	$ 7.3			$ 7.3	$ 7.3
2026	0.980	$ 7.3			$ 7.3	$ 7.1
2027	0.961	$ 52.7			$ 52.7	$ 50.6
2028	0.942	$ 52.7			$ 52.7	$ 49.6
2029	0.924	$ 52.7			$ 52.7	$ 48.6
2030	0.906	$ 7.3			$ 7.3	$ 6.6
2031	0.888	$ 7.3			$ 7.3	$ 6.5
2032	0.871	$ 93.7			$ 93.7	$ 81.6
2033	0.853	$ 86.4			$ 86.4	$ 73.7
2034	0.837	$ 86.4			$ 86.4	$ 72.3
2035	0.820	$ 86.4	$ 3.1		$ 89.5	$ 73.4
2036	0.804	$ 86.4	$ 6.1		$ 92.5	$ 74.4
2037	0.788	$ 86.4	$ 9.2		$ 95.6	$ 75.4
2038	0.773	$ 86.4	$ 12.2		$ 98.6	$ 76.2
2039	0.758	$ 86.4	$ 15.3		$ 101.7	$ 77.1
2040	0.743	$ 86.4	$ 18.3		$ 104.7	$ 77.8
2041	0.728		$ 21.4		$ 21.4	$ 15.6
2042	0.714		$ 21.4		$ 21.4	$ 15.3
2043	0.700		$ 21.4		$ 21.4	$ 15.0
2044	0.686		$ 21.4		$ 21.4	$ 14.7
2045	0.673		$ 21.4		$ 21.4	$ 14.4
2046	0.660		$ 21.4		$ 21.4	$ 14.1
2047	0.647		$ 21.4		$ 21.4	$ 13.8
2048	0.634		$ 21.4		$ 21.4	$ 13.6
2049	0.622		$ 21.4		$ 21.4	$ 13.3
2050	0.610		$ 21.4		$ 21.4	$ 13.0
2051	0.598		$ 21.4		$ 21.4	$ 12.8
2052	0.586		$ 21.4		$ 21.4	$ 12.5
2053	0.574		$ 21.4		$ 21.4	$ 12.3
2054	0.563		$ 21.4		$ 21.4	$ 12.1
2055	0.552		$ 21.4		$ 21.4	$ 11.8
2056	0.541		$ 21.4		$ 21.4	$ 11.6
2057	0.531		$ 21.4		$ 21.4	$ 11.4
2058	0.520		$ 21.4		$ 21.4	$ 11.1
2059	0.510		$ 21.4		$ 21.4	$ 10.9
2060	0.500	$ 18.2	$ 21.4		$ 39.6	$ 19.8
2061	0.490	$ 18.2	$ 21.4		$ 39.6	$ 19.4
2062	0.481	$ 18.2	$ 21.4		$ 39.6	$ 19.0
2063	0.471	$ 18.2	$ 21.4		$ 39.6	$ 18.6

Table 6. CBA-1: Haiku Groundwater (Baseline, A)

Costs			**Discount Rate**		2.0%
Capital	$	972.0	**Total PV**	**$**	**1,409.8**
R&R	$	109.0	**Baseline PV**	$	1,409.8
O&M	$	21.4	**Cost Savings**	$	-

Year	Discount Factor	Costs ($ millions)				
		Capital and R&R	O&M	Impacts vs. Baseline	Total	PV
2064	0.462	$ 18.2	$ 21.4		$ 39.6	$ 18.3
2065	0.453	$ 18.2	$ 21.4		$ 39.6	$ 17.9
2066	0.444		$ 21.4		$ 21.4	$ 9.5
2067	0.435		$ 21.4		$ 21.4	$ 9.3
2068	0.427		$ 21.4		$ 21.4	$ 9.1
2069	0.418		$ 21.4		$ 21.4	$ 9.0
2070	0.410		$ 21.4		$ 21.4	$ 8.8
2071	0.402		$ 21.4		$ 21.4	$ 8.6
2072	0.394		$ 21.4		$ 21.4	$ 8.4
2073	0.387		$ 21.4		$ 21.4	$ 8.3
2074	0.379		$ 21.4		$ 21.4	$ 8.1
2075	0.372		$ 21.4		$ 21.4	$ 8.0
2076	0.364		$ 21.4		$ 21.4	$ 7.8
2077	0.357		$ 21.4		$ 21.4	$ 7.6
2078	0.350		$ 21.4		$ 21.4	$ 7.5
2079	0.343		$ 21.4		$ 21.4	$ 7.3
2080	0.337		$ 21.4		$ 21.4	$ 7.2
2081	0.330		$ 21.4		$ 21.4	$ 7.1
2082	0.323		$ 21.4		$ 21.4	$ 6.9
2083	0.317		$ 21.4		$ 21.4	$ 6.8
2084	0.311		$ 21.4		$ 21.4	$ 6.7
2085	0.305		$ 21.4		$ 21.4	$ 6.5
2086	0.299		$ 21.4		$ 21.4	$ 6.4
2087	0.293		$ 21.4		$ 21.4	$ 6.3
2088	0.287		$ 21.4		$ 21.4	$ 6.1
2089	0.282		$ 21.4		$ 21.4	$ 6.0
2090	0.276		$ 21.4		$ 21.4	$ 5.9
Total		$ 1,081.0	$ 1,134.2	$ -	$ 2,215.2	$ 1,409.8

Table 7. CBA-2: Makawao, Waihee and Haiku Groundwater (B + I + A)

Costs			**Discount Rate**	2.0%
Capital	$	1,259.0	**Total PV**	**$ 1,620.6**
R&R	$	124.0	**Baseline PV**	$ 1,409.8
O&M	$	20.0	**Cost Savings**	$ (210.8)

Year	Discount Factor	Costs ($ millions)				
		Capital and R&R	O&M	Impacts vs. Baseline	Total	PV
2025	1.000	$ 9.4			$ 9.4	$ 9.4
2026	0.980	$ 9.4			$ 9.4	$ 9.3
2027	0.961	$ 68.2			$ 68.2	$ 65.5
2028	0.942	$ 68.2			$ 68.2	$ 64.3
2029	0.924	$ 68.2			$ 68.2	$ 63.0
2030	0.906	$ 9.4			$ 9.4	$ 8.6
2031	0.888	$ 9.4			$ 9.4	$ 8.4
2032	0.871	$ 121.4			$ 121.4	$ 105.6
2033	0.853	$ 111.9			$ 111.9	$ 95.5
2034	0.837	$ 111.9			$ 111.9	$ 93.6
2035	0.820	$ 111.9	$ 2.9		$ 114.8	$ 94.2
2036	0.804	$ 111.9	$ 5.7		$ 117.6	$ 94.6
2037	0.788	$ 111.9	$ 8.6		$ 120.5	$ 95.0
2038	0.773	$ 111.9	$ 11.4		$ 123.4	$ 95.4
2039	0.758	$ 111.9	$ 14.3		$ 126.2	$ 95.7
2040	0.743	$ 111.9	$ 17.2		$ 129.1	$ 95.9
2041	0.728		$ 20.0		$ 20.0	$ 14.6
2042	0.714		$ 20.0		$ 20.0	$ 14.3
2043	0.700		$ 20.0		$ 20.0	$ 14.0
2044	0.686		$ 20.0		$ 20.0	$ 13.7
2045	0.673		$ 20.0		$ 20.0	$ 13.5
2046	0.660		$ 20.0		$ 20.0	$ 13.2
2047	0.647		$ 20.0		$ 20.0	$ 13.0
2048	0.634		$ 20.0		$ 20.0	$ 12.7
2049	0.622		$ 20.0		$ 20.0	$ 12.5
2050	0.610		$ 20.0		$ 20.0	$ 12.2
2051	0.598		$ 20.0		$ 20.0	$ 12.0
2052	0.586		$ 20.0		$ 20.0	$ 11.7
2053	0.574		$ 20.0		$ 20.0	$ 11.5
2054	0.563		$ 20.0		$ 20.0	$ 11.3
2055	0.552		$ 20.0		$ 20.0	$ 11.1
2056	0.541		$ 20.0		$ 20.0	$ 10.8
2057	0.531		$ 20.0		$ 20.0	$ 10.6
2058	0.520		$ 20.0		$ 20.0	$ 10.4
2059	0.510		$ 20.0		$ 20.0	$ 10.2
2060	0.500	$ 20.7	$ 20.0		$ 40.7	$ 20.3
2061	0.490	$ 20.7	$ 20.0		$ 40.7	$ 19.9
2062	0.481	$ 20.7	$ 20.0		$ 40.7	$ 19.6
2063	0.471	$ 20.7	$ 20.0		$ 40.7	$ 19.2

Table 7. CBA-2: Makawao, Waihee and Haiku Groundwater (B + I + A)

Costs				
Capital	$ 1,259.0		Discount Rate	2.0%
R&R	$ 124.0		Total PV	**$ 1,620.6**
O&M	$ 20.0		Baseline PV	$ 1,409.8
			Cost Savings	$ (210.8)

Year	Discount Factor	Costs ($ millions)				
		Capital and R&R	O&M	Impacts vs. Baseline	Total	PV
2064	0.462	$ 20.7	$ 20.0		$ 40.7	$ 18.8
2065	0.453	$ 20.7	$ 20.0		$ 40.7	$ 18.4
2066	0.444		$ 20.0		$ 20.0	$ 8.9
2067	0.435		$ 20.0		$ 20.0	$ 8.7
2068	0.427		$ 20.0		$ 20.0	$ 8.5
2069	0.418		$ 20.0		$ 20.0	$ 8.4
2070	0.410		$ 20.0		$ 20.0	$ 8.2
2071	0.402		$ 20.0		$ 20.0	$ 8.1
2072	0.394		$ 20.0		$ 20.0	$ 7.9
2073	0.387		$ 20.0		$ 20.0	$ 7.7
2074	0.379		$ 20.0		$ 20.0	$ 7.6
2075	0.372		$ 20.0		$ 20.0	$ 7.4
2076	0.364		$ 20.0		$ 20.0	$ 7.3
2077	0.357		$ 20.0		$ 20.0	$ 7.2
2078	0.350		$ 20.0		$ 20.0	$ 7.0
2079	0.343		$ 20.0		$ 20.0	$ 6.9
2080	0.337		$ 20.0		$ 20.0	$ 6.7
2081	0.330		$ 20.0		$ 20.0	$ 6.6
2082	0.323		$ 20.0		$ 20.0	$ 6.5
2083	0.317		$ 20.0		$ 20.0	$ 6.4
2084	0.311		$ 20.0		$ 20.0	$ 6.2
2085	0.305		$ 20.0		$ 20.0	$ 6.1
2086	0.299		$ 20.0		$ 20.0	$ 6.0
2087	0.293		$ 20.0		$ 20.0	$ 5.9
2088	0.287		$ 20.0		$ 20.0	$ 5.8
2089	0.282		$ 20.0		$ 20.0	$ 5.6
2090	0.276		$ 20.0		$ 20.0	$ 5.5
Total		$ 1,383.0	$ 1,061.5	$ -	$ 2,444.5	$ 1,620.6

Table 8. CBA-3: Wailoa Ditch, High Flows (J)

Costs		
Capital	$	871.0
R&R	$	138.0
O&M	$	22.7

Discount Rate	2.0%
Total PV	**$ 1,588.1**
Baseline PV	$ 1,409.8
Cost Savings	$ (178.3)

Year	Discount Factor	Costs ($ millions)				
		Capital and R&R	O&M	Impacts vs. Baseline	Total	PV
2025	1.000	$ 6.5			$ 6.5	$ 6.5
2026	0.980	$ 6.5			$ 6.5	$ 6.4
2027	0.961	$ 47.2			$ 47.2	$ 45.3
2028	0.942	$ 47.2			$ 47.2	$ 44.5
2029	0.924	$ 47.2			$ 47.2	$ 43.6
2030	0.906	$ 6.5			$ 6.5	$ 5.9
2031	0.888	$ 6.5			$ 6.5	$ 5.8
2032	0.871	$ 84.0			$ 84.0	$ 73.1
2033	0.853	$ 77.4			$ 77.4	$ 66.1
2034	0.837	$ 77.4			$ 77.4	$ 64.8
2035	0.820	$ 77.4	$ 3.2	$ 4.0	$ 84.7	$ 69.5
2036	0.804	$ 77.4	$ 6.5	$ 4.8	$ 88.7	$ 71.3
2037	0.788	$ 77.4	$ 9.7	$ 5.6	$ 92.8	$ 73.1
2038	0.773	$ 77.4	$ 13.0	$ 6.4	$ 96.8	$ 74.8
2039	0.758	$ 77.4	$ 16.2	$ 7.2	$ 100.9	$ 76.4
2040	0.743	$ 77.4	$ 19.5	$ 8.0	$ 104.9	$ 77.9
2041	0.728		$ 22.7	$ 8.0	$ 30.7	$ 22.4
2042	0.714		$ 22.7	$ 8.0	$ 30.7	$ 21.9
2043	0.700		$ 22.7	$ 8.0	$ 30.7	$ 21.5
2044	0.686		$ 22.7	$ 8.0	$ 30.7	$ 21.1
2045	0.673		$ 22.7	$ 8.0	$ 30.7	$ 20.7
2046	0.660		$ 22.7	$ 8.0	$ 30.7	$ 20.3
2047	0.647		$ 22.7	$ 8.0	$ 30.7	$ 19.9
2048	0.634		$ 22.7	$ 8.0	$ 30.7	$ 19.5
2049	0.622		$ 22.7	$ 8.0	$ 30.7	$ 19.1
2050	0.610		$ 22.7	$ 8.0	$ 30.7	$ 18.7
2051	0.598		$ 22.7	$ 8.0	$ 30.7	$ 18.4
2052	0.586		$ 22.7	$ 8.0	$ 30.7	$ 18.0
2053	0.574		$ 22.7	$ 8.0	$ 30.7	$ 17.6
2054	0.563		$ 22.7	$ 8.0	$ 30.7	$ 17.3
2055	0.552		$ 22.7	$ 8.0	$ 30.7	$ 17.0
2056	0.541		$ 22.7	$ 8.0	$ 30.7	$ 16.6
2057	0.531		$ 22.7	$ 8.0	$ 30.7	$ 16.3
2058	0.520		$ 22.7	$ 8.0	$ 30.7	$ 16.0
2059	0.510		$ 22.7	$ 8.0	$ 30.7	$ 15.7
2060	0.500	$ 23.0	$ 22.7	$ 8.0	$ 53.7	$ 26.9
2061	0.490	$ 23.0	$ 22.7	$ 8.0	$ 53.7	$ 26.3
2062	0.481	$ 23.0	$ 22.7	$ 8.0	$ 53.7	$ 25.8
2063	0.471	$ 23.0	$ 22.7	$ 8.0	$ 53.7	$ 25.3

Table 8. CBA-3: Wailoa Ditch, High Flows (J)

Costs				Discount Rate		2.0%
Capital	$	871.0		**Total PV**	**$**	**1,588.1**
R&R	$	138.0		Baseline PV	$	1,409.8
O&M	$	22.7		Cost Savings	$	(178.3)

Year	Discount Factor	Costs ($ millions)				
		Capital and R&R	O&M	Impacts vs. Baseline	Total	PV
2064	0.462	$ 23.0	$ 22.7	$ 8.0	$ 53.7	$ 24.8
2065	0.453	$ 23.0	$ 22.7	$ 8.0	$ 53.7	$ 24.3
2066	0.444		$ 22.7	$ 8.0	$ 30.7	$ 13.6
2067	0.435		$ 22.7	$ 8.0	$ 30.7	$ 13.4
2068	0.427		$ 22.7	$ 8.0	$ 30.7	$ 13.1
2069	0.418		$ 22.7	$ 8.0	$ 30.7	$ 12.9
2070	0.410		$ 22.7	$ 8.0	$ 30.7	$ 12.6
2071	0.402		$ 22.7	$ 8.0	$ 30.7	$ 12.4
2072	0.394		$ 22.7	$ 8.0	$ 30.7	$ 12.1
2073	0.387		$ 22.7	$ 8.0	$ 30.7	$ 11.9
2074	0.379		$ 22.7	$ 8.0	$ 30.7	$ 11.6
2075	0.372		$ 22.7	$ 8.0	$ 30.7	$ 11.4
2076	0.364		$ 22.7	$ 8.0	$ 30.7	$ 11.2
2077	0.357		$ 22.7	$ 8.0	$ 30.7	$ 11.0
2078	0.350		$ 22.7	$ 8.0	$ 30.7	$ 10.8
2079	0.343		$ 22.7	$ 8.0	$ 30.7	$ 10.5
2080	0.337		$ 22.7	$ 8.0	$ 30.7	$ 10.3
2081	0.330		$ 22.7	$ 8.0	$ 30.7	$ 10.1
2082	0.323		$ 22.7	$ 8.0	$ 30.7	$ 9.9
2083	0.317		$ 22.7	$ 8.0	$ 30.7	$ 9.7
2084	0.311		$ 22.7	$ 8.0	$ 30.7	$ 9.5
2085	0.305		$ 22.7	$ 8.0	$ 30.7	$ 9.4
2086	0.299		$ 22.7	$ 8.0	$ 30.7	$ 9.2
2087	0.293		$ 22.7	$ 8.0	$ 30.7	$ 9.0
2088	0.287		$ 22.7	$ 8.0	$ 30.7	$ 8.8
2089	0.282		$ 22.7	$ 8.0	$ 30.7	$ 8.6
2090	0.276		$ 22.7	$ 8.0	$ 30.7	$ 8.5
Total		$ 1,009.0	$ 1,204.2	$ 436.0	$ 2,649.1	$ 1,588.1

Table 9. CBA-4: Wailoa Ditch, Reallocate Ag Water (K)

Costs		
Capital	$	695.0
R&R	$	110.0
O&M	$	22.7

Discount Rate		2.0%
Total PV	**$**	**1,428.3**
Baseline PV	$	1,409.8
Cost Savings	$	(18.5)

Year	Discount Factor	Costs ($ millions)				
		Capital and R&R	O&M	Impacts vs. Baseline	Total	PV
2025	1.000	$ 5.2			$ 5.2	$ 5.2
2026	0.980	$ 5.2			$ 5.2	$ 5.1
2027	0.961	$ 37.6			$ 37.6	$ 36.2
2028	0.942	$ 37.6			$ 37.6	$ 35.5
2029	0.924	$ 37.6			$ 37.6	$ 34.8
2030	0.906	$ 5.2			$ 5.2	$ 4.7
2031	0.888	$ 5.2			$ 5.2	$ 4.6
2032	0.871	$ 67.0			$ 67.0	$ 58.3
2033	0.853	$ 61.8			$ 61.8	$ 52.7
2034	0.837	$ 61.8			$ 61.8	$ 51.7
2035	0.820	$ 61.8	$ 3.2	$ 4.0	$ 69.0	$ 56.6
2036	0.804	$ 61.8	$ 6.5	$ 4.8	$ 73.1	$ 58.8
2037	0.788	$ 61.8	$ 9.7	$ 5.6	$ 77.1	$ 60.8
2038	0.773	$ 61.8	$ 13.0	$ 6.4	$ 81.2	$ 62.7
2039	0.758	$ 61.8	$ 16.2	$ 7.2	$ 85.2	$ 64.6
2040	0.743	$ 61.8	$ 19.5	$ 8.0	$ 89.3	$ 66.3
2041	0.728		$ 22.7	$ 8.0	$ 30.7	$ 22.4
2042	0.714		$ 22.7	$ 8.0	$ 30.7	$ 21.9
2043	0.700		$ 22.7	$ 8.0	$ 30.7	$ 21.5
2044	0.686		$ 22.7	$ 8.0	$ 30.7	$ 21.1
2045	0.673		$ 22.7	$ 8.0	$ 30.7	$ 20.7
2046	0.660		$ 22.7	$ 8.0	$ 30.7	$ 20.3
2047	0.647		$ 22.7	$ 8.0	$ 30.7	$ 19.9
2048	0.634		$ 22.7	$ 8.0	$ 30.7	$ 19.5
2049	0.622		$ 22.7	$ 8.0	$ 30.7	$ 19.1
2050	0.610		$ 22.7	$ 8.0	$ 30.7	$ 18.7
2051	0.598		$ 22.7	$ 8.0	$ 30.7	$ 18.4
2052	0.586		$ 22.7	$ 8.0	$ 30.7	$ 18.0
2053	0.574		$ 22.7	$ 8.0	$ 30.7	$ 17.6
2054	0.563		$ 22.7	$ 8.0	$ 30.7	$ 17.3
2055	0.552		$ 22.7	$ 8.0	$ 30.7	$ 17.0
2056	0.541		$ 22.7	$ 8.0	$ 30.7	$ 16.6
2057	0.531		$ 22.7	$ 8.0	$ 30.7	$ 16.3
2058	0.520		$ 22.7	$ 8.0	$ 30.7	$ 16.0
2059	0.510		$ 22.7	$ 8.0	$ 30.7	$ 15.7
2060	0.500	$ 18.3	$ 22.7	$ 8.0	$ 49.1	$ 24.5
2061	0.490	$ 18.3	$ 22.7	$ 8.0	$ 49.1	$ 24.0
2062	0.481	$ 18.3	$ 22.7	$ 8.0	$ 49.1	$ 23.6
2063	0.471	$ 18.3	$ 22.7	$ 8.0	$ 49.1	$ 23.1

Table 9. CBA-4: Wailoa Ditch, Reallocate Ag Water (K)

Costs				
Capital	$ 695.0		Discount Rate	2.0%
R&R	$ 110.0		Total PV	**$ 1,428.3**
O&M	$ 22.7		Baseline PV	$ 1,409.8
			Cost Savings	$ (18.5)

Year	Discount Factor	Costs ($ millions)				
		Capital and R&R	O&M	Impacts vs. Baseline	Total	PV
2064	0.462	$ 18.3	$ 22.7	$ 8.0	$ 49.1	$ 22.7
2065	0.453	$ 18.3	$ 22.7	$ 8.0	$ 49.1	$ 22.2
2066	0.444		$ 22.7	$ 8.0	$ 30.7	$ 13.6
2067	0.435		$ 22.7	$ 8.0	$ 30.7	$ 13.4
2068	0.427		$ 22.7	$ 8.0	$ 30.7	$ 13.1
2069	0.418		$ 22.7	$ 8.0	$ 30.7	$ 12.9
2070	0.410		$ 22.7	$ 8.0	$ 30.7	$ 12.6
2071	0.402		$ 22.7	$ 8.0	$ 30.7	$ 12.4
2072	0.394		$ 22.7	$ 8.0	$ 30.7	$ 12.1
2073	0.387		$ 22.7	$ 8.0	$ 30.7	$ 11.9
2074	0.379		$ 22.7	$ 8.0	$ 30.7	$ 11.6
2075	0.372		$ 22.7	$ 8.0	$ 30.7	$ 11.4
2076	0.364		$ 22.7	$ 8.0	$ 30.7	$ 11.2
2077	0.357		$ 22.7	$ 8.0	$ 30.7	$ 11.0
2078	0.350		$ 22.7	$ 8.0	$ 30.7	$ 10.8
2079	0.343		$ 22.7	$ 8.0	$ 30.7	$ 10.5
2080	0.337		$ 22.7	$ 8.0	$ 30.7	$ 10.3
2081	0.330		$ 22.7	$ 8.0	$ 30.7	$ 10.1
2082	0.323		$ 22.7	$ 8.0	$ 30.7	$ 9.9
2083	0.317		$ 22.7	$ 8.0	$ 30.7	$ 9.7
2084	0.311		$ 22.7	$ 8.0	$ 30.7	$ 9.5
2085	0.305		$ 22.7	$ 8.0	$ 30.7	$ 9.4
2086	0.299		$ 22.7	$ 8.0	$ 30.7	$ 9.2
2087	0.293		$ 22.7	$ 8.0	$ 30.7	$ 9.0
2088	0.287		$ 22.7	$ 8.0	$ 30.7	$ 8.8
2089	0.282		$ 22.7	$ 8.0	$ 30.7	$ 8.6
2090	0.276		$ 22.7	$ 8.0	$ 30.7	$ 8.5
Total		$ 805.0	$ 1,204.2	$ 436.0	$ 2,445.1	$ 1,428.3

Table 10. CBA-5: Makawao and Kamaole Groundwater, Lower Kula System Expansion (B + L + C)

Costs			Discount Rate	2.0%
Capital	$	1,327.0	Total PV	**$ 1,712.3**
R&R	$	134.0	Baseline PV	$ 1,409.8
O&M	$	21.2	Cost Savings	$ (302.5)

Year	Discount Factor	Costs ($ millions)				
		Capital and R&R	O&M	Impacts vs. Baseline	Total	PV
2025	1.000	$ 10.0			$ 10.0	$ 10.0
2026	0.980	$ 10.0			$ 10.0	$ 9.8
2027	0.961	$ 71.9			$ 71.9	$ 69.1
2028	0.942	$ 71.9			$ 71.9	$ 67.7
2029	0.924	$ 71.9			$ 71.9	$ 66.4
2030	0.906	$ 10.0			$ 10.0	$ 9.0
2031	0.888	$ 10.0			$ 10.0	$ 8.8
2032	0.871	$ 127.9			$ 127.9	$ 111.4
2033	0.853	$ 118.0			$ 118.0	$ 100.7
2034	0.837	$ 118.0			$ 118.0	$ 98.7
2035	0.820	$ 118.0	$ 3.0		$ 121.0	$ 99.3
2036	0.804	$ 118.0	$ 6.1		$ 124.0	$ 99.7
2037	0.788	$ 118.0	$ 9.1		$ 127.0	$ 100.2
2038	0.773	$ 118.0	$ 12.1		$ 130.1	$ 100.6
2039	0.758	$ 118.0	$ 15.2		$ 133.1	$ 100.9
2040	0.743	$ 118.0	$ 18.2		$ 136.1	$ 101.2
2041	0.728		$ 21.2		$ 21.2	$ 15.5
2042	0.714		$ 21.2		$ 21.2	$ 15.1
2043	0.700		$ 21.2		$ 21.2	$ 14.9
2044	0.686		$ 21.2		$ 21.2	$ 14.6
2045	0.673		$ 21.2		$ 21.2	$ 14.3
2046	0.660		$ 21.2		$ 21.2	$ 14.0
2047	0.647		$ 21.2		$ 21.2	$ 13.7
2048	0.634		$ 21.2		$ 21.2	$ 13.5
2049	0.622		$ 21.2		$ 21.2	$ 13.2
2050	0.610		$ 21.2		$ 21.2	$ 12.9
2051	0.598		$ 21.2		$ 21.2	$ 12.7
2052	0.586		$ 21.2		$ 21.2	$ 12.4
2053	0.574		$ 21.2		$ 21.2	$ 12.2
2054	0.563		$ 21.2		$ 21.2	$ 11.9
2055	0.552		$ 21.2		$ 21.2	$ 11.7
2056	0.541		$ 21.2		$ 21.2	$ 11.5
2057	0.531		$ 21.2		$ 21.2	$ 11.3
2058	0.520		$ 21.2		$ 21.2	$ 11.0
2059	0.510		$ 21.2		$ 21.2	$ 10.8
2060	0.500	$ 22.3	$ 21.2		$ 43.5	$ 21.8
2061	0.490	$ 22.3	$ 21.2		$ 43.5	$ 21.3
2062	0.481	$ 22.3	$ 21.2		$ 43.5	$ 20.9
2063	0.471	$ 22.3	$ 21.2		$ 43.5	$ 20.5

Table 10. CBA-5: Makawao and Kamaole Groundwater, Lower Kula System Expansion (B + L + C)

Costs			
Capital	$ 1,327.0	Discount Rate	2.0%
R&R	$ 134.0	Total PV	**$ 1,712.3**
O&M	$ 21.2	Baseline PV	$ 1,409.8
		Cost Savings	$ (302.5)

Year	Discount Factor	Costs ($ millions)				
		Capital and R&R	O&M	Impacts vs. Baseline	Total	PV
2064	0.462	$ 22.3	$ 21.2		$ 43.5	$ 20.1
2065	0.453	$ 22.3	$ 21.2		$ 43.5	$ 19.7
2066	0.444		$ 21.2		$ 21.2	$ 9.4
2067	0.435		$ 21.2		$ 21.2	$ 9.2
2068	0.427		$ 21.2		$ 21.2	$ 9.1
2069	0.418		$ 21.2		$ 21.2	$ 8.9
2070	0.410		$ 21.2		$ 21.2	$ 8.7
2071	0.402		$ 21.2		$ 21.2	$ 8.5
2072	0.394		$ 21.2		$ 21.2	$ 8.4
2073	0.387		$ 21.2		$ 21.2	$ 8.2
2074	0.379		$ 21.2		$ 21.2	$ 8.0
2075	0.372		$ 21.2		$ 21.2	$ 7.9
2076	0.364		$ 21.2		$ 21.2	$ 7.7
2077	0.357		$ 21.2		$ 21.2	$ 7.6
2078	0.350		$ 21.2		$ 21.2	$ 7.4
2079	0.343		$ 21.2		$ 21.2	$ 7.3
2080	0.337		$ 21.2		$ 21.2	$ 7.1
2081	0.330		$ 21.2		$ 21.2	$ 7.0
2082	0.323		$ 21.2		$ 21.2	$ 6.9
2083	0.317		$ 21.2		$ 21.2	$ 6.7
2084	0.311		$ 21.2		$ 21.2	$ 6.6
2085	0.305		$ 21.2		$ 21.2	$ 6.5
2086	0.299		$ 21.2		$ 21.2	$ 6.3
2087	0.293		$ 21.2		$ 21.2	$ 6.2
2088	0.287		$ 21.2		$ 21.2	$ 6.1
2089	0.282		$ 21.2		$ 21.2	$ 6.0
2090	0.276		$ 21.2		$ 21.2	$ 5.9
Total		$ 1,461.0	$ 1,124.2	$ -	$ 2,585.2	$ 1,712.3

Table 11. CBA-6: Waikapu and Waihee Groundwater, Reallocate Ag Water from Wailoa Ditch (F + I + K)

Costs		Discount Rate	2.0%
Capital	$ 1,025.0	Total PV	**$ 1,538.1**
R&R	$ 130.0	Baseline PV	$ 1,409.8
O&M	$ 19.5	Cost Savings	$ (128.3)

Year	Discount Factor	Costs ($ millions)				
		Capital and R&R	O&M	Impacts vs. Baseline	Total	PV
2025	1.000	$ 7.7			$ 7.7	$ 7.7
2026	0.980	$ 7.7			$ 7.7	$ 7.5
2027	0.961	$ 55.5			$ 55.5	$ 53.4
2028	0.942	$ 55.5			$ 55.5	$ 52.3
2029	0.924	$ 55.5			$ 55.5	$ 51.3
2030	0.906	$ 7.7			$ 7.7	$ 7.0
2031	0.888	$ 7.7			$ 7.7	$ 6.8
2032	0.871	$ 98.8			$ 98.8	$ 86.0
2033	0.853	$ 91.1			$ 91.1	$ 77.8
2034	0.837	$ 91.1			$ 91.1	$ 76.2
2035	0.820	$ 91.1	$ 2.8	$ 2.3	$ 96.2	$ 78.9
2036	0.804	$ 91.1	$ 5.6	$ 2.7	$ 99.4	$ 80.0
2037	0.788	$ 91.1	$ 8.4	$ 3.2	$ 102.7	$ 80.9
2038	0.773	$ 91.1	$ 11.2	$ 3.6	$ 105.9	$ 81.9
2039	0.758	$ 91.1	$ 14.0	$ 4.1	$ 109.2	$ 82.7
2040	0.743	$ 91.1	$ 16.8	$ 4.5	$ 112.4	$ 83.5
2041	0.728		$ 19.5	$ 4.5	$ 24.1	$ 17.5
2042	0.714		$ 19.5	$ 4.5	$ 24.1	$ 17.2
2043	0.700		$ 19.5	$ 4.5	$ 24.1	$ 16.9
2044	0.686		$ 19.5	$ 4.5	$ 24.1	$ 16.5
2045	0.673		$ 19.5	$ 4.5	$ 24.1	$ 16.2
2046	0.660		$ 19.5	$ 4.5	$ 24.1	$ 15.9
2047	0.647		$ 19.5	$ 4.5	$ 24.1	$ 15.6
2048	0.634		$ 19.5	$ 4.5	$ 24.1	$ 15.3
2049	0.622		$ 19.5	$ 4.5	$ 24.1	$ 15.0
2050	0.610		$ 19.5	$ 4.5	$ 24.1	$ 14.7
2051	0.598		$ 19.5	$ 4.5	$ 24.1	$ 14.4
2052	0.586		$ 19.5	$ 4.5	$ 24.1	$ 14.1
2053	0.574		$ 19.5	$ 4.5	$ 24.1	$ 13.8
2054	0.563		$ 19.5	$ 4.5	$ 24.1	$ 13.6
2055	0.552		$ 19.5	$ 4.5	$ 24.1	$ 13.3
2056	0.541		$ 19.5	$ 4.5	$ 24.1	$ 13.0
2057	0.531		$ 19.5	$ 4.5	$ 24.1	$ 12.8
2058	0.520		$ 19.5	$ 4.5	$ 24.1	$ 12.5
2059	0.510		$ 19.5	$ 4.5	$ 24.1	$ 12.3
2060	0.500	$ 21.7	$ 19.5	$ 4.5	$ 45.7	$ 22.9
2061	0.490	$ 21.7	$ 19.5	$ 4.5	$ 45.7	$ 22.4
2062	0.481	$ 21.7	$ 19.5	$ 4.5	$ 45.7	$ 22.0
2063	0.471	$ 21.7	$ 19.5	$ 4.5	$ 45.7	$ 21.6

Table 11. CBA-6: Waikapu and Waihee Groundwater, Reallocate Ag Water from Wailoa Ditch (F + I + K)

Costs				
Capital	$ 1,025.0		Discount Rate	2.0%
R&R	$ 130.0		Total PV	**$ 1,538.1**
O&M	$ 19.5		Baseline PV	$ 1,409.8
			Cost Savings	$ (128.3)

Year	Discount Factor	Costs ($ millions)				
		Capital and R&R	O&M	Impacts vs. Baseline	Total	PV
2064	0.462	$ 21.7	$ 19.5	$ 4.5	$ 45.7	$ 21.1
2065	0.453	$ 21.7	$ 19.5	$ 4.5	$ 45.7	$ 20.7
2066	0.444		$ 19.5	$ 4.5	$ 24.1	$ 10.7
2067	0.435		$ 19.5	$ 4.5	$ 24.1	$ 10.5
2068	0.427		$ 19.5	$ 4.5	$ 24.1	$ 10.3
2069	0.418		$ 19.5	$ 4.5	$ 24.1	$ 10.1
2070	0.410		$ 19.5	$ 4.5	$ 24.1	$ 9.9
2071	0.402		$ 19.5	$ 4.5	$ 24.1	$ 9.7
2072	0.394		$ 19.5	$ 4.5	$ 24.1	$ 9.5
2073	0.387		$ 19.5	$ 4.5	$ 24.1	$ 9.3
2074	0.379		$ 19.5	$ 4.5	$ 24.1	$ 9.1
2075	0.372		$ 19.5	$ 4.5	$ 24.1	$ 8.9
2076	0.364		$ 19.5	$ 4.5	$ 24.1	$ 8.8
2077	0.357		$ 19.5	$ 4.5	$ 24.1	$ 8.6
2078	0.350		$ 19.5	$ 4.5	$ 24.1	$ 8.4
2079	0.343		$ 19.5	$ 4.5	$ 24.1	$ 8.3
2080	0.337		$ 19.5	$ 4.5	$ 24.1	$ 8.1
2081	0.330		$ 19.5	$ 4.5	$ 24.1	$ 7.9
2082	0.323		$ 19.5	$ 4.5	$ 24.1	$ 7.8
2083	0.317		$ 19.5	$ 4.5	$ 24.1	$ 7.6
2084	0.311		$ 19.5	$ 4.5	$ 24.1	$ 7.5
2085	0.305		$ 19.5	$ 4.5	$ 24.1	$ 7.3
2086	0.299		$ 19.5	$ 4.5	$ 24.1	$ 7.2
2087	0.293		$ 19.5	$ 4.5	$ 24.1	$ 7.1
2088	0.287		$ 19.5	$ 4.5	$ 24.1	$ 6.9
2089	0.282		$ 19.5	$ 4.5	$ 24.1	$ 6.8
2090	0.276		$ 19.5	$ 4.5	$ 24.1	$ 6.6
Total		$ 1,155.0	$ 1,036.1	$ 247.0	$ 2,438.1	$ 1,538.1

Table 12. CBA-7: Waikapu and Paia Groundwater, Reallocate Ag Water from Wailoa Ditch (F + K + B)

Costs			
Capital	$ 1,040.0	Discount Rate	2.0%
R&R	$ 135.0	Total PV	**$ 1,554.9**
O&M	$ 20.9	Baseline PV	$ 1,409.8
		Cost Savings	$ (145.1)

Year	Discount Factor	Costs ($ millions) Capital and R&R	O&M	Impacts vs. Baseline	Total	PV
2025	1.000	$ 7.8			$ 7.8	$ 7.8
2026	0.980	$ 7.8			$ 7.8	$ 7.6
2027	0.961	$ 56.3			$ 56.3	$ 54.1
2028	0.942	$ 56.3			$ 56.3	$ 53.1
2029	0.924	$ 56.3			$ 56.3	$ 52.0
2030	0.906	$ 7.8			$ 7.8	$ 7.1
2031	0.888	$ 7.8			$ 7.8	$ 6.9
2032	0.871	$ 100.2			$ 100.2	$ 87.3
2033	0.853	$ 92.4			$ 92.4	$ 78.9
2034	0.837	$ 92.4			$ 92.4	$ 77.4
2035	0.820	$ 92.4	$ 3.0	$ 1.7	$ 97.1	$ 79.7
2036	0.804	$ 92.4	$ 6.0	$ 2.0	$ 100.4	$ 80.8
2037	0.788	$ 92.4	$ 8.9	$ 2.3	$ 103.7	$ 81.8
2038	0.773	$ 92.4	$ 11.9	$ 2.7	$ 107.0	$ 82.7
2039	0.758	$ 92.4	$ 14.9	$ 3.0	$ 110.4	$ 83.6
2040	0.743	$ 92.4	$ 17.9	$ 3.3	$ 113.7	$ 84.5
2041	0.728		$ 20.9	$ 3.3	$ 24.2	$ 17.6
2042	0.714		$ 20.9	$ 3.3	$ 24.2	$ 17.3
2043	0.700		$ 20.9	$ 3.3	$ 24.2	$ 17.0
2044	0.686		$ 20.9	$ 3.3	$ 24.2	$ 16.6
2045	0.673		$ 20.9	$ 3.3	$ 24.2	$ 16.3
2046	0.660		$ 20.9	$ 3.3	$ 24.2	$ 16.0
2047	0.647		$ 20.9	$ 3.3	$ 24.2	$ 15.7
2048	0.634		$ 20.9	$ 3.3	$ 24.2	$ 15.4
2049	0.622		$ 20.9	$ 3.3	$ 24.2	$ 15.1
2050	0.610		$ 20.9	$ 3.3	$ 24.2	$ 14.8
2051	0.598		$ 20.9	$ 3.3	$ 24.2	$ 14.5
2052	0.586		$ 20.9	$ 3.3	$ 24.2	$ 14.2
2053	0.574		$ 20.9	$ 3.3	$ 24.2	$ 13.9
2054	0.563		$ 20.9	$ 3.3	$ 24.2	$ 13.6
2055	0.552		$ 20.9	$ 3.3	$ 24.2	$ 13.4
2056	0.541		$ 20.9	$ 3.3	$ 24.2	$ 13.1
2057	0.531		$ 20.9	$ 3.3	$ 24.2	$ 12.8
2058	0.520		$ 20.9	$ 3.3	$ 24.2	$ 12.6
2059	0.510		$ 20.9	$ 3.3	$ 24.2	$ 12.3
2060	0.500	$ 22.5	$ 20.9	$ 3.3	$ 46.7	$ 23.4
2061	0.490	$ 22.5	$ 20.9	$ 3.3	$ 46.7	$ 22.9
2062	0.481	$ 22.5	$ 20.9	$ 3.3	$ 46.7	$ 22.5
2063	0.471	$ 22.5	$ 20.9	$ 3.3	$ 46.7	$ 22.0

Table 12. CBA-7: Waikapu and Paia Groundwater, Reallocate Ag Water from Wailoa Ditch (F + K + B)

Costs			Discount Rate	2.0%
Capital	$ 1,040.0		Total PV	**$ 1,554.9**
R&R	$ 135.0		Baseline PV	$ 1,409.8
O&M	$ 20.9		Cost Savings	$ (145.1)

Year	Discount Factor	Costs ($ millions)				
		Capital and R&R	O&M	Impacts vs. Baseline	Total	PV
2064	0.462	$ 22.5	$ 20.9	$ 3.3	$ 46.7	$ 21.6
2065	0.453	$ 22.5	$ 20.9	$ 3.3	$ 46.7	$ 21.2
2066	0.444		$ 20.9	$ 3.3	$ 24.2	$ 10.8
2067	0.435		$ 20.9	$ 3.3	$ 24.2	$ 10.5
2068	0.427		$ 20.9	$ 3.3	$ 24.2	$ 10.3
2069	0.418		$ 20.9	$ 3.3	$ 24.2	$ 10.1
2070	0.410		$ 20.9	$ 3.3	$ 24.2	$ 9.9
2071	0.402		$ 20.9	$ 3.3	$ 24.2	$ 9.7
2072	0.394		$ 20.9	$ 3.3	$ 24.2	$ 9.5
2073	0.387		$ 20.9	$ 3.3	$ 24.2	$ 9.4
2074	0.379		$ 20.9	$ 3.3	$ 24.2	$ 9.2
2075	0.372		$ 20.9	$ 3.3	$ 24.2	$ 9.0
2076	0.364		$ 20.9	$ 3.3	$ 24.2	$ 8.8
2077	0.357		$ 20.9	$ 3.3	$ 24.2	$ 8.6
2078	0.350		$ 20.9	$ 3.3	$ 24.2	$ 8.5
2079	0.343		$ 20.9	$ 3.3	$ 24.2	$ 8.3
2080	0.337		$ 20.9	$ 3.3	$ 24.2	$ 8.1
2081	0.330		$ 20.9	$ 3.3	$ 24.2	$ 8.0
2082	0.323		$ 20.9	$ 3.3	$ 24.2	$ 7.8
2083	0.317		$ 20.9	$ 3.3	$ 24.2	$ 7.7
2084	0.311		$ 20.9	$ 3.3	$ 24.2	$ 7.5
2085	0.305		$ 20.9	$ 3.3	$ 24.2	$ 7.4
2086	0.299		$ 20.9	$ 3.3	$ 24.2	$ 7.2
2087	0.293		$ 20.9	$ 3.3	$ 24.2	$ 7.1
2088	0.287		$ 20.9	$ 3.3	$ 24.2	$ 7.0
2089	0.282		$ 20.9	$ 3.3	$ 24.2	$ 6.8
2090	0.276		$ 20.9	$ 3.3	$ 24.2	$ 6.7
Total		$ 1,175.0	$ 1,106.6	$ 181.6	$ 2,463.3	$ 1,554.9

Table 13. CBA-8: Makawao and Paia Groundwater, Reallocate Ag Water from Wailoa Ditch (B + K + E)

Costs			
Capital	$ 1,165.0	**Discount Rate**	2.0%
R&R	$ 150.0	**Total PV**	**$ 1,654.0**
O&M	$ 21.1	**Baseline PV**	$ 1,409.8
		Cost Savings	$ (244.2)

Year	Discount Factor	Costs ($ millions) Capital and R&R	O&M	Impacts vs. Baseline	Total	PV
2025	1.000	$ 8.7			$ 8.7	$ 8.7
2026	0.980	$ 8.7			$ 8.7	$ 8.6
2027	0.961	$ 63.1			$ 63.1	$ 60.7
2028	0.942	$ 63.1			$ 63.1	$ 59.5
2029	0.924	$ 63.1			$ 63.1	$ 58.3
2030	0.906	$ 8.7			$ 8.7	$ 7.9
2031	0.888	$ 8.7			$ 8.7	$ 7.8
2032	0.871	$ 112.3			$ 112.3	$ 97.8
2033	0.853	$ 103.6			$ 103.6	$ 88.4
2034	0.837	$ 103.6			$ 103.6	$ 86.7
2035	0.820	$ 103.6	$ 3.0	$ 1.3	$ 107.9	$ 88.5
2036	0.804	$ 103.6	$ 6.0	$ 1.6	$ 111.2	$ 89.4
2037	0.788	$ 103.6	$ 9.0	$ 1.9	$ 114.5	$ 90.3
2038	0.773	$ 103.6	$ 12.1	$ 2.1	$ 117.7	$ 91.0
2039	0.758	$ 103.6	$ 15.1	$ 2.4	$ 121.0	$ 91.7
2040	0.743	$ 103.6	$ 18.1	$ 2.7	$ 124.3	$ 92.4
2041	0.728		$ 21.1	$ 2.7	$ 23.8	$ 17.3
2042	0.714		$ 21.1	$ 2.7	$ 23.8	$ 17.0
2043	0.700		$ 21.1	$ 2.7	$ 23.8	$ 16.6
2044	0.686		$ 21.1	$ 2.7	$ 23.8	$ 16.3
2045	0.673		$ 21.1	$ 2.7	$ 23.8	$ 16.0
2046	0.660		$ 21.1	$ 2.7	$ 23.8	$ 15.7
2047	0.647		$ 21.1	$ 2.7	$ 23.8	$ 15.4
2048	0.634		$ 21.1	$ 2.7	$ 23.8	$ 15.1
2049	0.622		$ 21.1	$ 2.7	$ 23.8	$ 14.8
2050	0.610		$ 21.1	$ 2.7	$ 23.8	$ 14.5
2051	0.598		$ 21.1	$ 2.7	$ 23.8	$ 14.2
2052	0.586		$ 21.1	$ 2.7	$ 23.8	$ 13.9
2053	0.574		$ 21.1	$ 2.7	$ 23.8	$ 13.7
2054	0.563		$ 21.1	$ 2.7	$ 23.8	$ 13.4
2055	0.552		$ 21.1	$ 2.7	$ 23.8	$ 13.1
2056	0.541		$ 21.1	$ 2.7	$ 23.8	$ 12.9
2057	0.531		$ 21.1	$ 2.7	$ 23.8	$ 12.6
2058	0.520		$ 21.1	$ 2.7	$ 23.8	$ 12.4
2059	0.510		$ 21.1	$ 2.7	$ 23.8	$ 12.1
2060	0.500	$ 25.0	$ 21.1	$ 2.7	$ 48.8	$ 24.4
2061	0.490	$ 25.0	$ 21.1	$ 2.7	$ 48.8	$ 23.9
2062	0.481	$ 25.0	$ 21.1	$ 2.7	$ 48.8	$ 23.4
2063	0.471	$ 25.0	$ 21.1	$ 2.7	$ 48.8	$ 23.0

Table 13. CBA-8: Makawao and Paia Groundwater, Reallocate Ag Water from Wailoa Ditch (B + K + E)

Costs			
Capital	$ 1,165.0	Discount Rate	2.0%
R&R	$ 150.0	Total PV	**$ 1,654.0**
O&M	$ 21.1	Baseline PV	$ 1,409.8
		Cost Savings	$ (244.2)

Year	Discount Factor	Costs ($ millions)				
		Capital and R&R	O&M	Impacts vs. Baseline	Total	PV
2064	0.462	$ 25.0	$ 21.1	$ 2.7	$ 48.8	$ 22.5
2065	0.453	$ 25.0	$ 21.1	$ 2.7	$ 48.8	$ 22.1
2066	0.444		$ 21.1	$ 2.7	$ 23.8	$ 10.6
2067	0.435		$ 21.1	$ 2.7	$ 23.8	$ 10.3
2068	0.427		$ 21.1	$ 2.7	$ 23.8	$ 10.1
2069	0.418		$ 21.1	$ 2.7	$ 23.8	$ 9.9
2070	0.410		$ 21.1	$ 2.7	$ 23.8	$ 9.8
2071	0.402		$ 21.1	$ 2.7	$ 23.8	$ 9.6
2072	0.394		$ 21.1	$ 2.7	$ 23.8	$ 9.4
2073	0.387		$ 21.1	$ 2.7	$ 23.8	$ 9.2
2074	0.379		$ 21.1	$ 2.7	$ 23.8	$ 9.0
2075	0.372		$ 21.1	$ 2.7	$ 23.8	$ 8.8
2076	0.364		$ 21.1	$ 2.7	$ 23.8	$ 8.7
2077	0.357		$ 21.1	$ 2.7	$ 23.8	$ 8.5
2078	0.350		$ 21.1	$ 2.7	$ 23.8	$ 8.3
2079	0.343		$ 21.1	$ 2.7	$ 23.8	$ 8.2
2080	0.337		$ 21.1	$ 2.7	$ 23.8	$ 8.0
2081	0.330		$ 21.1	$ 2.7	$ 23.8	$ 7.8
2082	0.323		$ 21.1	$ 2.7	$ 23.8	$ 7.7
2083	0.317		$ 21.1	$ 2.7	$ 23.8	$ 7.5
2084	0.311		$ 21.1	$ 2.7	$ 23.8	$ 7.4
2085	0.305		$ 21.1	$ 2.7	$ 23.8	$ 7.2
2086	0.299		$ 21.1	$ 2.7	$ 23.8	$ 7.1
2087	0.293		$ 21.1	$ 2.7	$ 23.8	$ 7.0
2088	0.287		$ 21.1	$ 2.7	$ 23.8	$ 6.8
2089	0.282		$ 21.1	$ 2.7	$ 23.8	$ 6.7
2090	0.276		$ 21.1	$ 2.7	$ 23.8	$ 6.6
Total		$ 1,315.0	$ 1,118.7	$ 145.3	$ 2,579.0	$ 1,654.0

Table 14. CBA-9: Makawao and Waihee Groundwater, High Flows from Wailoa Ditch (B + I + J)

Costs				Discount Rate		2.0%
Capital	$	1,205.0		Total PV	$	1,671.9
R&R	$	139.0		Baseline PV	$	1,409.8
O&M	$	20.5		Cost Savings	$	(262.1)

Year	Discount Factor	Costs ($ millions)				
		Capital and R&R	O&M	Impacts vs. Baseline	Total	PV
2025	1.000	$ 9.0			$ 9.0	$ 9.0
2026	0.980	$ 9.0			$ 9.0	$ 8.9
2027	0.961	$ 65.3			$ 65.3	$ 62.7
2028	0.942	$ 65.3			$ 65.3	$ 61.5
2029	0.924	$ 65.3			$ 65.3	$ 60.3
2030	0.906	$ 9.0			$ 9.0	$ 8.2
2031	0.888	$ 9.0			$ 9.0	$ 8.0
2032	0.871	$ 116.1			$ 116.1	$ 101.1
2033	0.853	$ 107.1			$ 107.1	$ 91.4
2034	0.837	$ 107.1			$ 107.1	$ 89.6
2035	0.820	$ 107.1	$ 2.9	$ 1.4	$ 111.5	$ 91.4
2036	0.804	$ 107.1	$ 5.9	$ 1.7	$ 114.7	$ 92.2
2037	0.788	$ 107.1	$ 8.8	$ 2.0	$ 117.9	$ 93.0
2038	0.773	$ 107.1	$ 11.7	$ 2.3	$ 121.1	$ 93.6
2039	0.758	$ 107.1	$ 14.6	$ 2.6	$ 124.3	$ 94.2
2040	0.743	$ 107.1	$ 17.6	$ 2.9	$ 127.6	$ 94.8
2041	0.728		$ 20.5	$ 2.9	$ 23.4	$ 17.0
2042	0.714		$ 20.5	$ 2.9	$ 23.4	$ 16.7
2043	0.700		$ 20.5	$ 2.9	$ 23.4	$ 16.4
2044	0.686		$ 20.5	$ 2.9	$ 23.4	$ 16.0
2045	0.673		$ 20.5	$ 2.9	$ 23.4	$ 15.7
2046	0.660		$ 20.5	$ 2.9	$ 23.4	$ 15.4
2047	0.647		$ 20.5	$ 2.9	$ 23.4	$ 15.1
2048	0.634		$ 20.5	$ 2.9	$ 23.4	$ 14.8
2049	0.622		$ 20.5	$ 2.9	$ 23.4	$ 14.5
2050	0.610		$ 20.5	$ 2.9	$ 23.4	$ 14.2
2051	0.598		$ 20.5	$ 2.9	$ 23.4	$ 14.0
2052	0.586		$ 20.5	$ 2.9	$ 23.4	$ 13.7
2053	0.574		$ 20.5	$ 2.9	$ 23.4	$ 13.4
2054	0.563		$ 20.5	$ 2.9	$ 23.4	$ 13.2
2055	0.552		$ 20.5	$ 2.9	$ 23.4	$ 12.9
2056	0.541		$ 20.5	$ 2.9	$ 23.4	$ 12.6
2057	0.531		$ 20.5	$ 2.9	$ 23.4	$ 12.4
2058	0.520		$ 20.5	$ 2.9	$ 23.4	$ 12.2
2059	0.510		$ 20.5	$ 2.9	$ 23.4	$ 11.9
2060	0.500	$ 23.2	$ 20.5	$ 2.9	$ 46.5	$ 23.3
2061	0.490	$ 23.2	$ 20.5	$ 2.9	$ 46.5	$ 22.8
2062	0.481	$ 23.2	$ 20.5	$ 2.9	$ 46.5	$ 22.4
2063	0.471	$ 23.2	$ 20.5	$ 2.9	$ 46.5	$ 21.9

Table 14. CBA-9: Makawao and Waihee Groundwater, High Flows from Wailoa Ditch (B + I + J)

Costs		
Capital	$	1,205.0
R&R	$	139.0
O&M	$	20.5

Discount Rate		2.0%
Total PV	**$**	**1,671.9**
Baseline PV	$	1,409.8
Cost Savings	$	(262.1)

Year	Discount Factor	Costs ($ millions)				
		Capital and R&R	O&M	Impacts vs. Baseline	Total	PV
2064	0.462	$ 23.2	$ 20.5	$ 2.9	$ 46.5	$ 21.5
2065	0.453	$ 23.2	$ 20.5	$ 2.9	$ 46.5	$ 21.1
2066	0.444		$ 20.5	$ 2.9	$ 23.4	$ 10.4
2067	0.435		$ 20.5	$ 2.9	$ 23.4	$ 10.2
2068	0.427		$ 20.5	$ 2.9	$ 23.4	$ 10.0
2069	0.418		$ 20.5	$ 2.9	$ 23.4	$ 9.8
2070	0.410		$ 20.5	$ 2.9	$ 23.4	$ 9.6
2071	0.402		$ 20.5	$ 2.9	$ 23.4	$ 9.4
2072	0.394		$ 20.5	$ 2.9	$ 23.4	$ 9.2
2073	0.387		$ 20.5	$ 2.9	$ 23.4	$ 9.0
2074	0.379		$ 20.5	$ 2.9	$ 23.4	$ 8.9
2075	0.372		$ 20.5	$ 2.9	$ 23.4	$ 8.7
2076	0.364		$ 20.5	$ 2.9	$ 23.4	$ 8.5
2077	0.357		$ 20.5	$ 2.9	$ 23.4	$ 8.3
2078	0.350		$ 20.5	$ 2.9	$ 23.4	$ 8.2
2079	0.343		$ 20.5	$ 2.9	$ 23.4	$ 8.0
2080	0.337		$ 20.5	$ 2.9	$ 23.4	$ 7.9
2081	0.330		$ 20.5	$ 2.9	$ 23.4	$ 7.7
2082	0.323		$ 20.5	$ 2.9	$ 23.4	$ 7.6
2083	0.317		$ 20.5	$ 2.9	$ 23.4	$ 7.4
2084	0.311		$ 20.5	$ 2.9	$ 23.4	$ 7.3
2085	0.305		$ 20.5	$ 2.9	$ 23.4	$ 7.1
2086	0.299		$ 20.5	$ 2.9	$ 23.4	$ 7.0
2087	0.293		$ 20.5	$ 2.9	$ 23.4	$ 6.8
2088	0.287		$ 20.5	$ 2.9	$ 23.4	$ 6.7
2089	0.282		$ 20.5	$ 2.9	$ 23.4	$ 6.6
2090	0.276		$ 20.5	$ 2.9	$ 23.4	$ 6.5
Total		$ 1,344.0	$ 1,086.6	$ 156.2	$ 2,586.8	$ 1,671.9

Table 15. CBA-10: No Action

Costs			
Capital	$ -	Discount Rate	2.0%
R&R	$ -	**Total PV**	**$ 30,994.9**
O&M	$ -	Baseline PV	$ 1,409.8
		Cost Savings	$ (29,585.1)

Year	Discount Factor	Costs ($ millions)				
		Capital and R&R	O&M	Impacts vs. Baseline	Total	PV
2025	1.000	$ -		$ -	$ -	$ -
2026	0.980	$ -		$ -	$ -	$ -
2027	0.961	$ -		$ -	$ -	$ -
2028	0.942	$ -		$ -	$ -	$ -
2029	0.924	$ -		$ -	$ -	$ -
2030	0.906	$ -		$ -	$ -	$ -
2031	0.888	$ -		$ -	$ -	$ -
2032	0.871	$ -		$ -	$ -	$ -
2033	0.853	$ -		$ -	$ -	$ -
2034	0.837	$ -		$ -	$ -	$ -
2035	0.820	$ -	$ -	$ 86.4	$ 86.4	$ 70.9
2036	0.804	$ -	$ -	$ 172.9	$ 172.9	$ 139.0
2037	0.788	$ -	$ -	$ 259.3	$ 259.3	$ 204.5
2038	0.773	$ -	$ -	$ 345.8	$ 345.8	$ 267.3
2039	0.758	$ -	$ -	$ 432.2	$ 432.2	$ 327.5
2040	0.743	$ -	$ -	$ 518.6	$ 518.6	$ 385.3
2041	0.728		$ -	$ 605.1	$ 605.1	$ 440.8
2042	0.714		$ -	$ 691.5	$ 691.5	$ 493.8
2043	0.700		$ -	$ 777.9	$ 777.9	$ 544.7
2044	0.686		$ -	$ 864.4	$ 864.4	$ 593.3
2045	0.673		$ -	$ 950.8	$ 950.8	$ 639.9
2046	0.660		$ -	$ 1,037.3	$ 1,037.3	$ 684.4
2047	0.647		$ -	$ 1,123.7	$ 1,123.7	$ 726.8
2048	0.634		$ -	$ 1,210.1	$ 1,210.1	$ 767.4
2049	0.622		$ -	$ 1,296.6	$ 1,296.6	$ 806.1
2050	0.610		$ -	$ 1,383.0	$ 1,383.0	$ 843.0
2051	0.598		$ -	$ 1,383.0	$ 1,383.0	$ 826.5
2052	0.586		$ -	$ 1,383.0	$ 1,383.0	$ 810.2
2053	0.574		$ -	$ 1,383.0	$ 1,383.0	$ 794.4
2054	0.563		$ -	$ 1,383.0	$ 1,383.0	$ 778.8
2055	0.552		$ -	$ 1,383.0	$ 1,383.0	$ 763.5
2056	0.541		$ -	$ 1,383.0	$ 1,383.0	$ 748.5
2057	0.531		$ -	$ 1,383.0	$ 1,383.0	$ 733.9
2058	0.520		$ -	$ 1,383.0	$ 1,383.0	$ 719.5
2059	0.510		$ -	$ 1,383.0	$ 1,383.0	$ 705.4
2060	0.500	$ -	$ -	$ 1,383.0	$ 1,383.0	$ 691.5
2061	0.490	$ -	$ -	$ 1,383.0	$ 1,383.0	$ 678.0
2062	0.481	$ -	$ -	$ 1,383.0	$ 1,383.0	$ 664.7
2063	0.471	$ -	$ -	$ 1,383.0	$ 1,383.0	$ 651.7

Table 15. CBA-10: No Action

Costs			Discount Rate	2.0%
Capital	$ -		Total PV	**$ 30,994.9**
R&R	$ -		Baseline PV	$ 1,409.8
O&M	$ -		Cost Savings	$ (29,585.1)

Year	Discount Factor	Costs ($ millions)				
		Capital and R&R	O&M	Impacts vs. Baseline	Total	PV
2064	0.462	$ -	$ -	$ 1,383.0	$ 1,383.0	$ 638.9
2065	0.453	$ -	$ -	$ 1,383.0	$ 1,383.0	$ 626.3
2066	0.444		$ -	$ 1,383.0	$ 1,383.0	$ 614.1
2067	0.435		$ -	$ 1,383.0	$ 1,383.0	$ 602.0
2068	0.427		$ -	$ 1,383.0	$ 1,383.0	$ 590.2
2069	0.418		$ -	$ 1,383.0	$ 1,383.0	$ 578.6
2070	0.410		$ -	$ 1,383.0	$ 1,383.0	$ 567.3
2071	0.402		$ -	$ 1,383.0	$ 1,383.0	$ 556.2
2072	0.394		$ -	$ 1,383.0	$ 1,383.0	$ 545.3
2073	0.387		$ -	$ 1,383.0	$ 1,383.0	$ 534.6
2074	0.379		$ -	$ 1,383.0	$ 1,383.0	$ 524.1
2075	0.372		$ -	$ 1,383.0	$ 1,383.0	$ 513.8
2076	0.364		$ -	$ 1,383.0	$ 1,383.0	$ 503.7
2077	0.357		$ -	$ 1,383.0	$ 1,383.0	$ 493.9
2078	0.350		$ -	$ 1,383.0	$ 1,383.0	$ 484.2
2079	0.343		$ -	$ 1,383.0	$ 1,383.0	$ 474.7
2080	0.337		$ -	$ 1,383.0	$ 1,383.0	$ 465.4
2081	0.330		$ -	$ 1,383.0	$ 1,383.0	$ 456.3
2082	0.323		$ -	$ 1,383.0	$ 1,383.0	$ 447.3
2083	0.317		$ -	$ 1,383.0	$ 1,383.0	$ 438.5
2084	0.311		$ -	$ 1,383.0	$ 1,383.0	$ 429.9
2085	0.305		$ -	$ 1,383.0	$ 1,383.0	$ 421.5
2086	0.299		$ -	$ 1,383.0	$ 1,383.0	$ 413.2
2087	0.293		$ -	$ 1,383.0	$ 1,383.0	$ 405.1
2088	0.287		$ -	$ 1,383.0	$ 1,383.0	$ 397.2
2089	0.282		$ -	$ 1,383.0	$ 1,383.0	$ 389.4
2090	0.276		$ -	$ 1,383.0	$ 1,383.0	$ 381.8
Total		$ -	$ -	$ 67,075.5	$ 67,075.5	$ 30,994.9