Māʻalaea Bay Watersheds Management Plan
Maui County, HI
2023

Prepared For:
Maui County
Office of Innovation and Sustainability
And
State of Hawaiʻi
Department of Health
Surface Water Protection Branch

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ACRONYMS

AURORA	Autonomous Unmanned Remote Monitoring Robotic Airship
A&B	Alexander & Baldwin, LLC
ATUs	Advanced Treatment Units
BLNR	Board of Land and Natural Resources
BMPs	Best Management Practices
BOD5	5-day Biological Oxygen Demand
CCAP	Coastal Change Analysis Program
COM	County of Maui
CWA	Clean Water Act
CWB	Clean Water Branch
CDUA	Conservation District Use Application
CFR	Code of Federal Regulations
DAR	Department of Aquatic Resources
DEM	Digital Elevation Model
DHHL	Department of Hawaiian Home Lands
DLNR	Division of Land and Natural Resources
DOFAW	Division of Forestry and Wildlife
DOH	Department of Health
EPA	Environmental Protection Agency
FTW	Floating Treatment Wetland
GIS	Geographic Information Systems
HAR	Hawaiʻi Administrative Rule
HDOH	Hawaiʻi Department of Health
HOKWO	Hui O Ka Wai Ola
HRS	Hawaiʻi Revised Statutes
IKONOS	Greek for Image – commercial earth observation satellite
InVEST	Integrated Valuation of Ecosystem Services and Trade-offs
IR	Integrated Water Quality Reports
IW	Injection Well
IWS	Individual Wastewater System
KDMP	Kīhei Drainage Master Plan
KPNWR	Keālia Pond National Wildlife Refuge
LID	Low Impact Design/Development
LLC	Limited Liability Company
LULC	Land Use and Land Cover
MEC	Maui Environmental Consulting, LLC
MECO	Maui Electric Company
MNMRC	Maui Nui Marine Resource Council
MS	Microsoft
MBWMP	Māʻalaea Bay Watersheds Management Plan
N	Nitrogen
NDMC	National Drought Mitigation Center
NDR	Nutrient Delivery Ratio
NFWF	National Fish and Wildlife Foundation
NOAA	National Oceanic and Atmospheric Administration

NO3 + NO2	Nitrate + Nitrite
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint Source
NRCS	Natural Resources Conservation Service
NTU	Nephelometric Turbidity Unit – unit used to measure turbidity
OHWM	Ordinary High-Water Mark
PRCP	Polluted Runoff Control Program
PUC	Public Utility Commission
QAPP	Quality Assurance Project Plan
R-factor	Rainfall erosivity
RUSLE2	Revised Universal Soil Loss Equation – Version 2
SDWA	Safe Drinking Water Act
SDR	Sediment Delivery Ratio
SOPs	Standard Operating Procedures
STEPL	Spreadsheet Tool for Estimating Pollutant Loads
STV	Statistical Threshold Value
SWCD	Soil and Water Conservation District
SWPB	Surface Water Protection Branch
TMDL	Total Maximum Daily Load
TMK	Tax Map Key
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
UIC	Underground Injection Control
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
USLE	Universal Soil Loss Equation
VB	Visual Basic
WBUS	Water Bodies of the United States
WOTUS	Waters of the United States
WQC	Water Quality Certification
WQS	Water Quality Standard

1.0 EXECUTIVE SUMMARY

A watershed is an area of land in which all sources of water discharge into a common waterbody such as a lake, river, stream, wetland, estuary, bay, or ocean. The types of activities, management measures, and practices that are conducted on the land within a watershed impact the quality of the receiving waterbodies. Watershed management plans are developed to protect natural resources and improve water quality by characterizing watersheds, identifying sources of pollution and impacted natural resources, engaging stakeholders, quantifying pollutant loads, and identifying and implementing management measures and best management practices to reduce sources of pollution.

Watershed planning efforts have been expanding across the island of Maui. In 2019 the Southwest Maui Watershed Management Plan was approved, and the same with the Pōhākea Watershed Plan in 2023. The Waikapū and Waiakoa Watersheds – together referred to as the Māʻalaea Bay Watersheds - converge in Maui's central isthmus, and bridge the gap between the two previsouly approved plans. Collectively these plans can work together to achieve water quality goals for the entirety of southwest Maui.

Reaching elevations of approximately 4,400 feet in the West Maui Mountains the Waikapū Watershed extends to the southeast and covers an area of 10,393 acres. The Waiakoa Watershed encompasses 35,331 acres, including the summit of Haleakalā at 10,023 feet. It extends northwest until its boundaries meet with the Waikapū Watershed. All but one of the streams within the Māʻalaea Bay Watershed are ephemeral, flowing only during stormwater events, and their waterways drain into Keālia Pond and the coastal waters of Māʻalaea Bay. Agriculture and Conservation land use districts make up the majority of the land area. Urban and rural land use districts comprise just over 6% of the area for each watershed.

Land management plays an important role in maintaining healthy coastal waters. Coral reefs are important culturally, economically, and ecologically. Traditionally, the ocean is relied upon as a source of sustenance both physically and spiritually. Used for canoeing, diving, fishing, limu gathering, ceremonial purposes, and so much more, Native Hawaiians have a strong connection to the sea. Residents and visitors alike rely on the coastal waters for recreational opportunities, and commercially they support tourism enterprises. To manage the land is to protect the water, and all who live, work, and recreate within the watersheds will benefit from measures to reduce pollution.

The goal of the Māʻalaea Bay Watersheds Management Plan is to identify the Critical Source Areas of pollution within the watersheds and to provide best management practices that will protect and improve the quality of water resources within the planning area. Critical Source Areas are areas within a watershed that contribute a disproportionately large amount of pollutant load to a water body. According to the Hawaiʻi Department of Health (DOH) Final 2020 and Final 2022 Integrated Water Quality Reports (IR) submitted to the Environmental Protection Agency (EPA) and Congress pursuant to Clean Water Act Section 303(d), the coastal waters of Waikapū and Waiakoa watersheds are listed as impaired for several parameters including total nitrogen, nitrate+nitrite, ammonium, turbidity, and chlorophyll-a at one or more sampling sites. The sampling sites within the Māʻalaea Bay Watersheds also lack adequate data for assessment of at least one water quality standard.

Management recommendations to reduce nonpoint source pollution in the Māʻalaea Bay Watersheds have been identified in Section 7.0. Targeted implementation projects proposed to meet water quality goals are discussed further in Section 8.0. Such projects include axis deer fencing, riparian protection, unimproved road stabilization, excavated detention basins, gabions in series, regional stormwater management parks, Low Impact Design (LID) infrastructure within urban areas, and reef friendly landscaping programs. Funding and feasibility of execution are limiting factors on the timeliness of this plan. At a minimum, water quality monitoring is recommended to narrow existing data gaps in water quality issues and to better determine where sediment and nutrient pollution is occurring throughout the Waikapū and Waiakoa watersheds even if none of the proposed management measures or projects are implemented.

Sediment was determined to be the major pollutant of concern within the Waiakoa Watershed. Nitrogen is the major pollutant of concern in the Waikapū watershed. Critical Source Areas for sediment loading were identified as the highly denuded rangelands in the lower and middle portions of the Waiakoa Watershed. Within the Waikapū Watershed, Critical Source Areas of Nitrogen loading were identified to exist at both golf courses and the agricultural lands surrounding Keālia Pond.

2.0 INTRODUCTION AND PURPOSE

The Māʻalaea Bay Watersheds Management Plan bridges the gap between two existing, EPA-approved watershed management plans - The Pōhākea Watershed Plan to the west and The Southwest Maui Watershed Plan to the southeast. Composed of Waikapū and Waiakoa Watersheds, the land area totals 45,724 acres and spans from elevations of approximately 4,400 feet in Mauna Kahālāwai to the summit of Haleakalā at 10,023 feet. Both watersheds converge in the isthmus of Maui and discharge into Keālia Pond and the coastal waters of Māʻalaea Bay. Upon completion of this Plan, all aquatic resources flowing from the southeast peaks of Mauna Kahālāwai and the southwest peaks of Haleakalā to the shorelines stretching from Makena Beach to beyond McGregor's Point will be included in a watershed management plan.

2.1 Building Partnerships

2.1.1 Community Outreach

A major step in the watershed planning effort is to engage stakeholders and gather public input. Large landowners within the watershed boundaries were contacted via phone or email and invited to participate in outreach events. Meetings were held in May, June, July, and September 2023 to inform the community of the plan, to identify common values among individuals, and to better understand issues or concerns regarding water resources. Implementation and execution of this plan will be a collaborative effort among all entities. Updates to the Plan will be posted on mauiwatershed.org, and questions and comments are also available through online outlets.

2.1.2 Partnerships with other Federal Agencies, Non-Government Organizations, Local Government, and Local Landowners and Businesses

In March of 2021, the National Fish and Wildlife Foundation (NFWF) published the Hawaiʻi Conservation Business Plan that highlights strategies and resources required to achieve desired conservation outcomes. The Business plan follows the framework set forth by State of Hawaiʻi's Sustainable Hawaiʻi Initiative that aims to protect 30% of priority watershed forests and establish 30% of nearshore waters as marine management areas by 2030 to increase freshwater security capacity, invasive species control, and native species restoration (NFWF, Hawaiʻi Conservation Business Plan).

Waiakoa Watershed was listed as a focal watershed forest with the 10-year goal of improving watershed condition and function in the Kamehamenui fence unit by:

1) Increasing the native plant cover from 10% – 35%
2) Establishing five endangered plant species
3) Increasing native species diversity from zero to five species per acre

Kīhei's coral reef system was listed as a focal reef with the 10-year goal of maintaining high coral cover and building resiliency by:

1) Increasing the proportion of reef building species by 10%
2) Increasing herbivore fish biomass by 35%
3) In the event of a disturbance, such as a bleaching event(s), recover coral cover significantly faster than comparison sites

Watershed protection is essential in sustaining Hawaiʻi's ecological, economic and cultural resources that provide critical habitats for native flora and fauna both on land and at sea. As with all watershed management work, the study could only be undertaken with the community and landowners as partners. Major landowners and stakeholders associated with the study area include Maui County, the State of Hawaiʻi, Department of Land and Natural Resources, United State Fish and Wildlife Service, Keālia Pond National Wildlife Refuge, Mahi Pono, Wailuku Water Company, Alexander & Baldwin, LLC (A & B), Department of Hawaiian Homelands (DHHL), Haleakalā Ranch, Kula Ranch, Māʻalaea C&D Landfill Condominium, and the Von Tempsky Ranch.

2.1.3 Key Stakeholders

Community support and cooperative action are key components in waterhsed planning efforts. As required by EPA nonpoint source pollutant control (Section 319) grant requirements, appropriate stakehoders within the community were engaged to gather concerns, seek input, and share information regarding water resources within the Māʻalaea Bay Watersheds. Stakeholders were tasked with determining how to best manage the watershed in ways that satisfy environmental health, human health, and economic interests. The entire community falling within the watershed boundaries is potentially affected by the implementation projects proposed in this Plan.

Key stakeholders in the Māʻalaea Bay Watersheds Management Plan include but are not limited to Maui County,West, Central, and Olinda – Kula Soil and Water Conservation Districts, Department of Land and Natural Resources (DLNR) – Division of Forestry and Wildlife, DLNR – Division of Aquatic Resources, DLNR – Division of Boating and Ocean Recreation, Keālia Pond National Wildlife Refuge, Maui Nui Marine Resource Council, Maui Environmental Consulting, LLC, Maui Surfrider Foundation, Hui O Ka Wai Ola, United States Army Corps of Engineers (USACE), Environmental Protection Agency, U.S. Fish and Wildlife Service, National Oceanic and Atmospheric Administration, Hawaiʻi Tourism Authority, Maui County Fire Department, Hawaiʻi Department of Transportation, Maui Visitor's Bureau, Maui Tourism Authority, Boat/Tour Companies, Coral Reef Alliance, Hawaiʻi Wildlife Fund, Maui Cultural Lands, Maui Electric Company, Alexander & Baldwin, LLC, Department of Hawaiian Homelands, Haleakalā Ranch, Kula Ranch, Māʻalaea C & D Lanfill and Condominiums, Mahi Pono, LLC, Haleakalā National Park, Von Tempsky Ranch, Nishikiʻs Market, the Sugar Beach Condos, Bayer, Kula Community Association, Leeward Haleakalā Watershed Partnership, County of Maui Parks Department, Puʻunene Heavy Industrial Subdivision, Wailuku Water Company/Hanaula Ranch, Mauna Kāhālawai Watershed Partnership, Kahili and King Kamehameha golf courses, Waikapū Properties, Waikapū Town, Kuihelani Solar, and others.

Working with Tova Callender of West Maui Ridge to Reef Initiative, MEC held meetings with individual entities and organizations. MEC reached out to stakeholders to provide and receive information on issues and concerns within the watersheds. Brief surveys were sent and available online to collect initial feedback on watershed concerns. The kickoff outreach event was held on May 30th, 2023 at the Keālia Pond National Wildlife Refuge. To accommodate upcountry community members, MEC presented at the Kula Community Association meeting on June 14th, 2023. To provide updates and progress of the Plan an interim meeting was held on July 25th, 2023, and a draft version of the Plan was shared with the Kula Community Association on July 31st, 2023. Final public presentations were given on September 18th, 2023 at the Waikapū Community Association meeting, and again at Keālia Pond National Wildlife Refuge on September 26th, 2023. From the restorative work being done by Maui Nui Marine Resource Council, to water quality testing in the coastal waters by the Hui O Ka Wai Ola (HOKWO), to small business owners who rely on healthy and clean coastal waters for their business, MEC has identified stakeholders that have knowledge of existing programs and can serve as resources of information.

The Department of Health Clean Water Branch (CWB) Polluted Runoff Control Program (PRCP) and Maui County can also provide technical and financial assistance with project implementation. The following table was created to note key stakeholders and their role in the Māʻalaea Bay Watersheds Management Plan (MBWMP) (Table 1. Stakeholder Capacity in the Māʻalaea Bay Watersheds Management Plan).

Table 1. Stakeholder Capacity in the Māʻalaea Bay Watersheds Management Plan

Stakeholders	Stakeholder Capacity				
	Stakeholders responsible for implementing the Plan	Stakeholders affected by Plan implementation	Stakeholders who can provide information on issues and concerns in the watershed	Stakeholders who have knowledge of existing programs and resources	Stakeholders who can provide technical and financial assistance in implementing the Plan
Olinda-Kula, West, and Central Maui Soil and Water Conservation Districts					**X**
Maui County	**X**	**X**	**X**	**X**	**X**
Hawaiʻi Department of Health Clean Water Branch Polluted Runoff Control Program			**X**	**X**	**X**
Hawaiʻi Department of Land and Natural Resources			**X**	**X**	**X**
U.S. Environmental Protection Agency			**X**	**X**	**X**

Stakeholders	Stakeholder Capacity				
	Stakeholders responsible for implementing the Plan	Stakeholders affected by Plan implementation	Stakeholders who can provide information on issues and concerns in the watershed	Stakeholders who have knowledge of existing programs and resources	Stakeholders who can provide technical and financial assistance in implementing the Plan
Rural Land Owners	**X**	**X**	**X**		**X**
Urban Land Owners	**X**	**X**	**X**		**X**
Small Businesses		**X**	**X**		**X**

2.1.4 Education and Outreach

Stakeholders representing diverse interests including local, state, and federal agencies; private landowners, nonprofit organizations, and community residents were invited to participate in the watershed planning effort. Public outreach meetings were held in May, June, July, and September 2023 to discuss the process and gather input. Information and updates were available on the www.mauiwatershed.org website.

2.1.5 Setting Goals and Identifying Stakeholder Concerns

As a result of reviewing water quality data, it has been determined that the primary source and most problematic pollutants are sediment and nitrogen species, including nitrate-nitrite and ammonia. Stakeholder concerns have included:

- Brown water events (Water Quality) including sediment, nutrients and pathogens
- Flooding impacts to traffic and businesses in North Kīhei
- Debris clogging stormwater infrastructure and damaging roads
- Piles of sediment near waterways
- Wetlands being smothered by sediment
- Impervious surfaces
- Feral ungulates and erosion
- Fire hazards
- Cultural site protection/preservation
- Keālia Pond salinity and aquatic bird habitat

2.1.6 Identify Possible Management Strategies

Management strategies were developed based on the land use types within the watershed. Most of the land in the Waiakoa Watershed is designated as agricultural land. While the same is true of Waikapū Watershed, conservation lands are also a dominant land use. Within conservation lands, efforts should focus on ungulate fencing and native forest rehabilitation.

3.0 WATERSHED CHARACTERIZATION

The Māʻalaea Bay Watersheds Management Plan is unique in that it includes two watersheds that extend mauka to makai on the slopes of both volcanic mountain formations that make up the island of Maui (Figure 1. Māʻalaea Bay Watershed Boundaries). The Waikapū Watershed reaches elevations of 4,400 feet in the West Maui Mountains, or Mauna Kahālāwai, and the Waiakoa Watershed begins at the summit of Haleakalā at approximately 10,023 feet. The two watersheds converge in the central valley of Maui where their waterways drain into Keālia Pond and the coastal waters of Māʻalaea Bay. In this document, the Waikapū and Waiakoa Watersheds are collectively referred to as the Māʻalaea Bay Watersheds.

The information provided in this section describes the current conditions of Waikapū and Waiakoa Watersheds. Watershed characterization helps identify and prioritize areas of concern, and likewise, areas of least concern. Throughout this document the terms gulch and stream are used interchangeably.

The Māʻalaea Bay Watersheds are comprised of 4,060 different Tax Map Keys. Of these, 268 occur in the Waikapū Watershed (Figure 2. Waikapū TMK Map) and 3,792 occur in the Waiakoa Watershed (Figure 3. Waiakoa TMK Map) in Maui County, Hawaiʻi, with the large landowners shown in the maps below (Figures 31-32. Large Landowner Maps).

Waikapū Watershed begins at approximately 4,400 feet at the summit of the West Maui Mountains. This watershed discharges directly into Keālia Pond. Major roads running through the makai portions of this watershed include Honoapiʻilani Highway, Kuihelani Highway, and North Kīhei Road (Figure 4. Waikapū Location Map). The approximately 10,393-acre watershed is composed of several different land formations. Hillslope is relatively steep at the upper portions of the West Maui Mountains, with grade leveling off considerably at approximately 1,000 feet and continuing to gradually drop along the coastal areas to the ocean (Figure 6. Waikapū Quadrangle Map).

The Waiakoa Watershed begins at approximately 10,000 feet at the summit of Haleakalā. Some streams in this watershed discharge into the eastern portions of Māʻalaea Bay while others first flow into Keālia Pond. Major roads running through the mauka portions of the watershed include Haleakalā Highway, Kekaulike Highway, and Kula Highway. Omaopio and Pūlehu Roads run mauka to makai, connecting upcountry to the central valley. Mokulele Highway runs north to south along the central isthmus and is the only major road associated with the makai portions of the Waiakoa Watershed (Figure 5. Waiakoa Location Map). The approximately 35,330-acre watershed is composed of several different land formations. Hillslope grade is fairly steep associated with the summit of Haleakalā, but decreases and eventually becomes relatively gradual in slope, continuing to gradually drop along the coastal areas to the ocean (Figure 7. Waiakoa Quadrangle Map).

Figure 1. Māʻalaea Bay Watershed Boundaries

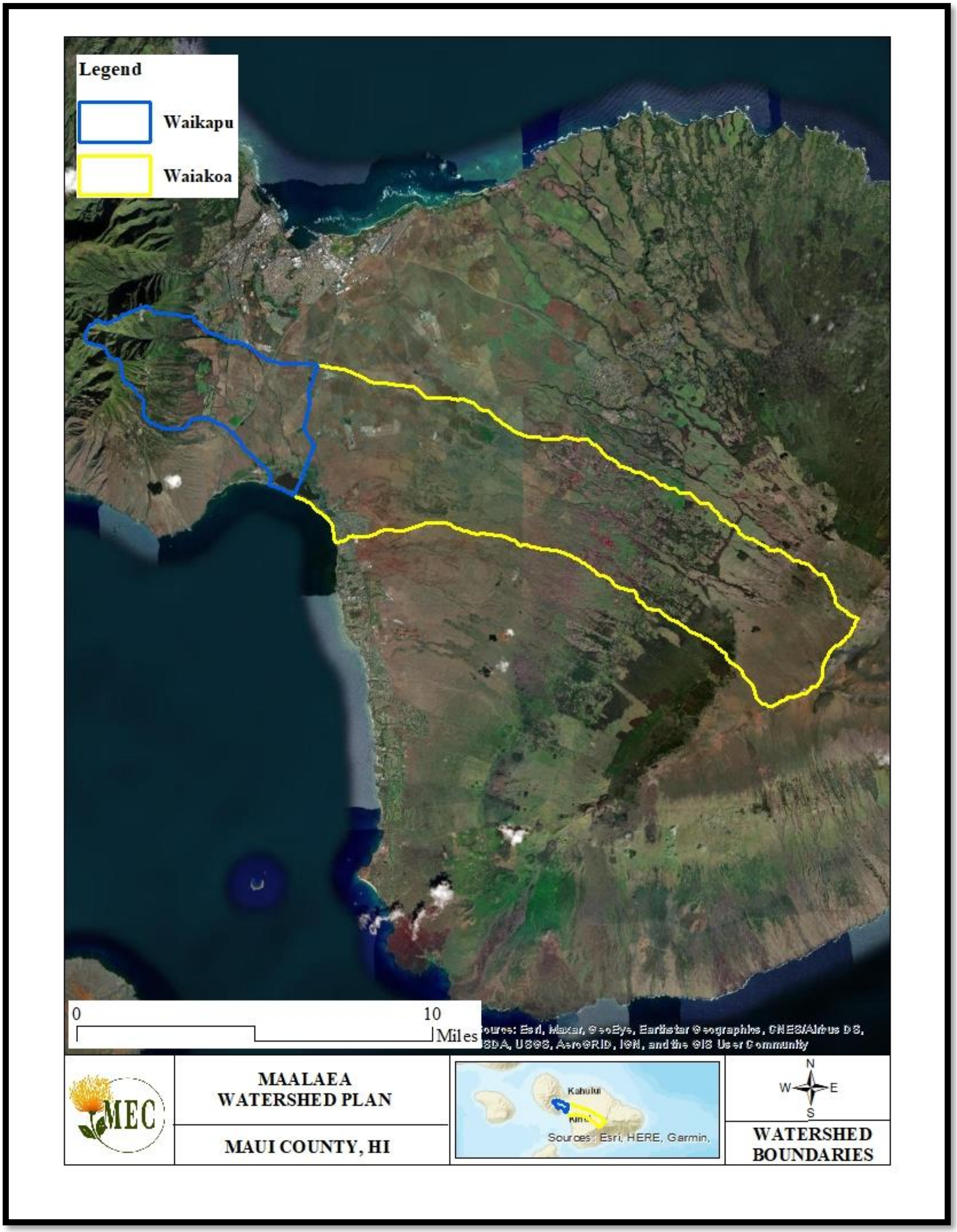


Figure 2. Waikapū TMK Map

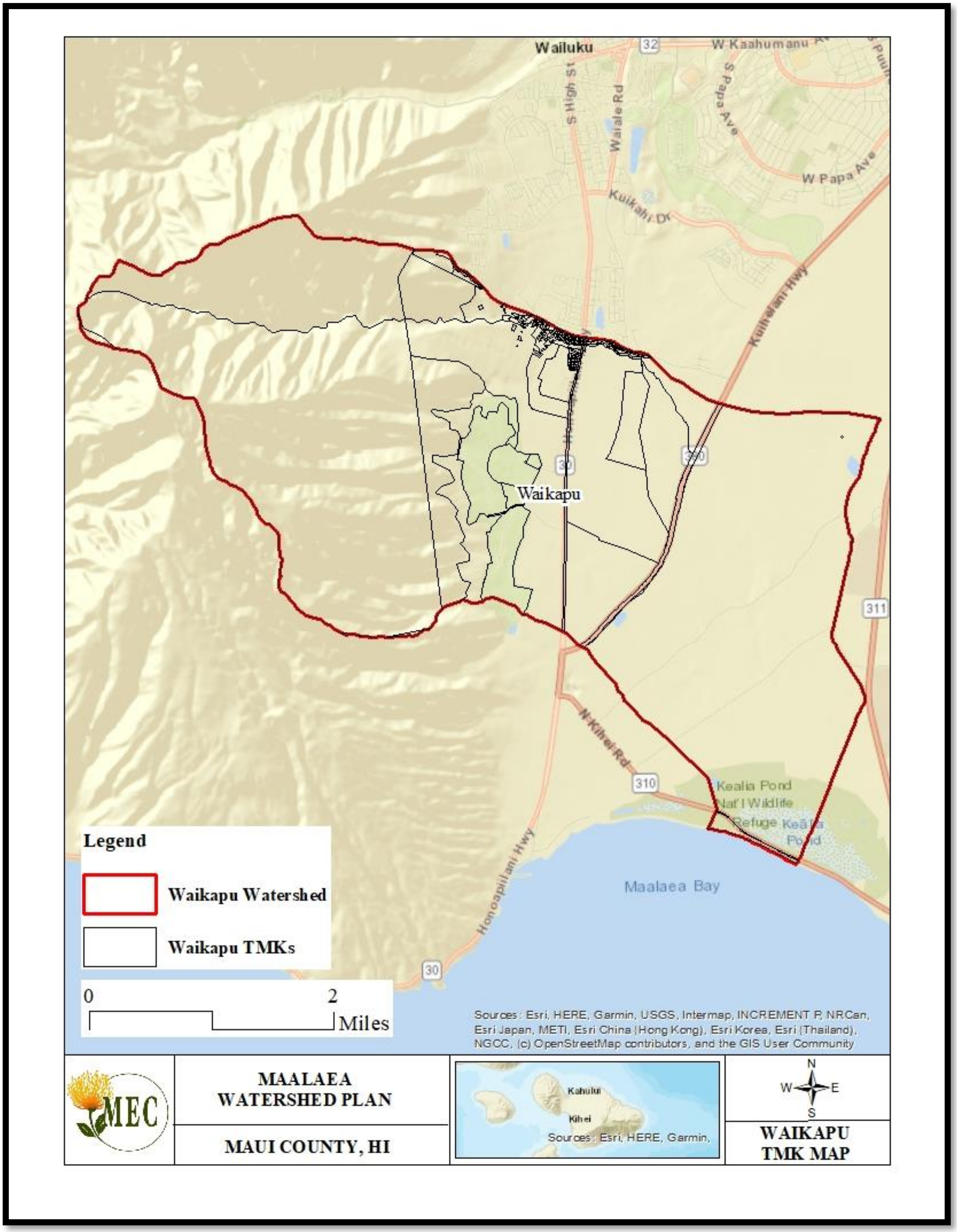


Figure 3. Waiakoa TMK Map

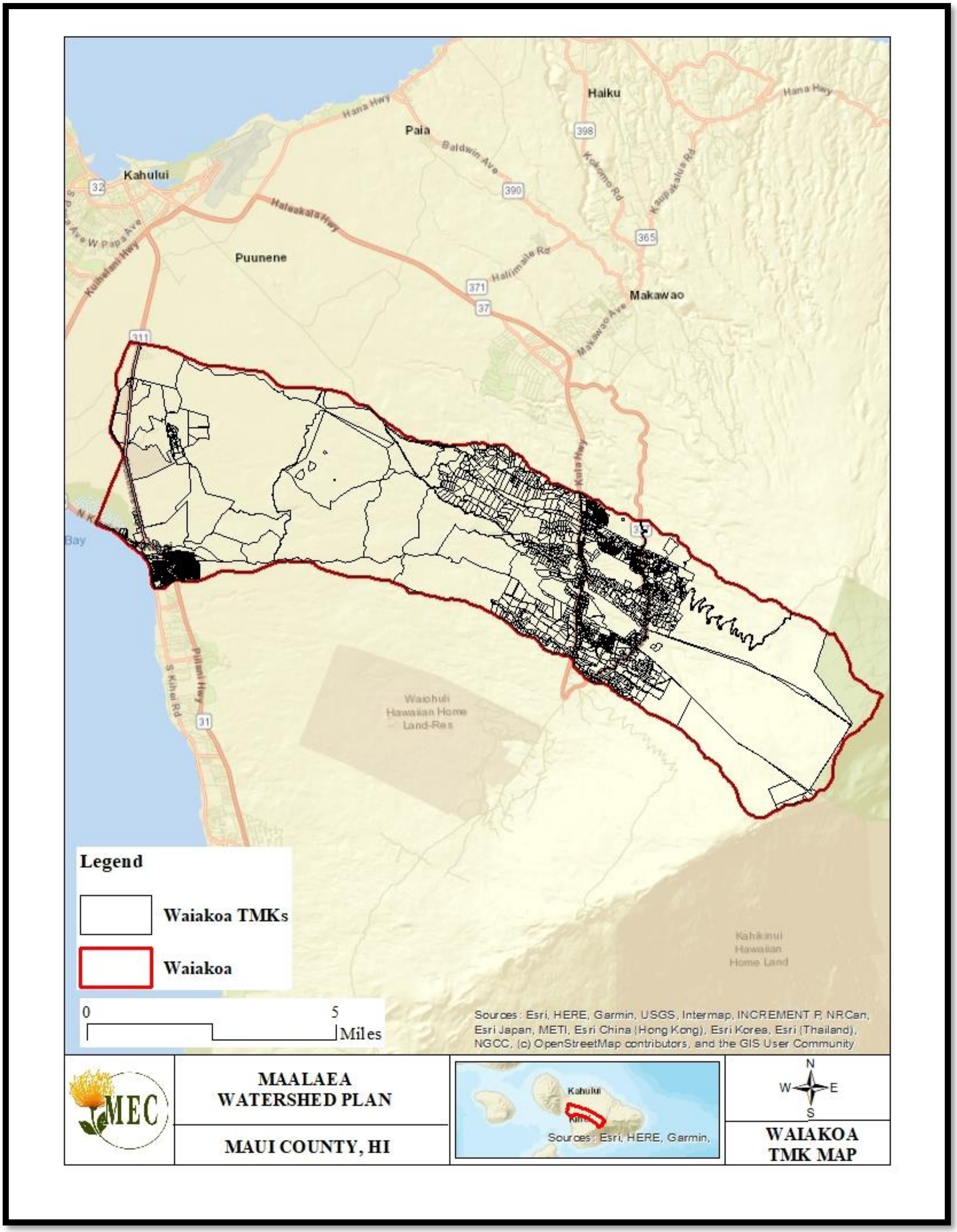


Figure 4. Waikapū Location Map

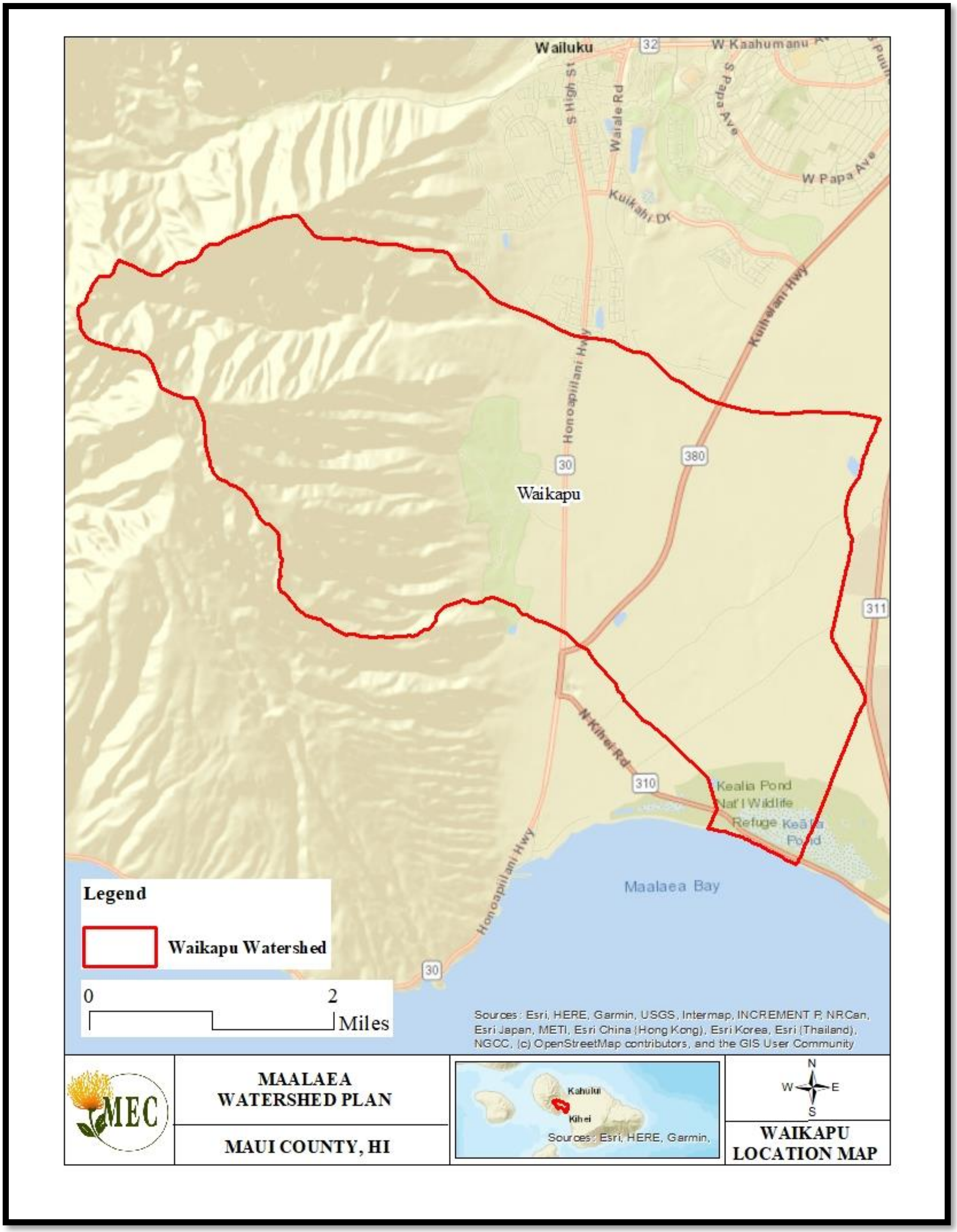


Figure 5. Waiakoa Location Map

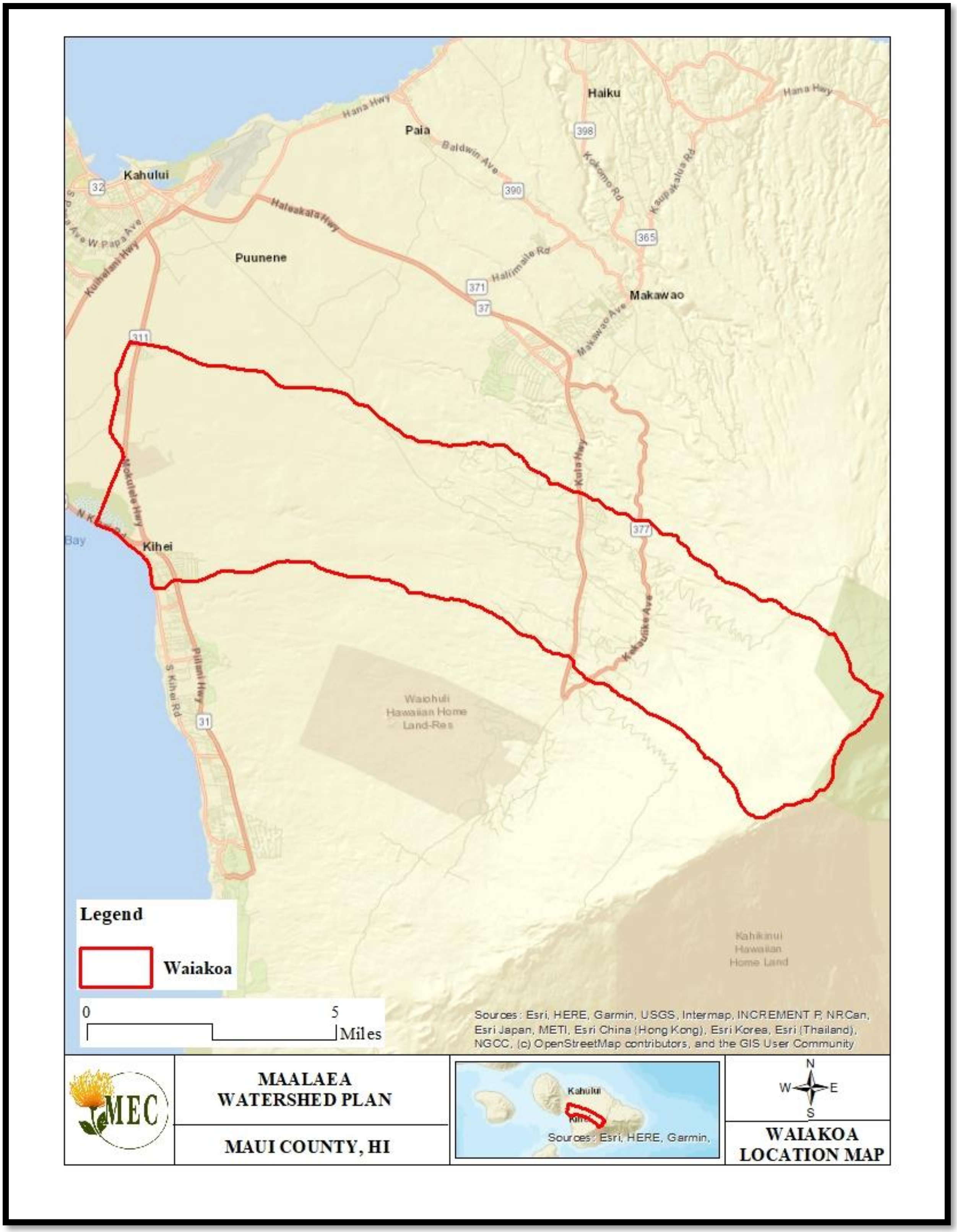


Figure 6. Waikapū Quadrangle Map

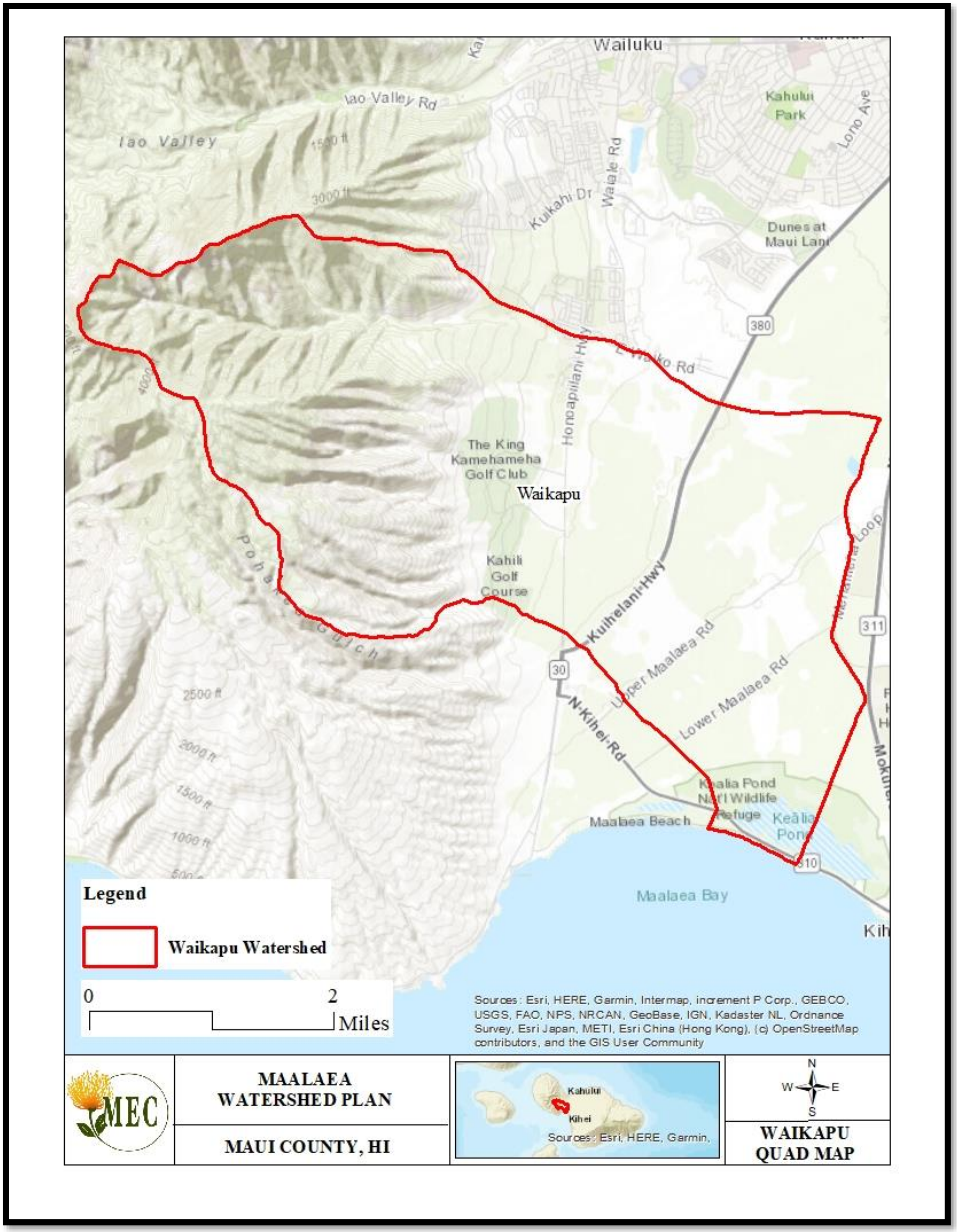
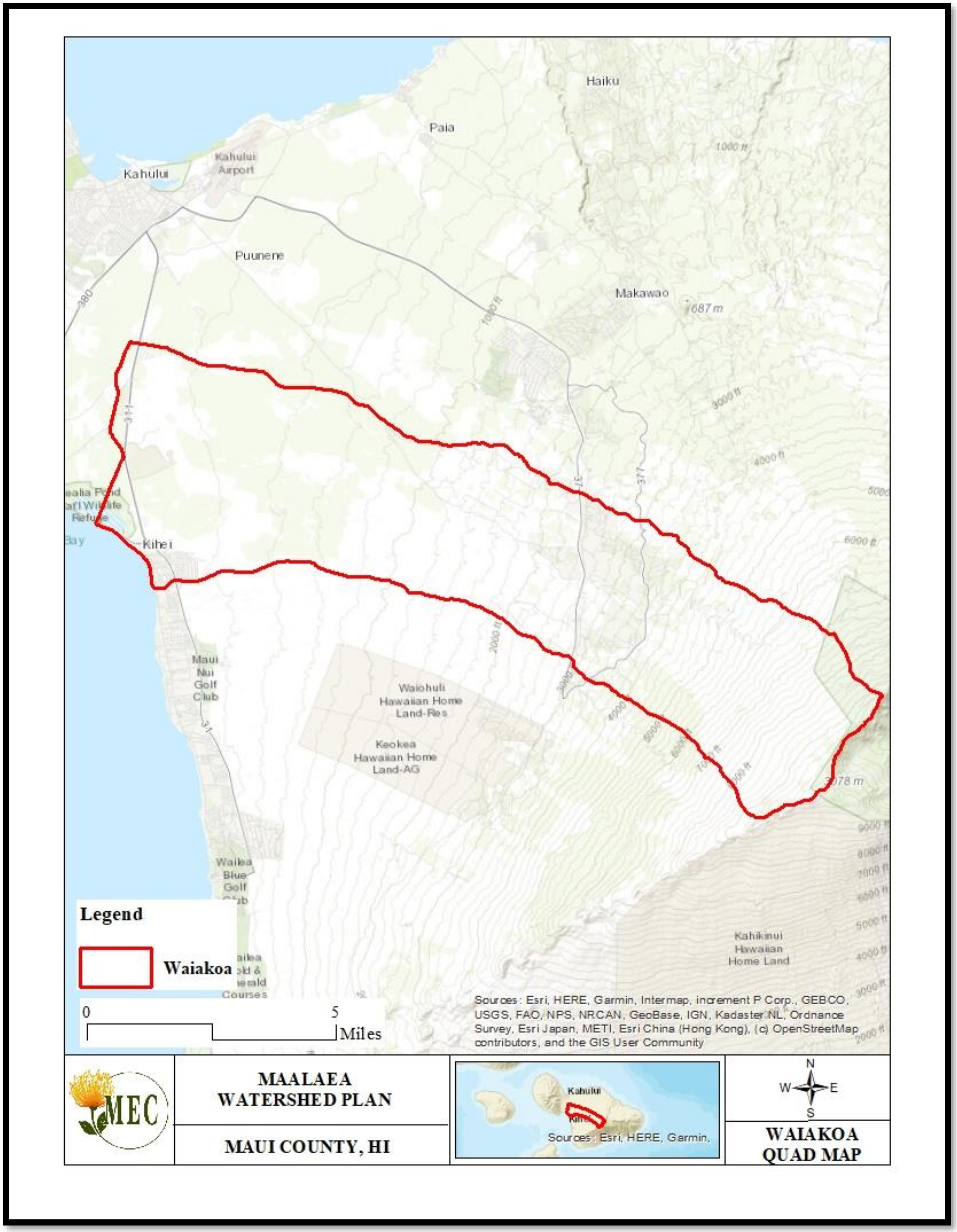


Figure 7. Waiakoa Quadrangle Map



3.1 Geology

The island of Maui is comprised of two steep volcanoes known as Haleakalā and the West Maui Mountains or Mauna Kahālāwai. Haleakalā stands at 10,023 feet, and the West Maui Mountains highest peak is at 5,788 feet. The two volcanoes are connected by a shallow isthmus where a lava flow from Haleakalā once met the base of the West Maui Mountains. The volcanic rocks of Maui are considered diverse and include basalts, gabbros, picritic basalts, nepheline basanites, basaltic andesites, andesites, and soda trachytes (Stearns and Macdonald, 1942). Lava types are Pahoehoe (smooth) flows that can form lava tubes, and A'a (rough), dense basalt that can form beds of clinkers (Stearns and Macdonald, 1942).

The West Maui Mountains are estimated to be 1.15 - 1.3 million years old and have been divided into three volcanic series: the Wailuku, Honolua, and Lahaina (Mink and Lau, 2006). The Waikapū Watershed spans from the coastal isthmus of Maui to the northwest into the West Maui Mountains, and is dominated by the Wailuku Volcanic Series. Composed primarily of pahoehoe and aʻa lava flows, the Wailuku series consists of tholeiite, olivine tholeiite, and oceanite with hawaiite and alkalic basalt found at upper grades. (Macdonald, et al. 1983). The mountain range spans approximately 18 miles and is deeply dissected by stream erosion.

The Waiakoa Watershed extends from the shores of the central valley eastward to the upper elevations of Haleakalā. At approximately 800,000 years old, Haleakalā is the youngest of the two volcaones of Maui, with its most recent eruption occurring as recent as the late 1700's (Mink and Lau, 2006). Being a relatively young mountain, Haleakalā has had less time to erode from wind and rain. It remains largely in the shape of a dome – a shape that is representative of the shield volcanoes that have formed the Hawaiian islands. Waiakoa Watershed is located almost completely within the Kula volcanic series comprised predominantly of Hawaiite with lesser amounts of ankaramite and alkalic olivine basalt (Stearns and Macdonald, 1942).

3.2 Topography

A spatial analysis of the USGS, Digital Elevation Model (DEM) shows that slope ranges from 0 to 78 percent within the planning area for Waikapū (Figure 8. Waikapū Slope Map). Steeper slopes are associated with higher elevations, along the steep ridges and sides of Waikapū Gulch, and along the steep banks of Ooawa Kilika, Paleaahu, and Kaonohua Gulches. Waiakoa is less steep, with slopes ranging from 0 to 28 degrees, with the steeper portions occurring at the upper reaches of Haleakalā (Figure 9. Waiakoa Slope Map).

Figure 8. Waikapū Slope in Degrees

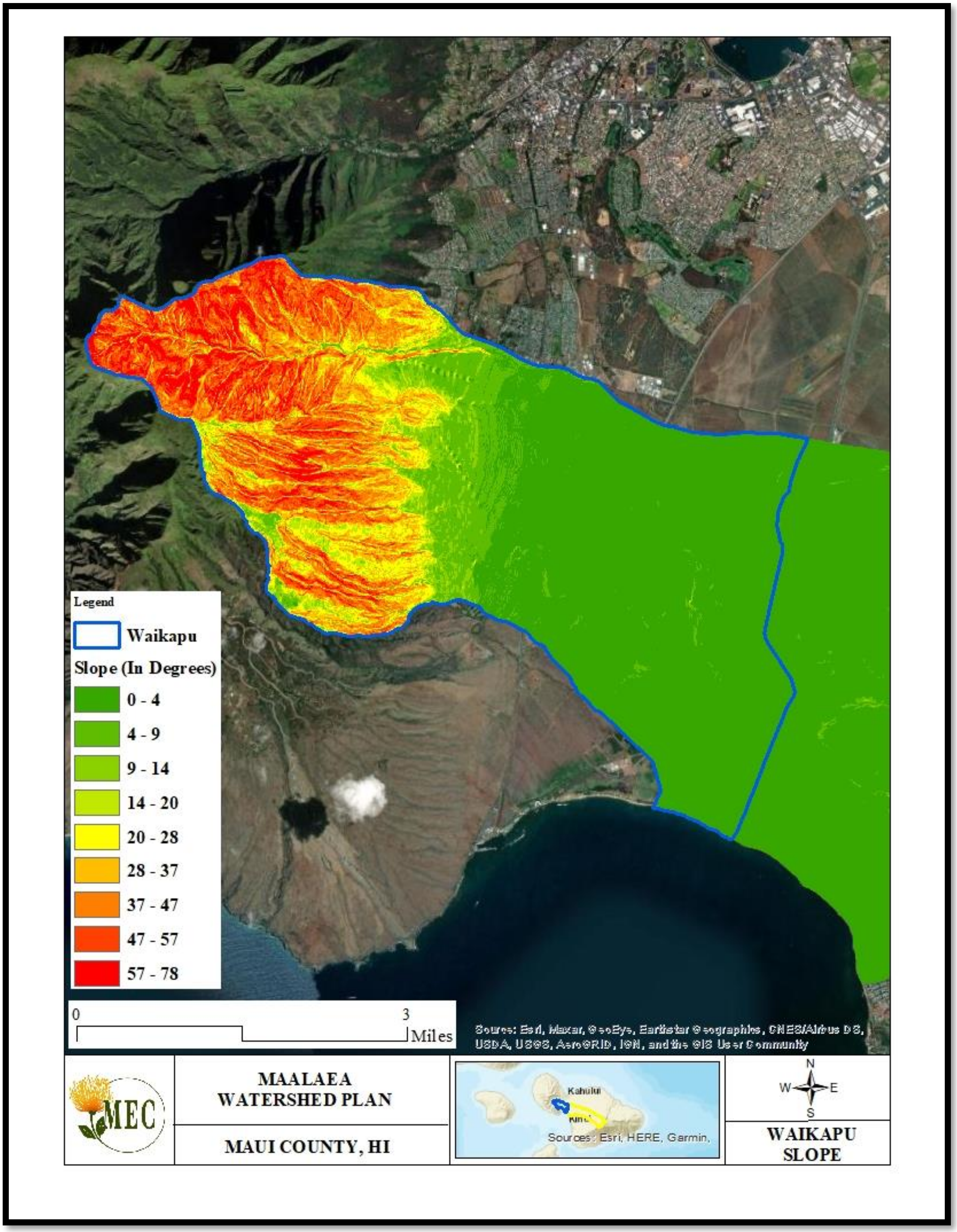
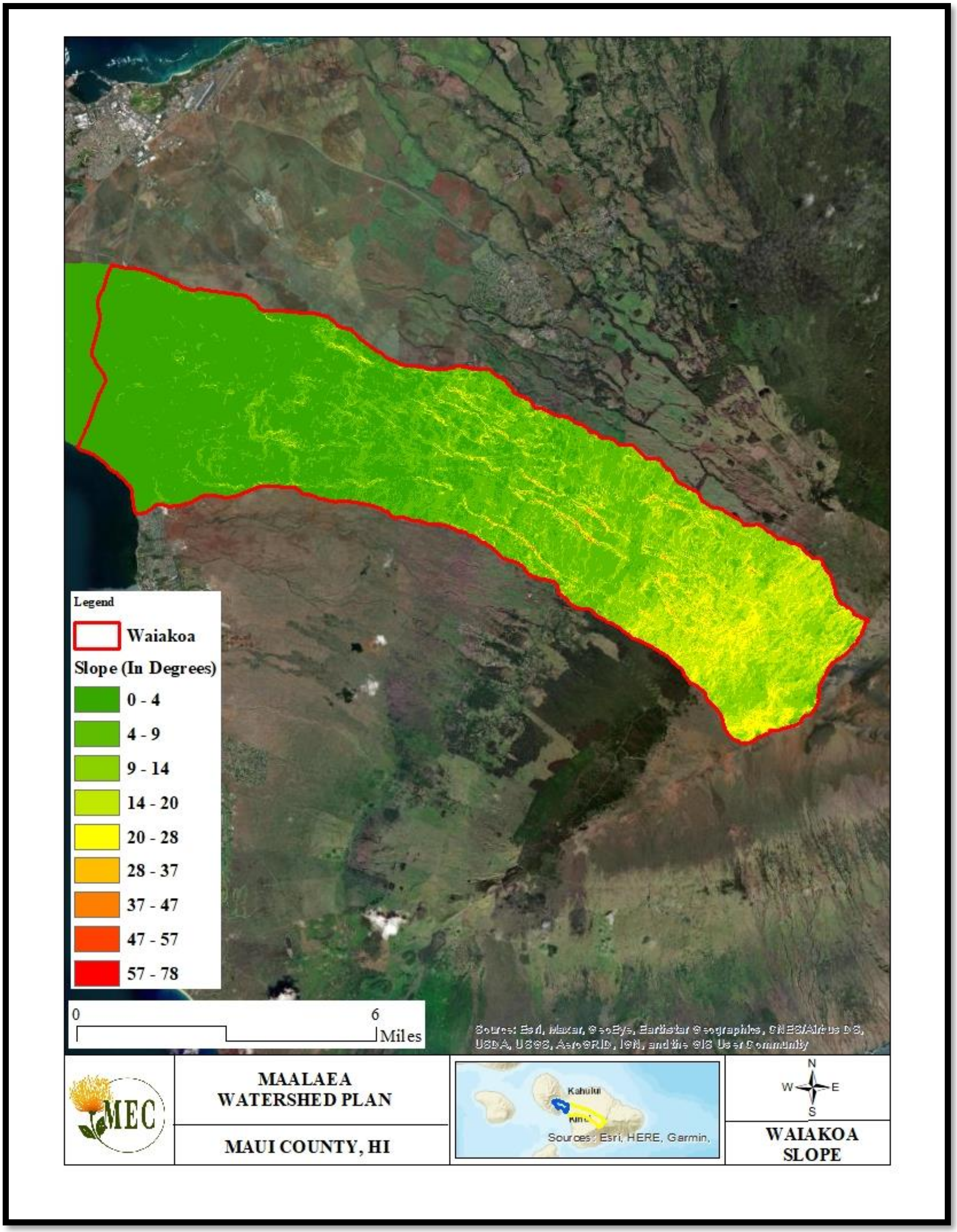


Figure 9. Waiakoa Slope in Degrees



3.3 Soils

Based on the USDA/NRCS Soil Survey for Maui County (Version 15, October 3rd, 2017), 30 soil types are mapped within the Waikapū Watershed (Figure 10. Waikapū Soils Map), and 54 soil types are mapped within the Waiakoa Watershed (Figure 11. Waiakoa Soils Map). Listed below are the soil types found within each watershed and general descriptions of their characteristics.

Table 2. Waikapū Watershed Soils

Soil Symbol	Soil Name	Mean Annual Precipitation (inches)	Elevation (feet)	Slope (percent)	Drainage Class	Runoff Class	Frequency of Flooding	Acreage	Percent of Watershed
AcA	Alae Cobbly Sandy Loam	14 to 19	20 to 380	0 to 3	Excessively Drained	Very Low	Occasional	6.18	0.06
BS	Beaches	10 to 75	0 to 10	1 to 5	Excessively Drained	Very Low	Frequent	11.39	0.11
EaA	Ewa Silty Clay Loam	16 to 23	0 to 240	0 to 3	Well Drained	Very Low	None	16.01	0.16
EcA	Ewa Cobbly Silty Clay Loam	15 to 20	0 to 10	0 to 3	Well Drained	Low	None	21.00	0.21
EsB	Ewa Silty Clay	17 to 25	0 to 320	3 to 7	Well Drained	Medium	None	59.23	0.58
GPI	Gravel Pits							35.88	0.35
IbB	Iao Cobbly Silty Clay	25 to 40	100 to 500	3 to 7	Well Drained	Medium	None	9.62	0.09
IcB	Iao Cobbly Silty Clay	25 to 40	100 to 500	7 to 15	Well Drained	Medium	None	403.39	3.94

Soil Symbol	Soil Name	Mean Annual Precipitation (inches)	Elevation (feet)	Slope (percent)	Drainage Class	Runoff Class	Frequency of Flooding	Acreage	Percent of Watershed
IcC	Iao Clay	32 to 41	390 to 870	7 to 15	Well Drained	Medium	None	40.54	0.40
JaC	Jaucas Sand	13 to 77	0 to 1,140	0 to 15	Excessively Drained	Low	Rare	1572.81	15.35
KMW	Keālia Silt Loam	10 to 41	0 to 260	0 to 1	Poorly Drained	Negligible	Frequent	264.22	2.58
NAC	Naiwa Silty Clay Loam	45 to 95	600 to 3,030	13 to 45	Well Drained	High	None	117.05	1.14
OFC	Olelo Silty Clay	60 to 10	1,430 to 3,420	15 to 50	Well Drained	High	None	12.88	0.13
OMB	Oli Silt Loam	30 to 40	1,000 to 2,250	3 to 10	Well Drained	Medium	None	117.19	1.14
PpA	Pūlehu Silt Loam	10 to 35	0 to 300	0 to 3	Well Drained	Low	Occasional	601.54	5.87
PpB	Pūlehu Silt Loam	10 to 35	0 to 300	3 to 7	Well Drained	Low	Occasional	239.57	2.34
PrA	Pūlehu Cobbly Silt Loam	10 to 35	0 to 300	0 to 3	Well Drained	Low	Occasional	120.21	1.17

Soil Symbol	Soil Name	Mean Annual Precipitation (inches)	Elevation (feet)	Slope (percent)	Drainage Class	Runoff Class	Frequency of Flooding	Acreage	Percent of Watershed
PrB	Pūlehu Cobbly Silt Loam	10 to 35	0 to 300	3 to 7	Well Drained	Medium	Occasional	373.21	3.64
PsA	Pūlehu Clay Loam	10 to 50	0 to 300	0 to 3	Well Drained	Low	Rare	460.42	4.49
PtA	Pūlehu Cobbly Clay Loam	10 to 35	0 to 300	0 to 3	Well Drained	Low	Occasional	144.00	1.41
PtB	Pūlehu Cobbly Clay Loam	10 to 35	0 to 300	3 to 7	Well Drained	Medium	Occasional	523.27	5.11
PZUE	Puuone Sand	20 to 30	50 to 350	7 to 30	Somewhat Excessively Drained	Medium	None	262.26	2.56
rRO	Rock Outcrop	10 to 175	0 to 10,000	5 to 99	Well Drained	Very High	None	937.07	9.15
rRR	Rough Broken Land	20 to 200	0 to 4,000	40 to 70	Well Drained	Very High	None	795.94	7.77
rRS	Rough Broken and Stony Land	20 to 200	0 to 4,000	40 to 70	Well Drained	Very High	Frequent	120.18	1.17

Soil Symbol	Soil Name	Mean Annual Precipitation (inches)	Elevation (feet)	Slope (percent)	Drainage Class	Runoff Class	Frequency of Flooding	Acreage	Percent of Watershed
rRT	Rough Mountainous Land	NA	0 to 6,000	50 to 99	Well Drained	Very High	None	2161.73	21.10
rSM	Stony Alluvial Land	10 to 50	0 to 1,000	3 to 15	Well Drained	Medium	Frequent	540.42	5.27
WvB	Wailuku Silty Clay	20 to 40	50 to 1,000	3 to 7	Well Drained	Medium	None	43.86	0.43
WvC	Wailuku Silty Clay	20 to 40	50 to 1000	7 to 15	Well Drained	Medium	None	234.49	2.29

*Precipitation data is associated with the USDA, NRCS soil descriptions.

The dominant soil type within Waikapū Watershed is rRt – Rough Mountainous Land. This soil type is found at the upper elevations, has steep slopes, and is well drained with very high runoff potential. Similar soil types include rRO – Rock Outcrop, rRR – Rough Broken Land, rRS – Rough Broken and Stony Land, and rRT – Rough Mountainous Land, are found throughout the upper and middle ranges of the watershed where slopes are steepest. NAC – Naiwa Silty Clay Loam and OFC – Olelo Silty Clay are also found in the upper reaches. Together, these soils have high runoff potential and make up approximately 40% of the land area within Waikapū Watershed.

Figure 10. Waikapū Soils Map

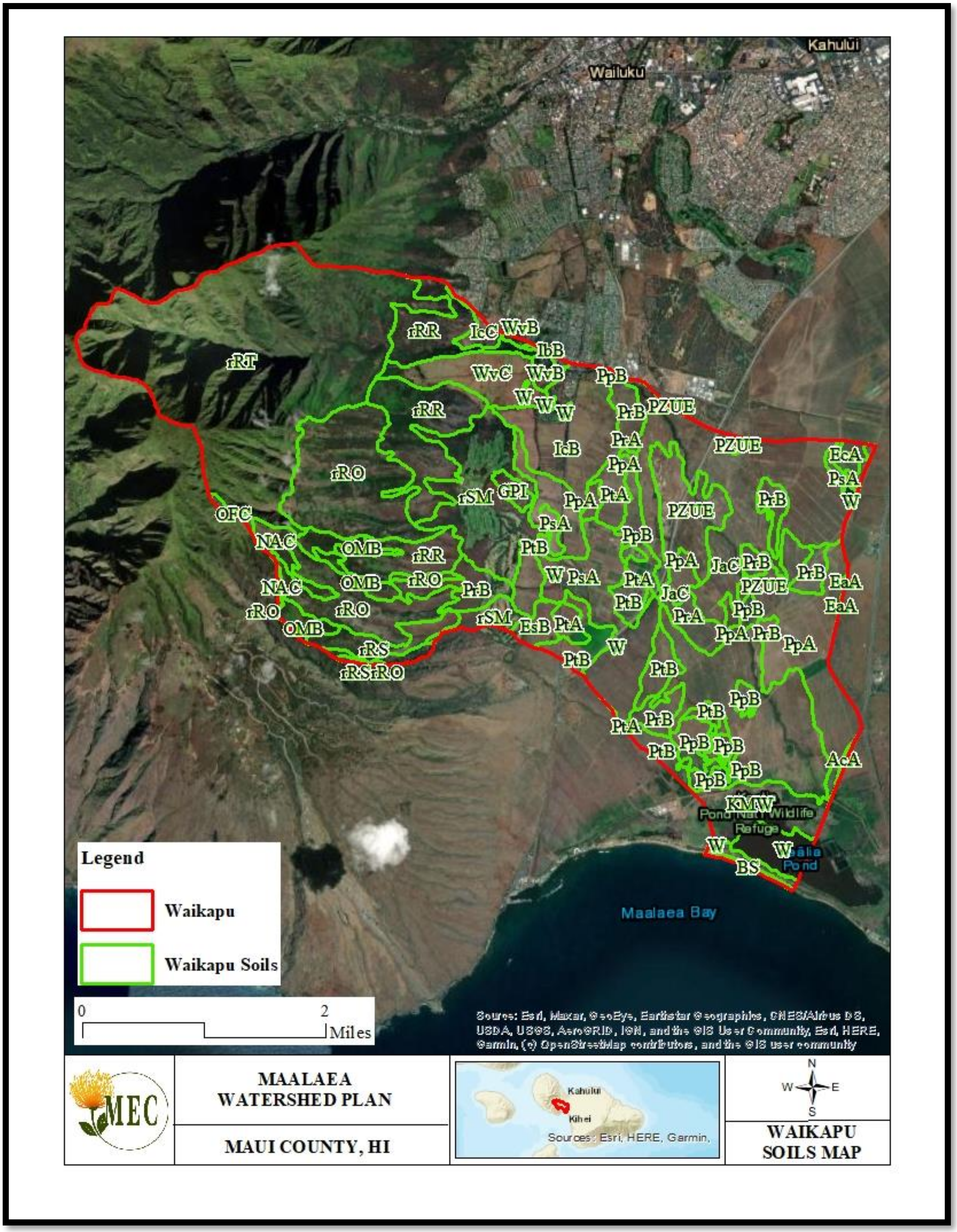


Table 3. Waiakoa Watershed Soils

Soil Symbol	Soil Name	Mean Annual Precipitation (inches)	Elevation (feet)	Slope (percent)	Drainage Class	Runoff Class	Frequency of Flooding	Acreage	Percent of Watershed
8	Lava Flows-Cinder Land Complex	15 to 30	6,560 to 13,680	2 to 40	Excessively Drained	Very Low	NA	2718.14	7.73
AaB	Alae Sandy Loam	13 to 19	10 to 450	3 to 7	Excessively Drained	Low	Occasional	579.76	1.65
AcA	Alae Cobbly Sandy Loam	14 to 19	20 to 380	0 to 3	Excessively Drained	Very Low	Occasional	660.82	1.88
AcB	Alae Cobbly Sandy Loam	14 to 20	90 to 400	3 to 7	Excessively Drained	Low	Occasional	186.88	0.53
BS	Beaches	10 to 75	0 to 10	1 to 5	Excessively Drained	Very Low	Frequent	22.53	0.06
DL	Dune Land	15 to 90	0 to 150	NA	NA	NA	NA	37.81	0.11
EaA	Ewa Silty Clay Loam	16 to 23	0 to 240	0 to 3	Well Drained	Very Low	None	596.64	1.70
EcA	Ewa Cobbly Silty Clay Loam	15 to 20	0 to 10	0 to 3	Well Drained	Low	None	376.40	1.07
EcB	Ewa Cobbly Silty Clay Loam	16 to 17	120 to 220	3 to 7	Well Drained	Medium	None	423.03	1.20
IaA	Iao Silty Clay	25 to 40	100 to 500	0 to 3	Well Drained	Low	None	0.25	0.00

Soil Symbol	Soil Name	Mean Annual Precipitation (inches)	Elevation (feet)	Slope (percent)	Drainage Class	Runoff Class	Frequency of Flooding	Acreage	Percent of Watershed
JaC	Jaucas Sand	13 to 77	0 to 1,140	0 to 15	Excessively Drained	Low	Rare	11.91	0.03
KDIE	Kaipoioi Loam	30 to 45	3,500 to 6,000	7 to 40	Well Drained	High	None	1790.65	5.09
KDVE	Kaipoioi Very Rocky Loam	10 to 175	0 to 10,000	7 to 40	Well Drained	High	None	265.37	0.75
KGKC	Kamaole Very Stony Silt Loam	15 to 25	1,500 to 2,300	3 to 15	Well Drained	Medium	High	2196.21	6.25
KGLC	Kamaole Extremely Stony Silt Loam	15 to 25	1,500 to 2,300	3 to 15	Well Drained	Medium	None	6.63	0.02
KMW	Keālia Silt Loam	10 to 41	0 to 260	0 to 1	Poorly Drained	Negligible	Frequent	207.75	0.59
KnaB	Keahua Cobbly Silty Clay Loam	15 to 25	600 to 1,500	3 to 7	Well Drained	Medium	None	714.15	2.03
KnaC	Keahua Cobbly Silty Clay Loam	15 to 25	600 to 1,500	7 to 15	Well Drained	Medium	None	1501.00	4.27
KnaD	Keahua Cobbly Silty Clay Loam	15 to 25	600 to 1,500	15 to 25	Well Drained	High	None	315.83	0.90

Soil Symbol	Soil Name	Mean Annual Precipitation (inches)	Elevation (feet)	Slope (percent)	Drainage Class	Runoff Class	Frequency of Flooding	Acreage	Percent of Watershed
KnB	Keahua Silty Clay Loam	15 to 25	600 to 1,500	3 to 7	Well Drained	Low	None	1101.14	3.13
KnbD	Keahua Very Stony Silty Clay Loam	15 to 25	600 to 1,500	1 to 25	Well Drained	Medium	None	1025.75	2.92
KnC	Keahua Silty Clay Loam	15 to 25	600 to 1,500	7 to 15	Well Drained	Medium	None	744.51	2.12
KncC	Keahua Silty Clay	15 to 25	600 to 1,500	7 to 15	Well Drained	Medium	None	106.67	0.30
KnhC	Keahua Cobbly Silty Clay	15 to 25	600 to 1,500	7 to 15	Well Drained	Medium	None	532.36	1.51
KnsC	Keahua Stony Silty Clay	15 to 25	600 to 1,500	7 to 15	Well Drained	Medium	None	327.88	0.93
KxaD	Kula Cobbly Medial Loam	25 to 40	2,000 to 3,500	12 to 20	Well Drained	Medium	None	1524.63	4.34
KxbE	Kula - Rock Outcrop Complex	25 to 40	2,000 to 3,500	12 to 40	Well Drained	Medium	None	125.63	0.36
KxC	Kula Loam	25 to 40	2,000 to 3,500	4 to 12	Well Drained	Low	None	78.34	0.22

Soil Symbol	Soil Name	Mean Annual Precipitation (inches)	Elevation (feet)	Slope (percent)	Drainage Class	Runoff Class	Frequency of Flooding	Acreage	Percent of Watershed
KxD	Kula Loam	25 to 40	2,000 to 3,500	12 to 20	Well Drained	Low	None	1293.13	3.68
LME	Laumaia Loam	35 to 70	5,500 to 8,000	7 to 40	Well Drained	Medium	None	1243.50	3.54
LMF	Laumaia Loam	35 to 70	5,500 to 8,000	40 to 70	Well Drained	Medium	None	506.26	1.44
LNE	Laumaia Extremely Stony Loam	35 to 70	5,500 to 8,000	7 to 40	Well Drained	Medium	None	2047.30	5.82
MuA	Molokai Silty Clay Loam	20 to 25	0 to 1,500	0 to 3	Well Drained	Low	None	39.36	0.11
MuB	Molokai Silty Clay Loam	20 to 25	0 to 1,500	3 to 7	Well Drained	Medium	None	7.66	0.02
PpA	Pūlehu Silt Loam	10 to 35	0 to 300	0 to 3	Well Drained	Low	Occasional	797.78	2.27
PpB	Pūlehu Silt Loam	10 to 35	0 to 300	3 to 7	Well Drained	Low	Occasional	499.38	1.42
PrA	Pūlehu Cobbly Silt Loam	10 to 35	0 to 300	0 to 3	Well Drained	Low	Occasional	613.52	1.74
PrB	Pūlehu Cobbly Silt Loam	10 to 35	0 to 300	3 to 7	Well Drained	Medium	Occasional	121.00	0.34

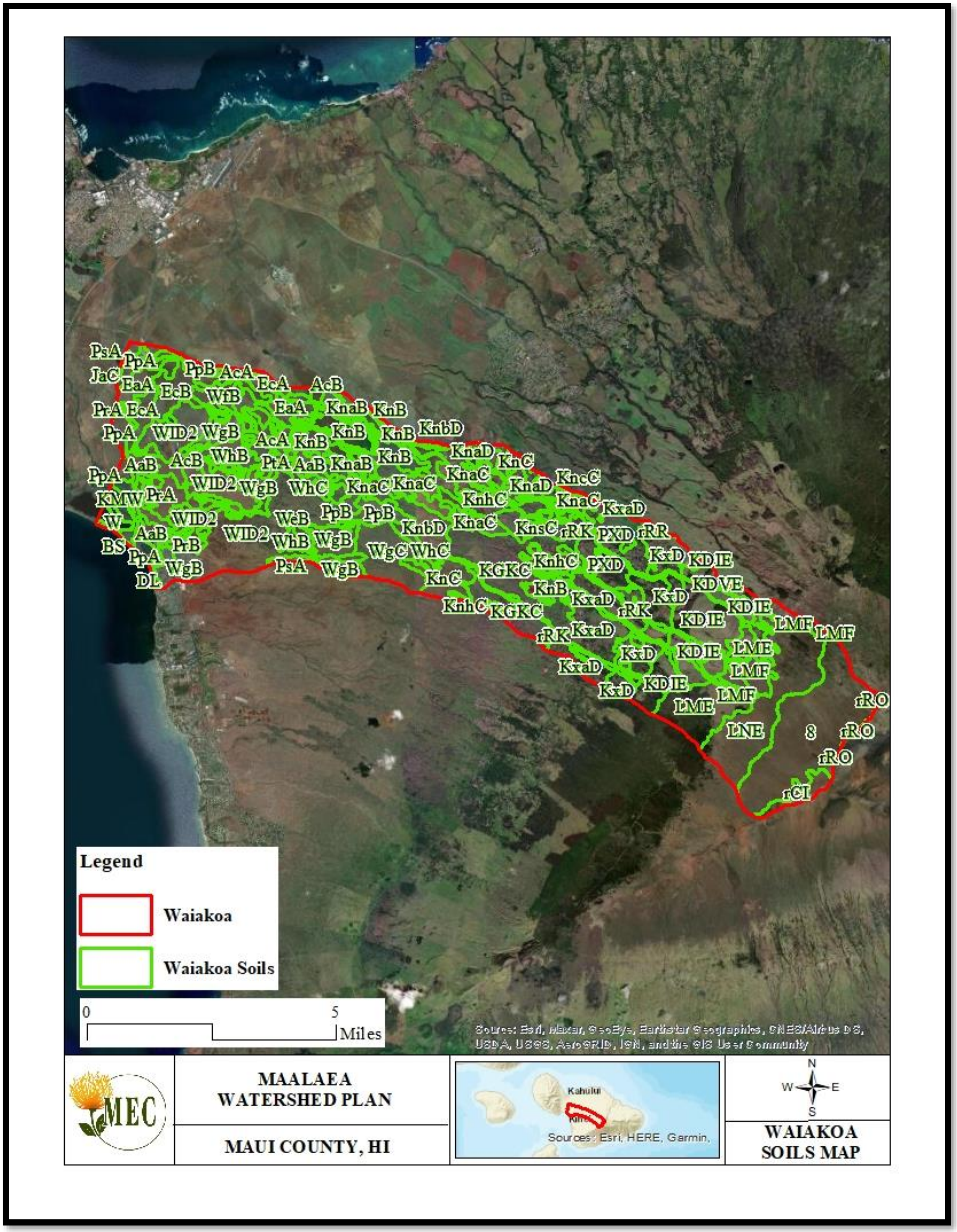
Soil Symbol	Soil Name	Mean Annual Precipitation (inches)	Elevation (feet)	Slope (percent)	Drainage Class	Runoff Class	Frequency of Flooding	Acreage	Percent of Watershed
PsA	Pūlehu Clay Loam	10 to 50	0 to 300	0 to 3	Well Drained	Low	Rare	202.44	0.58
PtA	Pūlehu Cobbly Clay Loam	10 to 35	0 to 300	0 to 3	Well Drained	Low	Occasional	212.85	0.61
PXD	Pane Silt Loam	30 to 50	2,000 to 3,500	7 to 25	Well Drained	Low	None	1093.81	3.11
rCI	Cinder Land	20 to 100	8,000 to 10,000	NA	NA	NA	NA	240.45	0.68
rRK	Rock Land	15 to 60	0 to 6,000	0 to 70	Well Drained	Very High	None	949.96	2.70
rRO	Rock Outcrop	10 to 175	0 to 10,000	5 to 99	Well Drained	Very High	None	10.66	0.03
rRR	Rough Broken Land	20 to 200	0 to 4,000	40 to 70	Well Drained	Very High	None	12.79	0.04
WeB	Waiakoa Silty Clay Loam	12 to 20	100 to 1,000	3 to 7	Well Drained	Medium	None	239.38	0.68
WeC	Waiakoa Silty Clay Loam	12 to 20	100 to 1,000	7 to 15	Well Drained	Medium	None	35.58	0.10
WfB	Waiakoa Cobbly Silty Clay Loam	12 to 20	100 to 1,000	3 to 7	Well Drained	Medium	None	120.75	0.34

Soil Symbol	Soil Name	Mean Annual Precipitation (inches)	Elevation (feet)	Slope (percent)	Drainage Class	Runoff Class	Frequency of Flooding	Acreage	Percent of Watershed
WgB	Waiakoa Very Stony Silty Clay Loam	14 to 21	100 to 1,000	3 to 7	Well Drained	Medium	None	1331.09	3.79
WgC	Waiakoa Very Stony Silty Clay Loam	16 to 21	750 to 1,150	7 to 15	Well Drained	Medium	None	802.62	2.28
WhB	Waiakoa Extremely Stony Silty Clay Loam	14 to 19	20 to 460	3 to 7	Well Drained	Medium	None	259.28	0.74
WhC	Waiakoa Extremely Stony Silty Clay Loam	17 to 19	460 to 1,280	7 to 15	Well Drained	Medium	None	249.05	0.71
WID2	Waiakoa Extremely Stony Silty Clay Loam	14 to 19	100 to 1,000	3 to 25	Well Drained	High	None	4055.99	11.53

*Precipitation data is associated with the USDA, NRCS soil descriptions.

There are 54 different soil types within Waiakoa Watershed that differ in clay, sand, and silt content and also in texture, slope, and aggregate size. The dominant soil type within Waiakoa Watershed is WID2 – *Waiakoa Extremely Stony Silty Clay Loam*. This soil has a depth of 20 to 40 inches and is well drained. The water movement in the most restrictive layer is moderately high, available water to a depth of 60 inches is low, shrink-swell potential is low, there is no zone of water saturation within a depth of 72 inches, the organic matter content in the surface horizon is about 2 percent, it does not meet hydric criteria, and it can be found on slopes that range from 3 to 25 percent (Soil Conservation Service, 2001).

Figure 11. Waiakoa Soils Map



3.4 Climate

The climate on the island of Maui is highly variable. Its proximity to the equator, steep volcanic peaks, and consistent trade winds, create subsidence inversions that greatly influence the weather patterns of the island (Giambelluca & Nullet, 1991). Orographic rainfall occurs on the windward side as the moisture from the ocean is uplifted and cools to form rain at upper elevations of the mountain, where the highest rainfall occurs. Rainfall decreases gradually toward the coastline as elevations descend. On windward sides of the mountains, northeasterly trade winds generate heavy rainfall while the leeward sides remain dry. Generally speaking, there is a wet winter season (October to April) and a dry summer season (May to September).

3.5 Precipitation

The Waikapū 390 rain gauge located at 20.8536 degrees latitude and -156.5088 degrees longitude with an elevation of 483 feet was used to represent rainfall within Waikapū Watershed. The Kula Branch Station rain gauge lies within Waiakoa Watershed at 20.75868 degrees latitude and -156.3211 degrees longitude at an elevation of 3125 feet. Rainfall data from the nearby Haleakalā Ranger Station rain gauge was also used to reference rainfall amounts for upper elevations of Waiakoa Watershed. It is located less than 2,000 feet, or 0.3 miles, to the north of the watershed boundary. Additional rainfall data was reviewed from GIS generated isohyets. Data used to generate the isohyets (Figure 13. Waikapū Rainfall Map and Figure 14. Waiakoa Rainfall Map) were pulled from the State of Hawaiʻi, Office of Planning Geographic Information System Data Portal.

To capture recent rainfall trends associated with the Māʻalaea Bay Watersheds, the last five years (2018-2022) of rainfall data from the Waikapū 390 station, Kula Branch Station, and Haleakalā Ranger Station were analyzed. The period-of-record began 16 August 1916 and continues through present day. Monthly and annual rainfall totals are displayed in the tables below. The island of Maui has experienced varying levels of drought conditions during the past five years, and rainfall amounts coincide with the drought conditions reported by NOAA's National Integrated Drought Information System. From 2018 until the end of 2022, drought conditions increased in both duration and intensity (U.S. Drought Monitor, 2023) (Figure 12. Maui Drought Conditions from 2018-2022).

Table 4. Waikapū 390 Rainfall by Month from 2018 to 2022

Month	Year				
	2018	2019	2020	2021	2022
January	0.05	2.56	1.37	5.61	0.32
February	8.92	6.49	2.95	1.75	0.00
March	2.19	0.75	1.89	4.51	0.07
April	4.89	No Data	1.6	0.07	0.12
May	1.85	1.24	0.85	0.07	0.02
June	0.05	0	0	0.02	0.06
July	0.67	0.08	0.01	0	0.04
August	1.34	0.44	0.01	0.24	0.16
September	4.36	0.01	0.21	0.02	0.34
October	2.11	0.29	0.36	0.12	0.62
November	2.73	0.28	0.09	0	0.3

Month	Year				
	2018	2019	2020	2021	2022
December	1.29	0.61	0	3.6	0.78
Totals	30.45	12.75	9.34	16.01	2.83

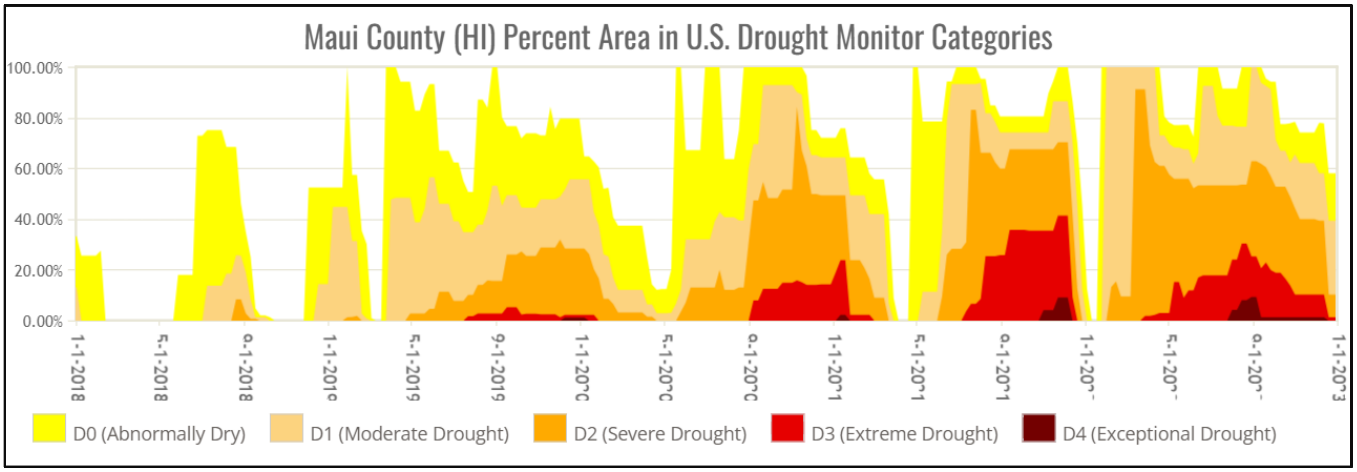
Table 5. Kula Branch Station Rainfall by Month from 2018 to 2022

Month	Year				
	2018	2019	2020	2021	2022
January	2.34	2.16	1.69	0.91	0.05
February	8.9	9.77	2.54	1.05	0.67
March	3.05	0.11	7.18	2.75	0.36
April	5.38	1.93	3.4	0.29	0.07
May	1.62	3.59	1.23	1.00	0.11
June	0.04	0.85	0.52	0.00	0.22
July	0.48	0.31	2.7	0.01	0
August	6.51	3.48	0.1	0.45	0.54
September	3.5	2.75	0.7	0.65	0.2
October	2.37	0.43	4.08	0.23	0.85
November	0.4	1.55	0.12	0.16	0.78
December	0.05	1.45	0.17	1.39	5.84
Totals	34.64	28.38	24.43	8.89	9.69

Table 6. Haleakalā Ranger Station Rainfall by Month from 2018 to 2022

Month	Year				
	2018	2019	2020	2021	2022
January	0.48	No Data	14.12	11.76	0.3
February	5.99	No Data	No Data	2.17	0.25
March	1.83	No Data	No Data	14.99	0.22
April	7.49	No Data	No Data	2.14	1.2
May	1.35	No Data	No Data	1.91	No Data
June	0.49	No Data	No Data	0.1	0.91
July	1.56	No Data	0.61	0.2	0.46
August	4.11	No Data	0.06	2.11	0.45
September	2.43	No Data	0.23	0.9	0.98
October	No Data	No Data	1.25	10.7	0.26
November	No Data	0	1.9	1.43	2.59
December	No Data	5.48	2.76	14.86	10.01
Totals	25.73	5.48	20.93	63.27	17.63

Figure 12. Maui Drought Conditions from 2018-2022



*The U.S. Drought Monitor is jointly produced by the National Drought Mitigation Center at the University of Nebraska-Lincoln, the United States Department of Agriculture, and the National Oceanic and Atmospheric Administration. Graph courtesy of NDMC.

Figure 13. Waikapū Rainfall Map

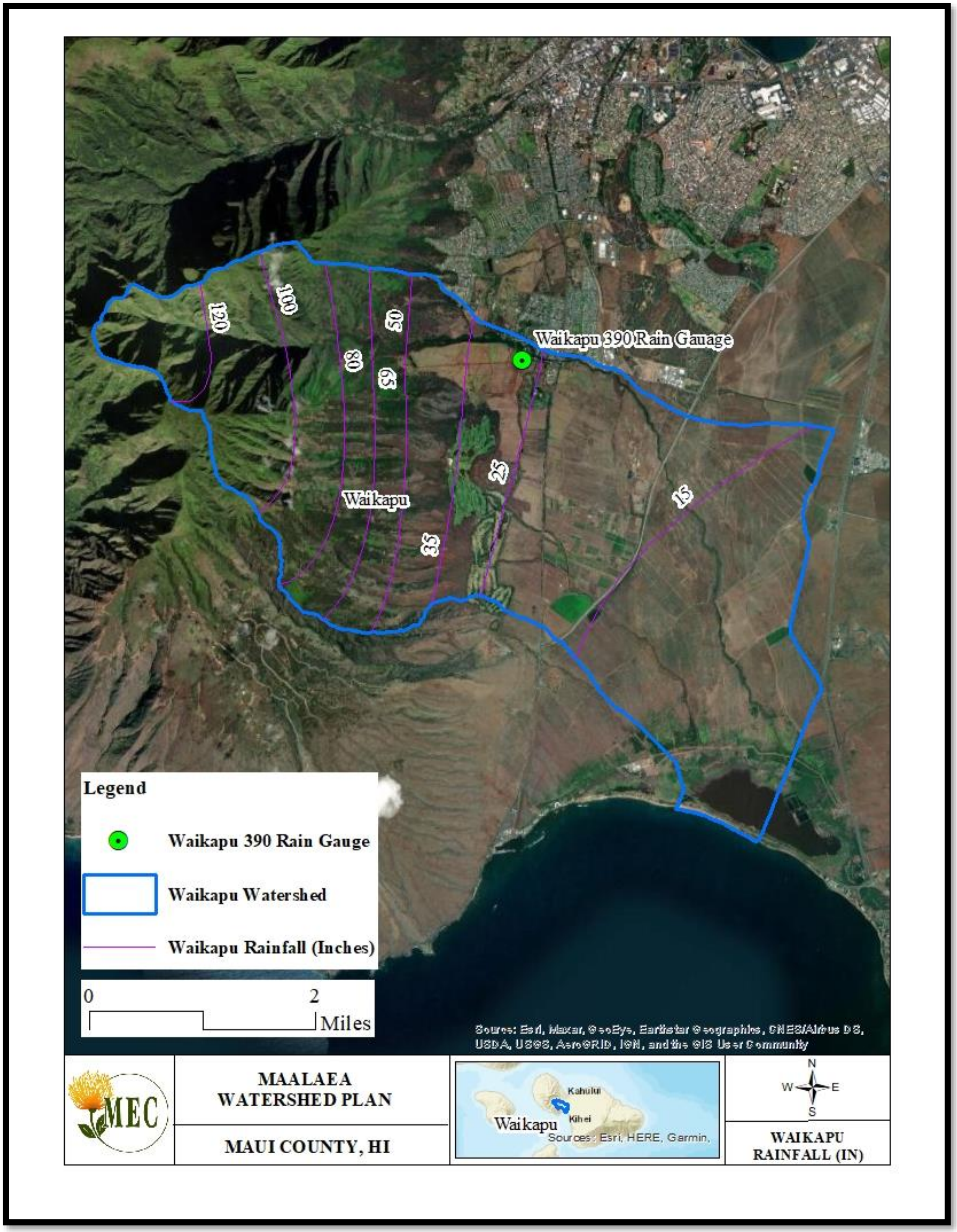
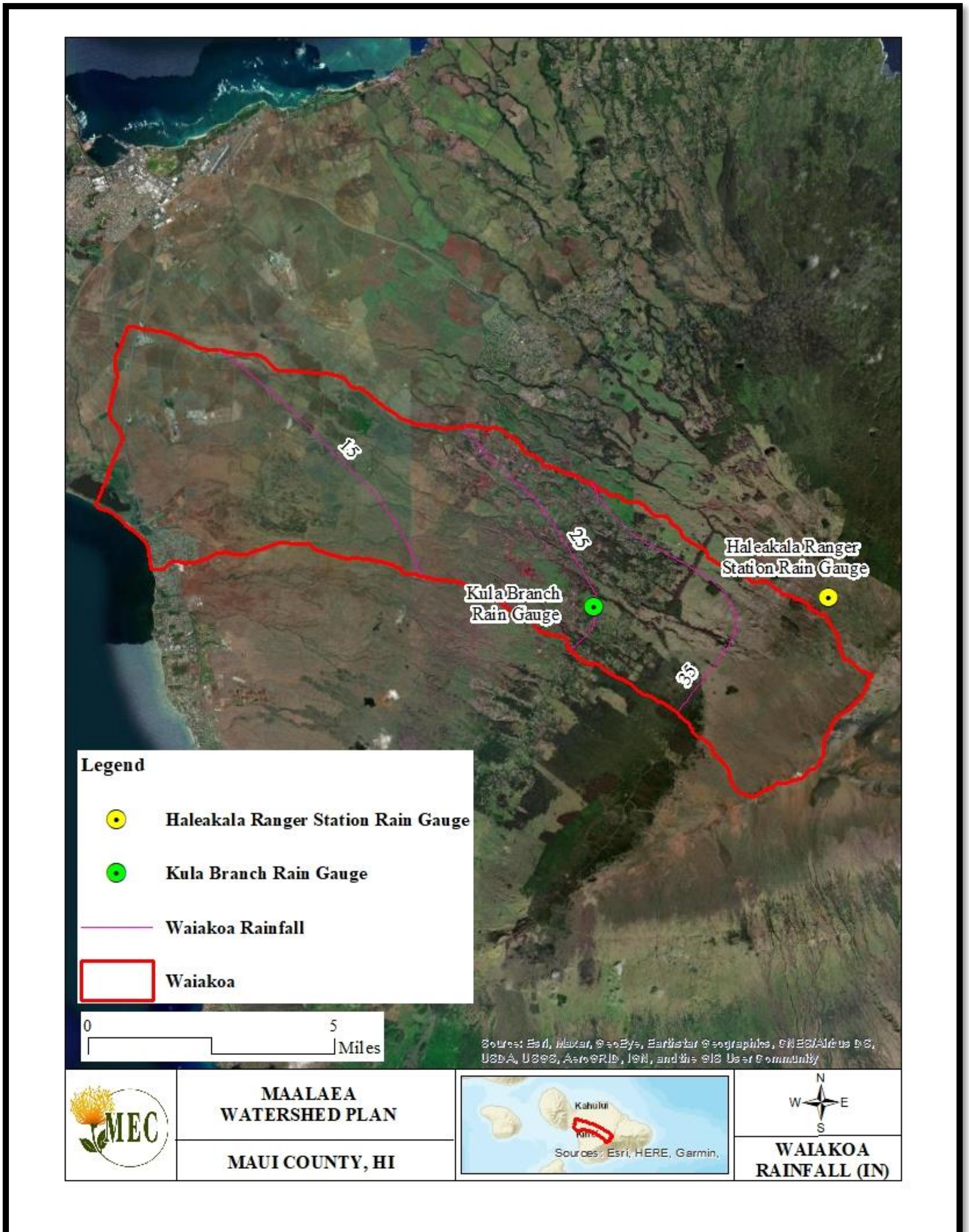


Figure 14. Waiakoa Rainfall Map



3.6 Hydrology

3.6.1 Surface Water: Māʻalaea Bay Watershed Landscape and Major Drainageways

Table 7. Māʻalaea Watershed Streams

Watershed	Streams/Gulches	Classification
Waikapū	Waikapū	Perennial
	Ooawa Kilika Gulch	Ephemeral
	Paleaahu Gulch	Ephemeral
	Kaonohua Gulch	Ephemeral
Waiakoa	Pohaku o ka La Gulch	Ephemeral
	Pūlehu Gulch	Ephemeral
	Kolaloa Gulch	Ephemeral
	Waikapū	Ephemeral
	Keahuaiwi Gulch	Ephemeral
	Waiakoa Gulch	Ephemeral

3.6.1.1 Waikapū Watershed Streams

Waikapū Watershed consists of two major drainage ways, both of which are referred to as Waikapū Stream (Figure 15. Waikapū Streams and Wetlands Map). The northern-most Waikapū Stream originates at apporximately 3,300 feet in the West Maui Mountains and has several smaller tributaries that flow into it at upper elevations. It flows due east until it reaches Honoapiʻilani Highway at 400 feet of elevation, and then bends to the south where it discharges into Keālia Pond. This is the only perennial stream within the Māʻalaea Bay Watersheds.

To the south exists several tributaries that flow into an ephemeral stream that is also named Waikapū Stream. The two northern most tributaries are referenced as Waikapū, and they merge into the main stream at approximately 440 feet of elevation. Moving to the south are Ooawa Kilika, Paleaahu, and Kaonohua Gulches, each of which merge into Waikapū Stream at approximately 400 feet of elevation. These gulches all join together into one stream at approximately 220 feet of elevation in between Honoapiʻilani Highway and Kuihelani Highway. The Waikapū Stream flows southeast into Keālia Pond.

3.6.1.2 Waiakoa Watershed Streams

The streams within Waiakoa watershed are all ephermeral (Figure 16. Waiakoa Streams and Wetlands Map). Pohaku o Ka La Gulch and Pūlehu Gulch originate at approximately 8,000 feet and 6,400 feet of elevation respectively. Pūlehu Gulch merges into Pohaku o ka La Gulch at approximately 4,400 feet and continues northwest into the central isthmus of Maui. The gulch makes a sharp bend to the south where it then flows into Keālia Pond. Makai of Mokulele Highway, this gulch is essentially a ditch as it passes through agricultural lands.

At approximately 8,000 feet Kalaloa Gulch begins flowing. It flows northwest before turning southwest. Like Pūlehu Gulch, Kalaloa enters a ditch system immediately west of Mokulele Highway before discharging into Keālia Pond.

Keahuaiwi Gulch begins at approximately 8,100 feet. This gulch runs generally west through Kula and agricultural lands before discharging into a narrow strip of land immediately north of the intersection of North and South Kīhei Roads. This swale is intended to discharge into the eastern boundary of Keālia Pond but often floods roads and condos associated with the area.

Waiakoa Gulch runs parallel to Keahuaiwi Gulch, originating at approximately 5,000 feet. This gulch also runs through Kula and agricultural lands before discharging into the Pacific Ocean just north of the Kīhei Canoe Club and just south of the intersection of South and North Kīhei Roads.

Figure 15. Waikapū Streams and Wetlands Map

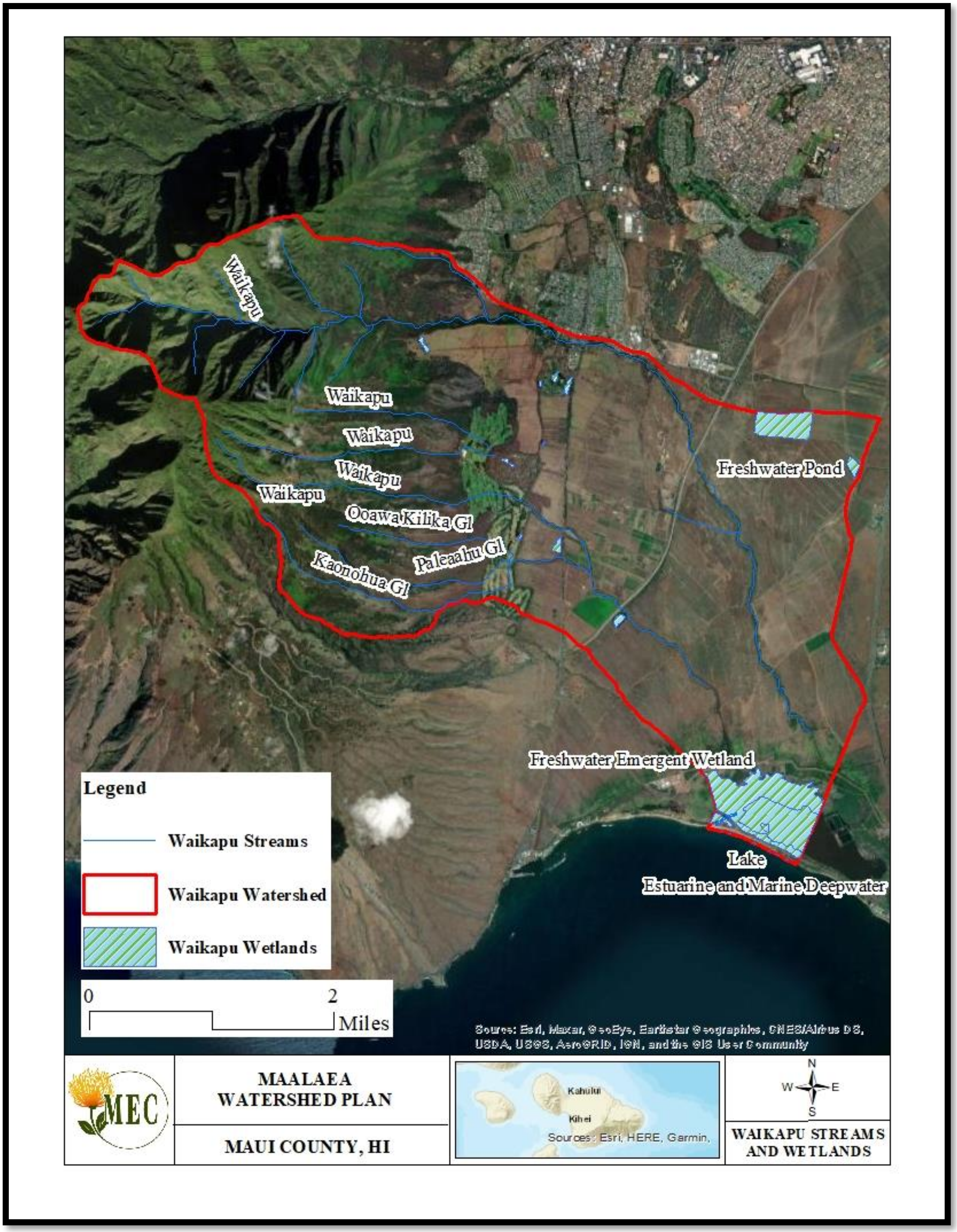
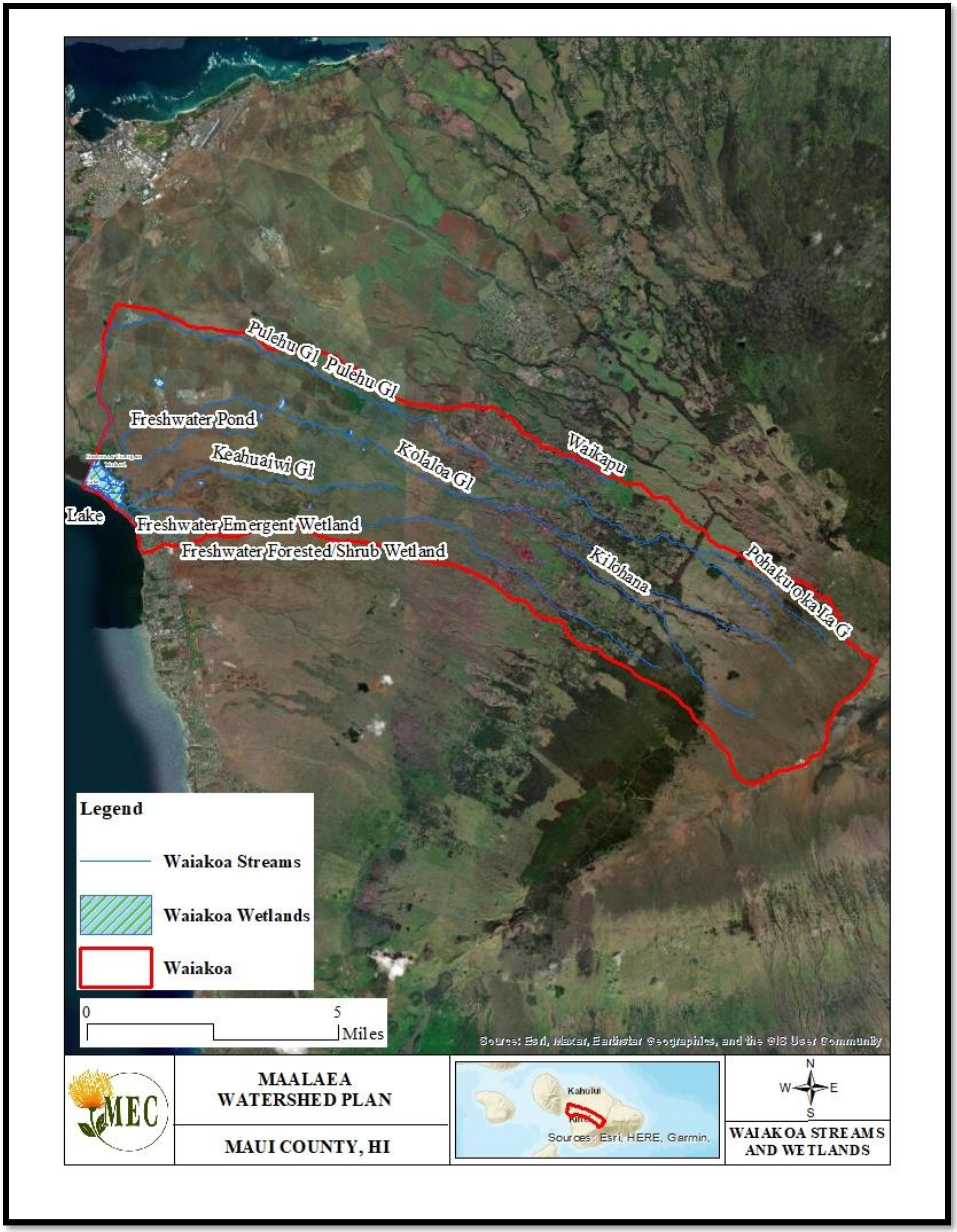


Figure 16. Waiakoa Streams and Wetlands Map



3.6.2 Surrounding Watersheds

There are five watersheds surrounding the Waikapū Watershed (Figure 17. Waikapū Surrounding Watersheds Map). These include ʻĪao to the north, Waiakoa to the east, Pōhākea to the south, Ukumehame to southwest, and small section of Olowalu along the western edge. Waiakoa Watershed is adjacent to Kalialinui to the north, Piinau, Manawainui Gulch, and Kipapa along the southeastern edge, Hāpapa to the south, and Waikapū to the west, and a small shared boundary with ʻĪao on the northwestern corner (Figure 18. Waiakoa Surrounding Watersheds Map). The major surrounding watersheds are discussed below.

3.6.2.1 ʻĪao Watershed

The ʻĪao Watershed is approximately 14,290 acres and borders the Waikapū Watershed to the north. Beginning in the highest peaks of the West Maui Mountains 5,788 feet, the ʻĪao Watershed extends in a northeasterly direction to the coastal waters of the north central valley of Maui. It encompasses the cities of Wailuku and Kahului almost entirely. The major streams of ʻĪao Watershed include ʻĪao, Puulio, and Kaiapaokailio.

3.6.2.2 Kalialinui Watershed

The Kalialinui Watershed is approximately 19,187 acres, and borders Waiakoa Watershed along its length to the north. It originates at an elevation of 9,300 feet on Haleakalā, and extends northwest to the northern coastlines of Maui's central valley. Three major streams/gulches exist within the Kalialinui Watershed. All are ephemeral and generally flow northwest. They include Kalialinui Gulch, Kaluapulani Gulch, and Waiale Gulch.

3.6.2.3 Hāpapa Watershed

The Hāpapa Watershed borders the Waiakoa Watershed along its southern boundaries. This watershed, along with Wailea and Mooloa Watersheds make up the Southwest Maui Watershed Plan approved in 2020. It spans 26,493 acres from the coastal waters of North Kīhei to the southeast where it reaches elevations of 9,400 feet on the slopes of Haleakalā. The four major streams within Hāpapa Watershed are Kūlanihākoʻi Gulch, Waipuilani Gulch, Kēōkea Gulch, and Waimahaihai Gulch. Each of these streams are ephemeral and flow in a westerly direction into the coastal waters of Kīhei.

3.6.2.4 Pōhākea Watershed

The Pōhākea Watershed encompasses 5,268 acres, and is located directly southeast of the Waikapū Watershed. It begins at approximately 4,600 feet at the summit of Hanaula within the West Maui Mountains. Along the coast, this watershed stretches from Keālia Pond and continues west past McGregor's Point. The four major streams associated with the watershed are Pōhākea, Kanaio, Māʻalaea, and Malalowaiaole, all of which have ephemeral flow regimes. Pōhākea Gulch discharges into Keālia Pond and ulitmately into Māʻalaea Bay. This watershed plan was approved in 2023.

Figure 17. Waikapū Surrounding Watersheds

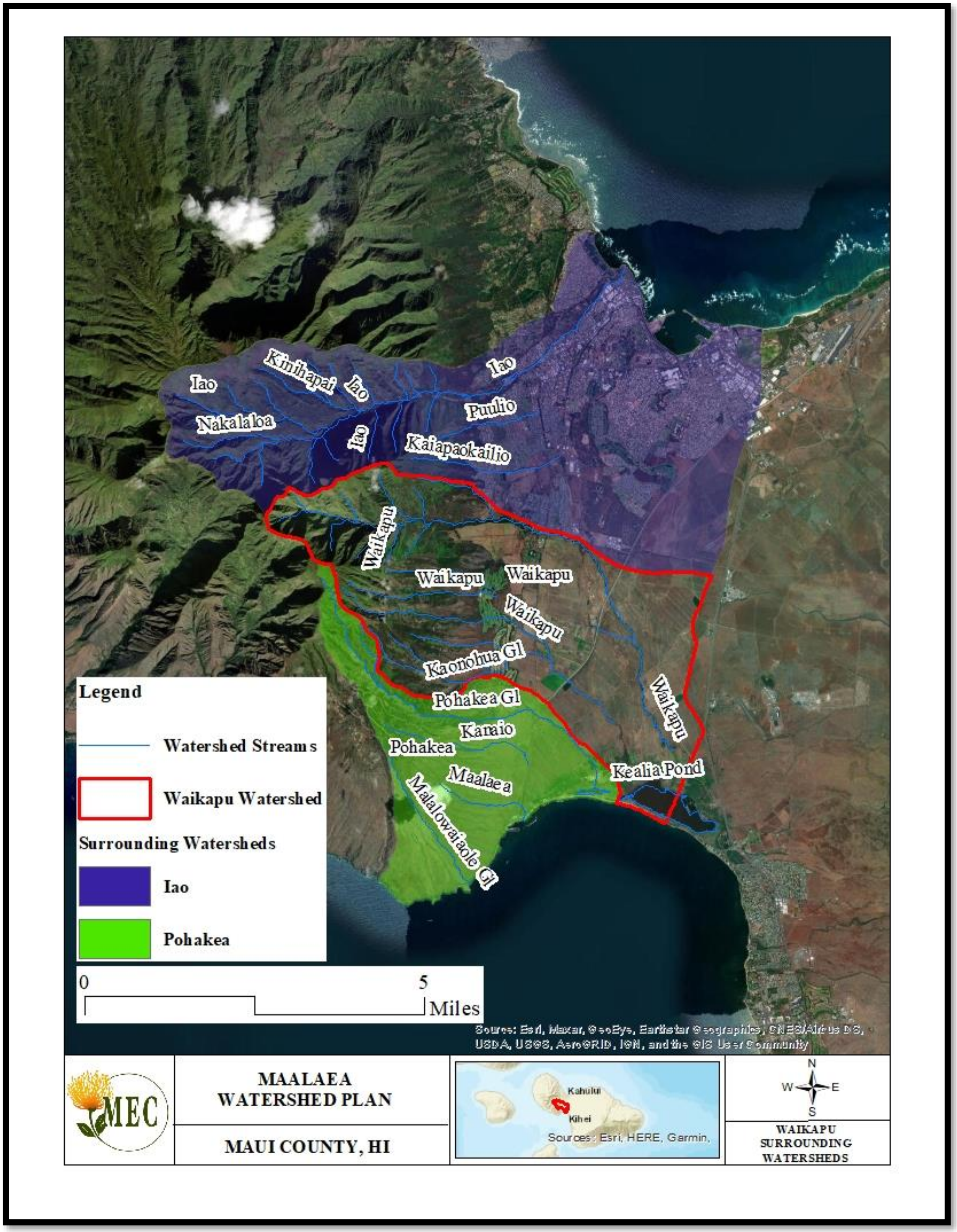
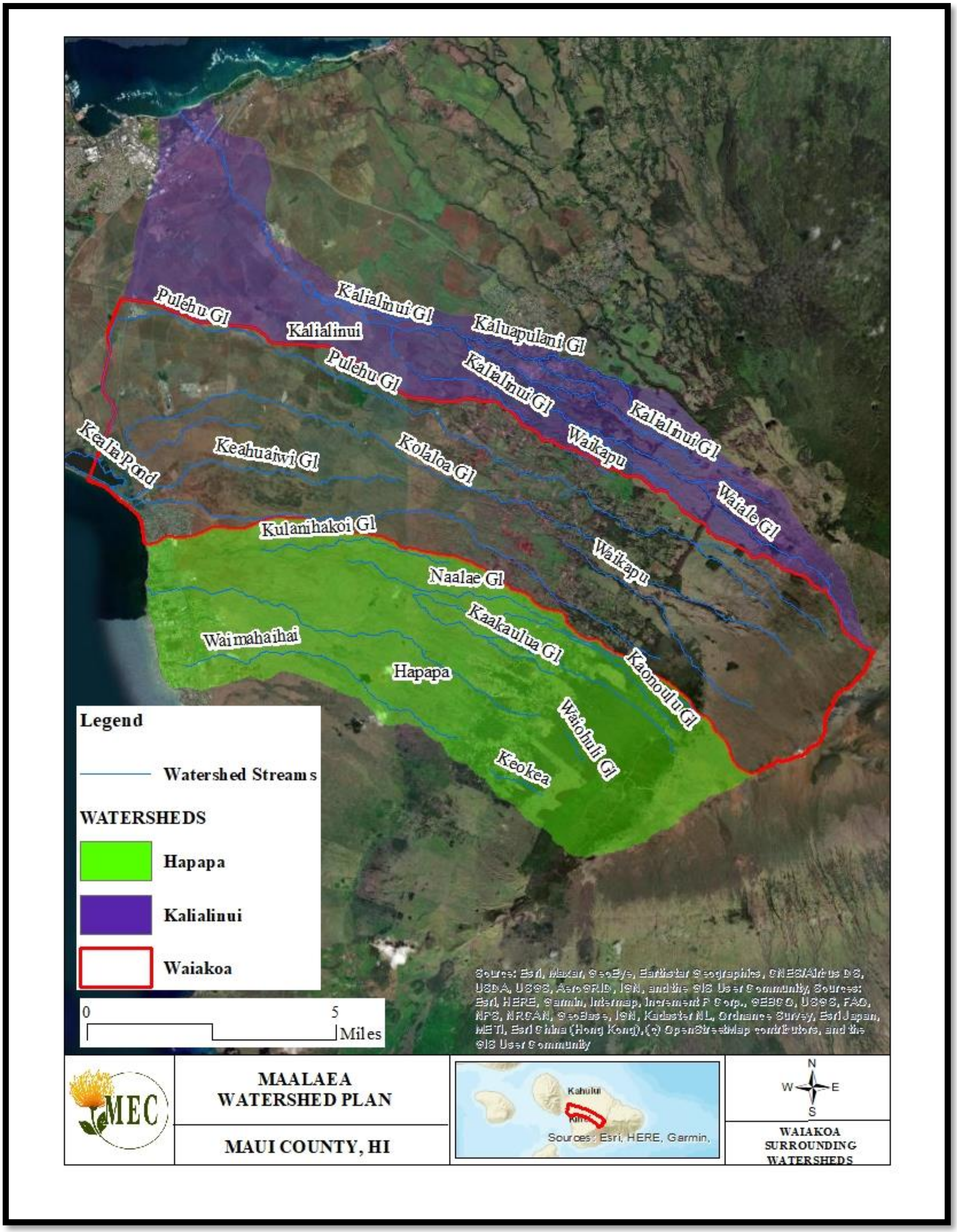


Figure 18. Waiakoa Surrounding Watersheds



3.7 Terrestrial Habitat

The Māʻalaea Bay Watersheds are divided into four land use districts: conservation, agriculture, rural, and urban. Of those four districts, conservation lands make up 7,823.59 acres, or 17.1% of the combined project area. The remainder of the watersheds are designated as 76.7% agriculture, 3.3% rural, and 2.9% urban. Both Waikapū and Waiakoa Watersheds discharge into Keālia Pond National Wildlife Refuge (Figure 19. Waikapū Terrestrial Habitat Map and Figure 20. Waiakoa Terrestrial Habitat Map). The pond provides critical habitat for many endangered bird species. The refuge protects some of the last remaining native wetland habitat in the State. Feral ungulates such as axis deer, goats, and pigs can be found throughout the entire planning area. These animals, especially the uncontrolled population of axis deer, contribute greatly to land degradation associated with erosion. Axis deer are known to forage on native and endangered plant species which also results in further habitat loss for listed species of fauna.

The upper elevations of Waikapū watershed share a boundary with the West Maui Forest Reserve and provide a critical habitat for high densities of native vegetation. Within the montane wet ecosystem, endangered plants such as *Cytrandra oxybapha* (Haʻiwale) or *Remya mauiensis* (Maui remya) can be found. At lower elevations, the lowland dry ecosystems can provide habitat for endangered plants such as *Ctenitis squamigera* (Pauoa) and *Canavalia pubescens* (ʻāwikiwiki).

As the elevation climbs within Waiakoa Watershed, higher densities of listed species are present. Dense forests of *Metrosideros polymorpha* (ʻōhiʻa lehua) and *Acacia koa* (koa) exist at upper elevations, providing habitat for many species of endangered birds. Some of Hawaiʻi's rarest plants and animals occupy the watershed where its boundaries overlap with Haleakalā National Park. Most notably is the Silversword or *Argyroxiphium sandwicense ssp. macrocephalum* (ʻĀhinihina), an endemic and endangered plant found only on the summits of Hawaiʻi's volcanoes.

3.8 Benthic Habitat

The National Oceanographic and Atmospheric Administration (NOAA) has published benthic habitat data for the planning area. Vector boundaries of habitat areas were delineated by photo interpreting georeferenced color aerial photography, AURORA hyperspectral, and IKONOS satellite imagery. Overall accuracy of the major habitat classifications in these data is greater than 90%. Habitat boundaries are based on photo-interpretation of imagery of ground condition at the time the imagery was collected. Shore lines are subject to change over time due to natural erosion and vegetation growth processes. Habitat boundaries are subject to change over time due to population dynamics of the dominant biological communities. Benthic habitat is comprised of "pavement" or exposed rock horizontal with the sea floor with many crevices or joints, aggregate reef, aggregate patch reef, rock, rubble, sand, and scattered coral and rock composites (Figure 21. Waikapū Benthic Habitat Map and Figure 22. Waiakoa Benthic Habitat Map). Moving offshore aggregate reefs, aggregate patch reefs, and individual patch reefs are scattered along a sandy bottom (NOAA, 2007).

The coastal waters offshore from the Māʻalaea Bay Watersheds are protected by various federal and state agencies (Figure 23. Waikapū Marine Environments Map and Figure 24. Waiakoa Marine Environments Map). The Hawaiian Humpback Whale Sanctuary extends along the Maui coastline north from Lipoa Point to its southern boundary offshore from Cape Hanamanioa and just beyond ʻĀhihi-Kīnaʻu Natural Area Reserve. The sanctuary spans half of the ʻAlalākeiki Channel in between Maui and Kahoʻolawe, completely encompassing the ʻAuʻau and Kalohi Channels in between Maui and Lanaʻi and Lanai and

Molokaʻi respectively, as well as most of the Pailolo Channel separating Maui and Molokaʻi. Within three miles of the entire shoreline of the island of Maui, a State of Hawaiʻi Department of Natural Resources Division of Aquatic Resources Marine Managed Area exists and places a prohibition on the use of lay nets (DLNR DAR 2017). Beginning at Haycraft Park, Coral reef exists directly offshore along the entire coastal boundary of the Waikapū Watershed. Moving southeast, coral reefs extend into the Waikoa Watershed coastline adjacent to Keālia pond and beyond (Figure 25. Waikapū Coral Reefs Map and Figure 26. Waiakoa Coral Reefs Map).

3.8.1 Aquatic and Marine Life

Both aquatic and marine life are abundant in the coastal ecosystems that receive inputs from the watershed lands, streams, and groundwater. The several streams and gulches within the Māʻalaea Bay Watersheds discharge directly into Keālia Pond, which is one of the largest remaining wetlands on Maui. Hawaiian traditional and customary gathering rights, subsistence fishing, commercial and recreational fishing, and commercial recreational activities, such as snorkeling, diving, and whale-watching, depend on balanced aquatic ecosystems. These systems support aquatic life and wildlife, such as coral, Hawaiian stilts, Hawaiian monk seals, hawksbill turtles, green sea turtles (honu), humpback whales, etc. The entire coastline of the planning area is part of the Hawaiian Islands Humpback Whale National Marine Sanctuary.

Figure 19. Waikapū Terrestrial Habitat Map

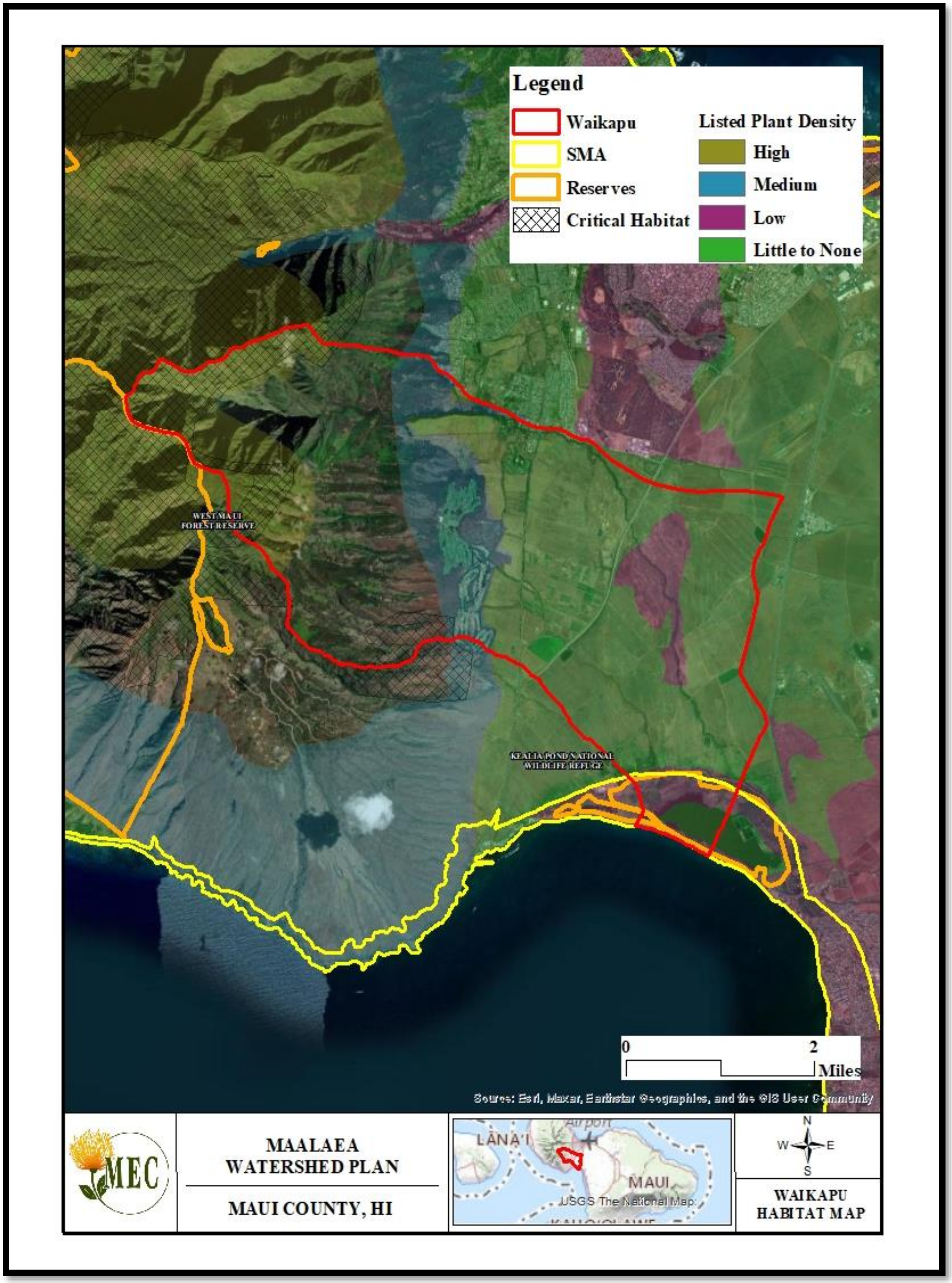


Figure 20. Waiakoa Terrestrial Habitat Map

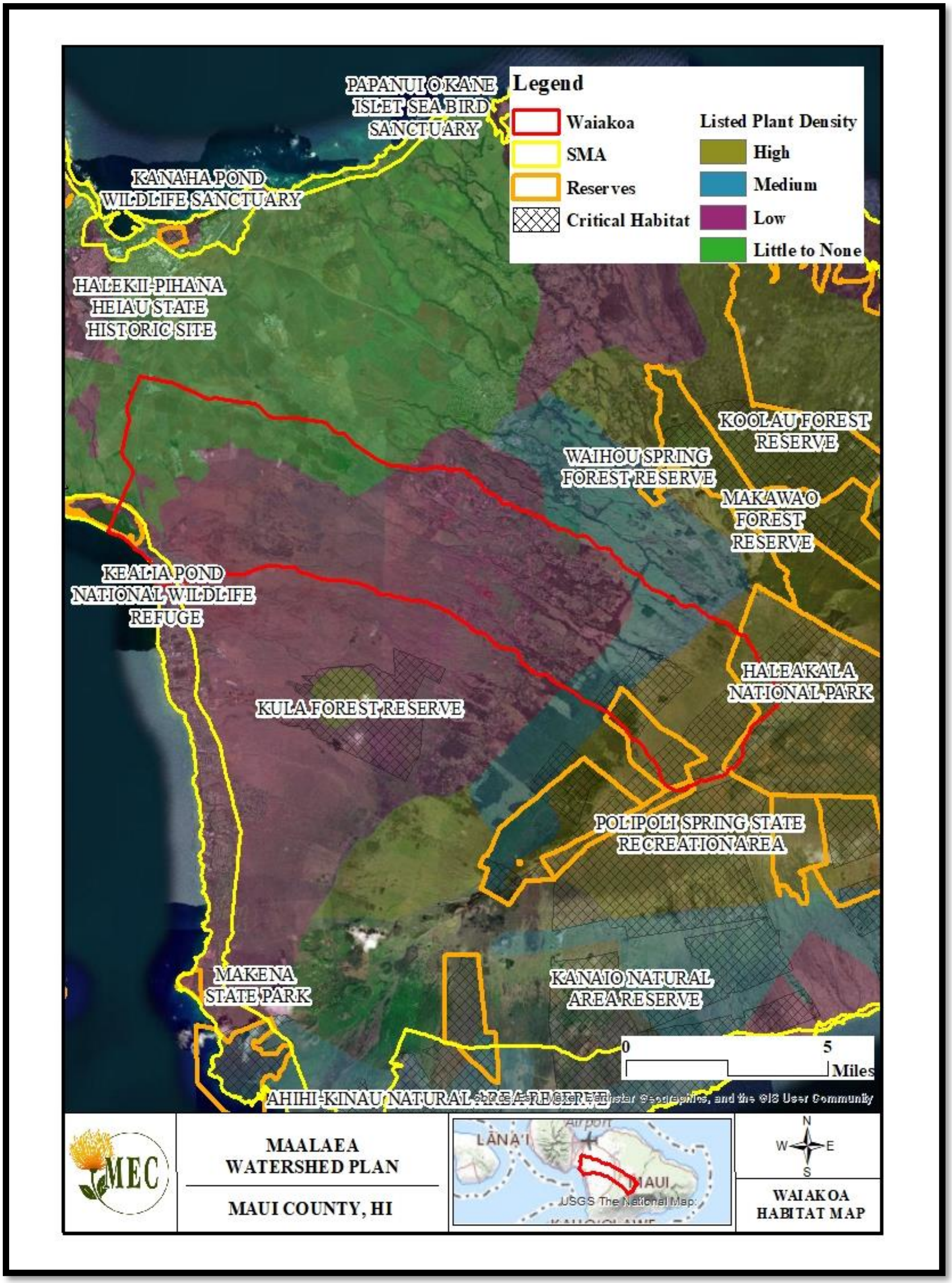


Figure 21. Waikapū Benthic Habitat

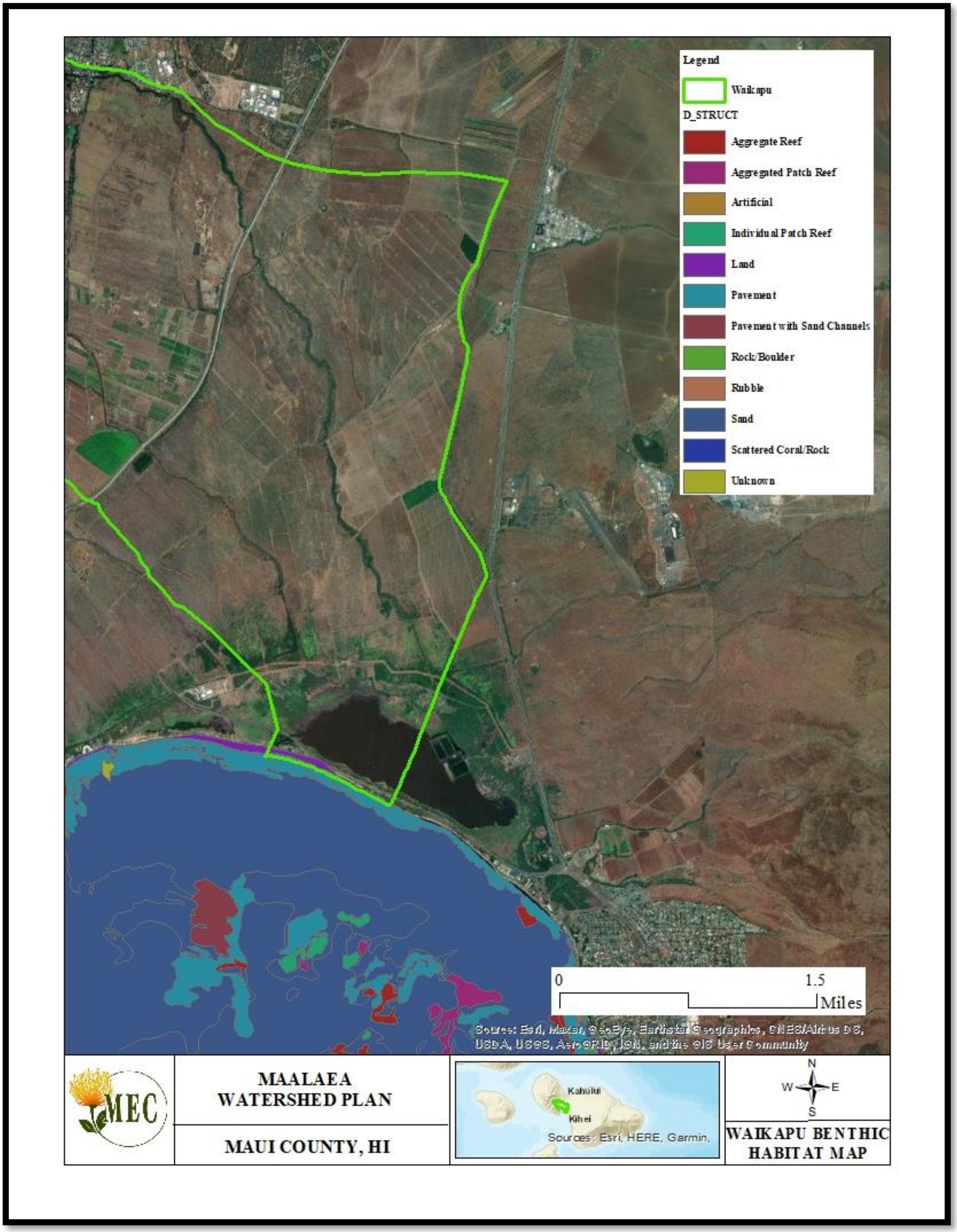


Figure 22. Waiakoa Benthic Habitat

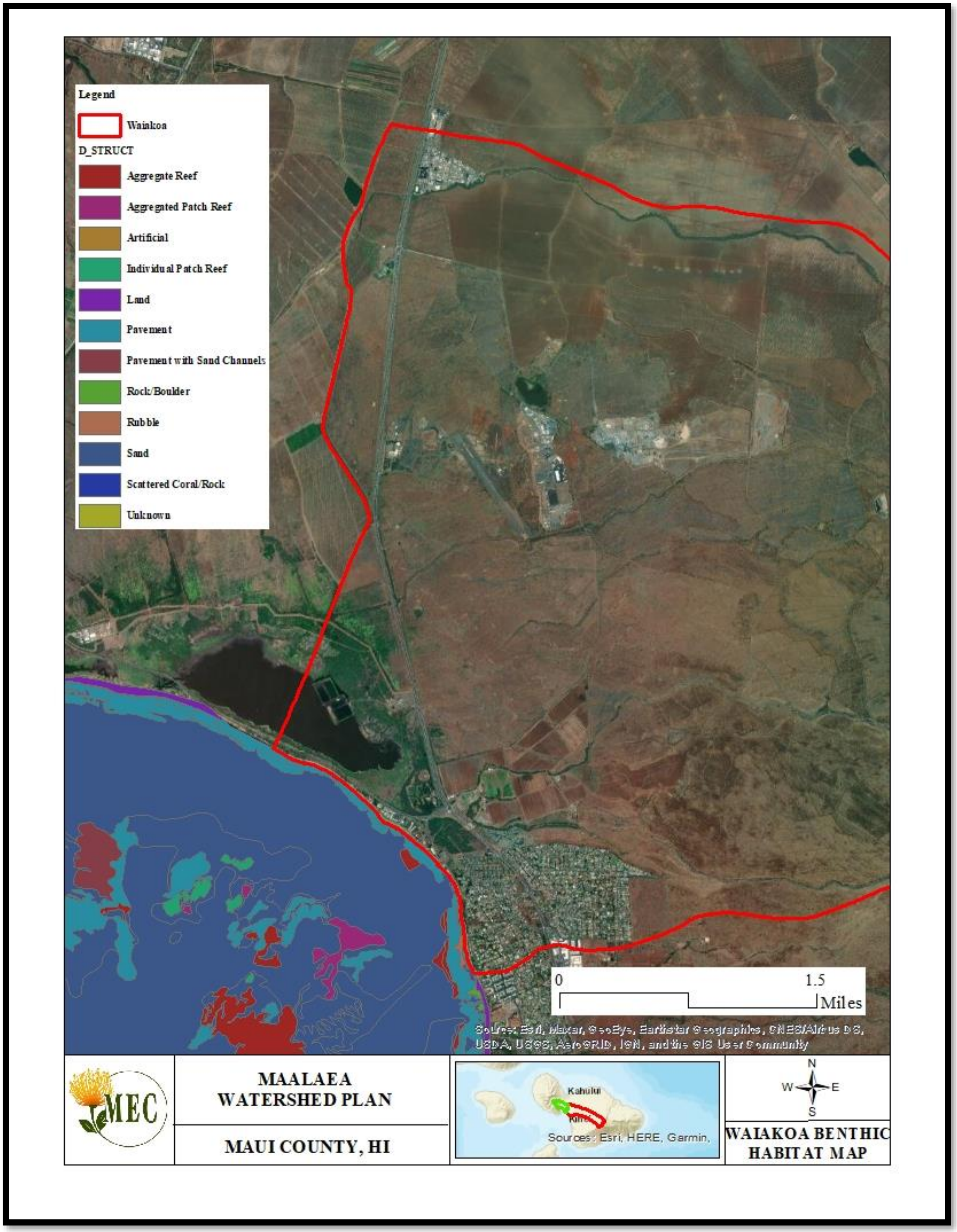


Figure 23. Waikapū Marine Environments Map

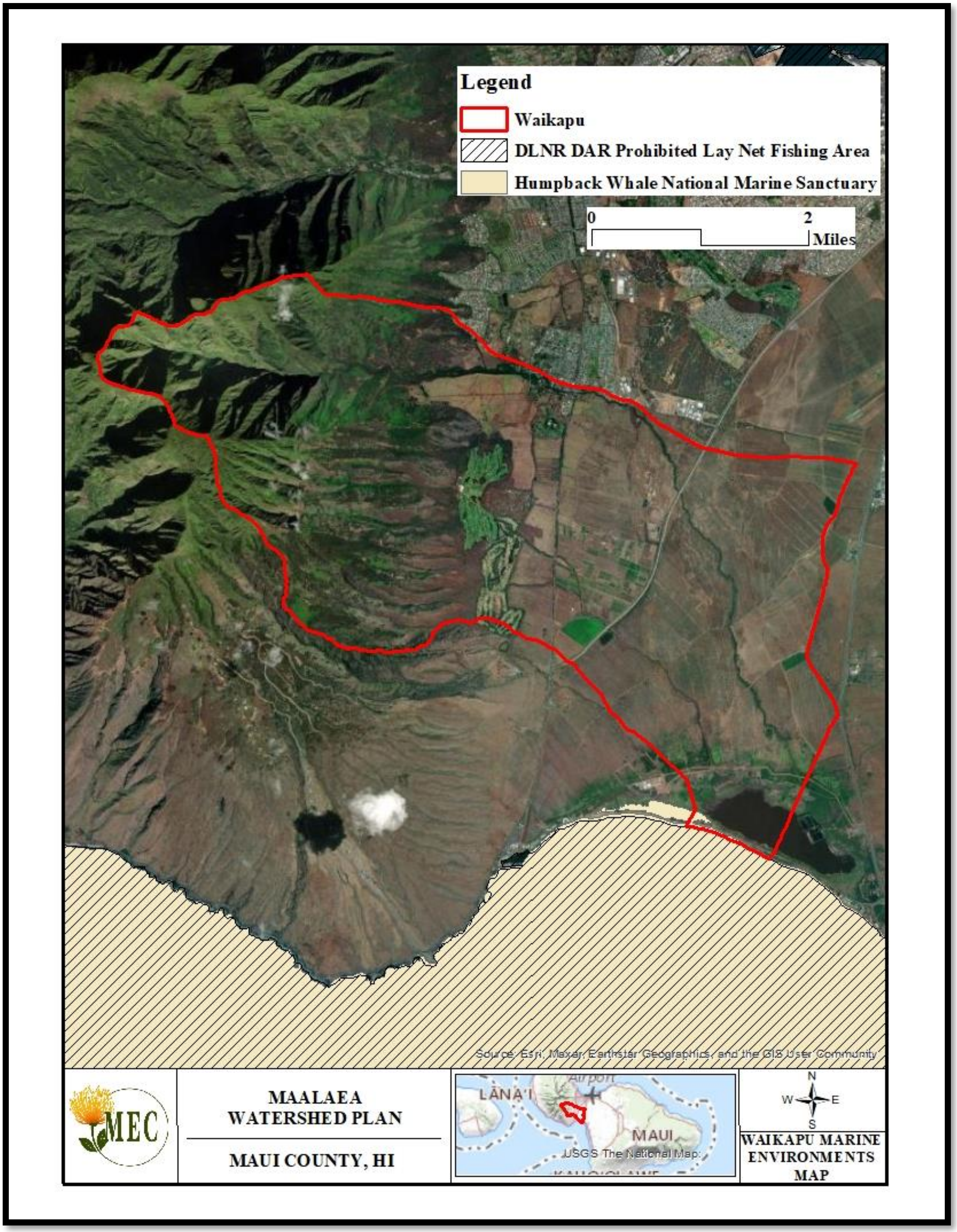


Figure 24. Waiakoa Marine Environments Map

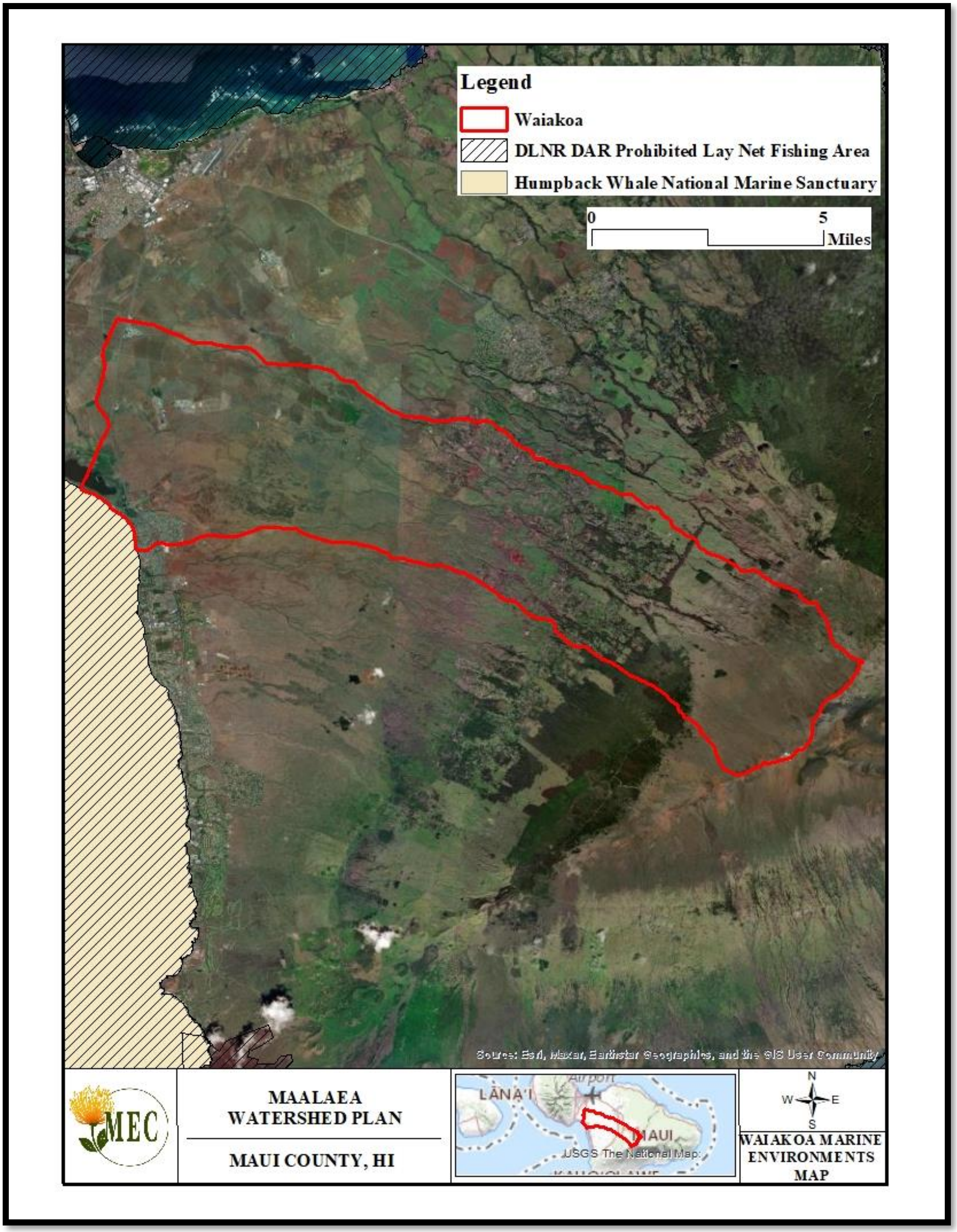


Figure 25. Waikapū Coral Reefs Map

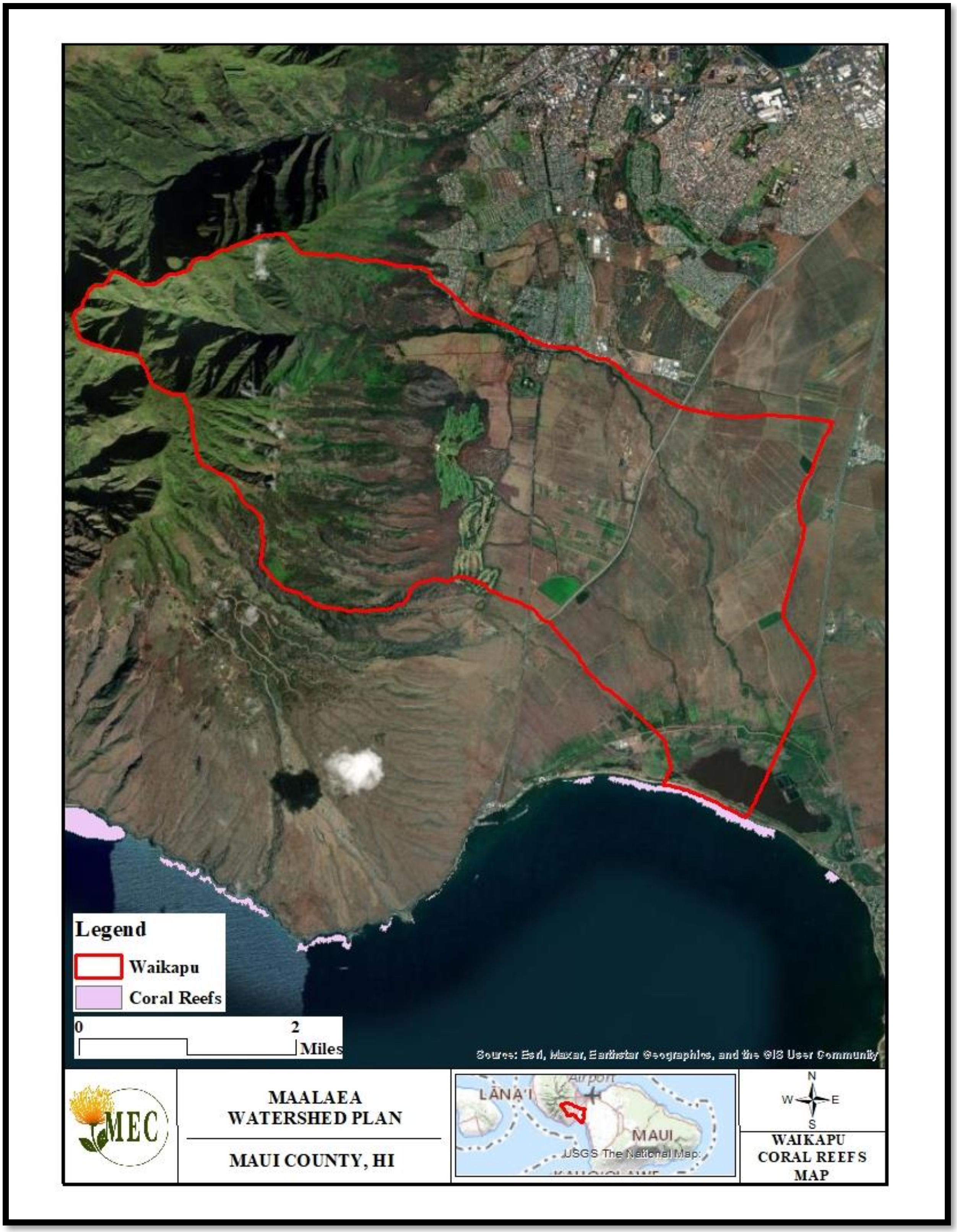
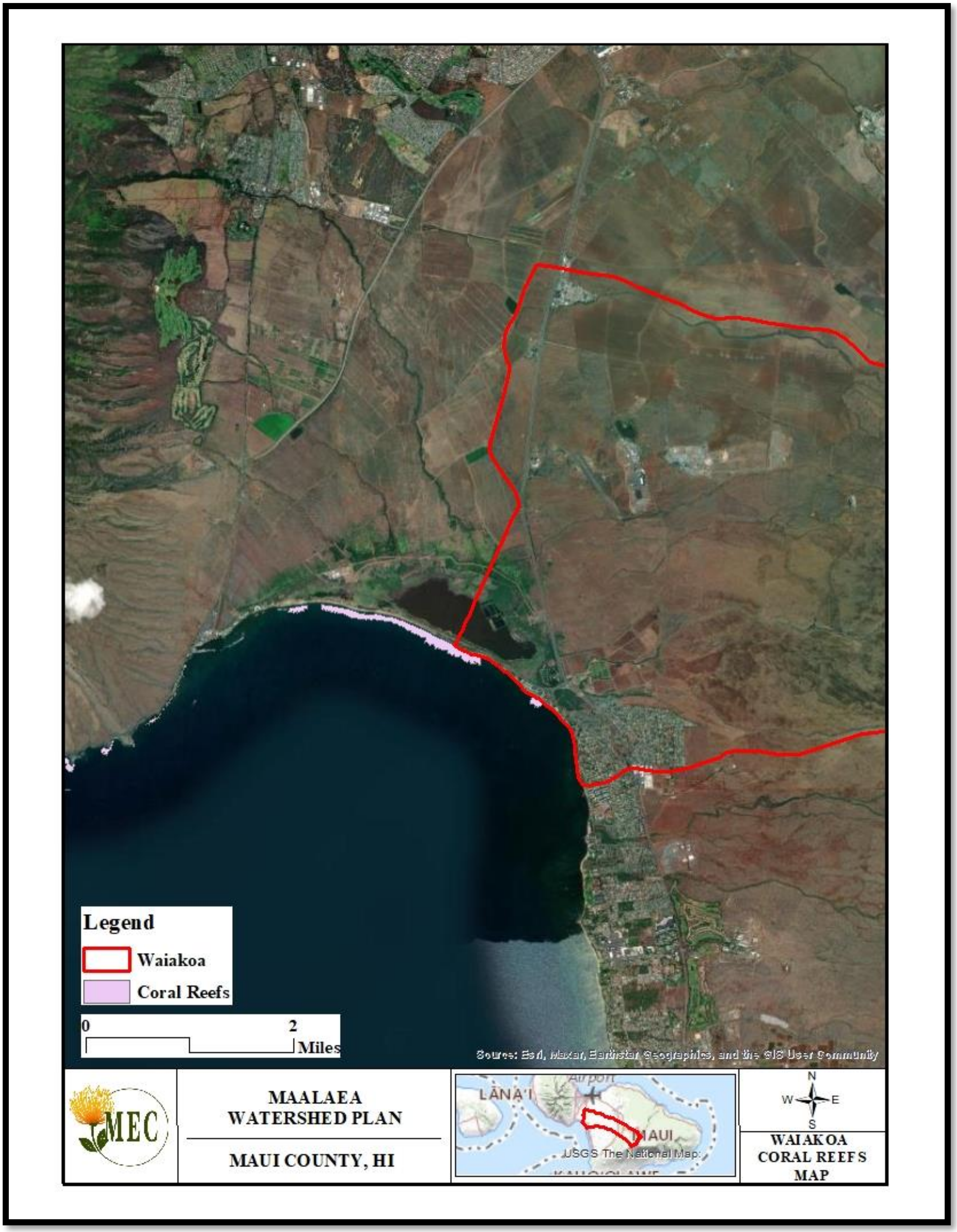


Figure 26. Waiakoa Coral Reefs Map



4.0 LAND USE AND POPULATION

4.1 Land Use Districts

Four land use districts exist within the Māʻalaea Bay Watersheds: conservation, agriculture, rural, and urban (Figure 27. Waikapū State Land Use Districts Map and Figure 28. Waiakoa State Land Use Districts Map). Agriculture is the largest land use district for both Waikapū and Waiakoa Watersheds, and occupies the majority of the land area of Maui's central valley from sea level to 1,500 and 3,000 feet respectively. Conservation lands include Keālia Pond along the coast, and the upper elevations of the West Maui Mountians and Haleakalā for Waikapū and Waiakoa Watersheds respectively. Rural and Urban lands are clustered together along the northern boundaries, and comprise a combined 6.07 percent of the Waikapū Watershed. These lands are associated with the Waikapū township. Within the Waiakoa Watershed Rural and Urban land use districts make up 6.26 percent of land area. A small section of rural and urban lands exist along the western shorlines of the watershed boundaries in Kīhei while the majority are at elevations around 3,500 feet in the town of Kula. State land use boundaries were compiled by the State Land Use Commission and were most recently updated in 2023.

Table 8. Māʻalaea Bay Watershed Land Use Districts

Land Use District	Waikapū		Waiakoa	
	Acres	Percent	Acres	Percent
Agriculture	5,856.08	56.35	29,202.67	82.66
Conservation	3,907.04	37.59	3,916.55	11.09
Rural	136.80	1.32	1,394.26	3.95
Urban	493.24	4.75	817.19	2.31

4.2 Land Use Classifications

State land use and land cover data consists of historical land use and land cover classifications that were based on the manual interpretation of 1970's and 1980's aerial photography. There are 21 possible categories of cover types, and ten exist within the Waikapū Watershed boundary. These include Residential, Cropland and Pasture, Herbaceous Rangeland, Shrub and Brush Rangeland, Mixed Rangeland, Evergreen Forest Land, Lakes, Reservoirs, Non-forested Wetland, Strip Mines, Quarries, and Gravel Pits. Cropland and Pasture is the largest land cover type, making up nearly half of the watershed (Figure 29. Waikapū State Land Use Classifications Map).

Waiakoa Watershed is diverse in its land cover types, containing 14 different categories. Cropland and Pasture and Shrub and Brush Rangeland are the two major land covers, comprising over 85 percent of the land area. The twelve other land coverstypes are: Residential, Commercial and Services, Cropland and Pasture, Orchards, Groves, Vineyards, Nurseries and Ornamental, Other Agricultural Land, Herbaceous Rangeland, Shrub and Brush Rangeland, Mixed Rangeland, Evergreen Forest Land, Lakes, Reservoirs, Nonforested Wetland, Bare Exposed Rock, and Transitional Areas (Figure 30. Waiakoa State Land Use Classifications Map).

Table 9. Māʻalaea Bay Watershed Land Use Classifications

Land Cover	Land Use Description	Acreage	Percentage
Waikapū			
11	Residential	55.29	0.53
21	Cropland and Pasture	4789.09	46.09
31	Herbaceous Rangeland	670.01	6.45
32	Shrub and Brush Rangeland	1587.82	15.28
33	Mixed Rangeland	73.8	0.71
42	Evergreen Forest Land	2853.54	27.46
52	Lakes	101.76	0.98
53	Reservoirs	16.07	0.15
62	Non forested Wetland	186.34	1.79
75	Strip Mines, Quarries, and Gravel Pits	57.80	0.56
Waiakoa			
11	Residential	763.15	2.16
12	Commercial and Services	134.92	0.38
21	Cropland and Pasture	15931.59	45.10
22	Orchards, Groves, Vineyards, Nurseries, Ornamental	67.05	0.19
24	Other Agricultural Land	51.90	0.15
31	Herbaceous Rangeland	1251.27	3.54
32	Shrub and Brush Rangeland	14216.75	40.25
33	Mixed Rangeland	253.77	0.72
42	Evergreen Forest Land	1643.66	4.65
52	Lakes	79.19	0.22
53	Reservoirs	55.16	0.16
62	Non forested Wetland	103.06	0.29
74	Bare Exposed Rock	7.18	0.02
76	Transitional Areas	765.30	2.17

Figure 27. Waikapū State Land Use Districts Map

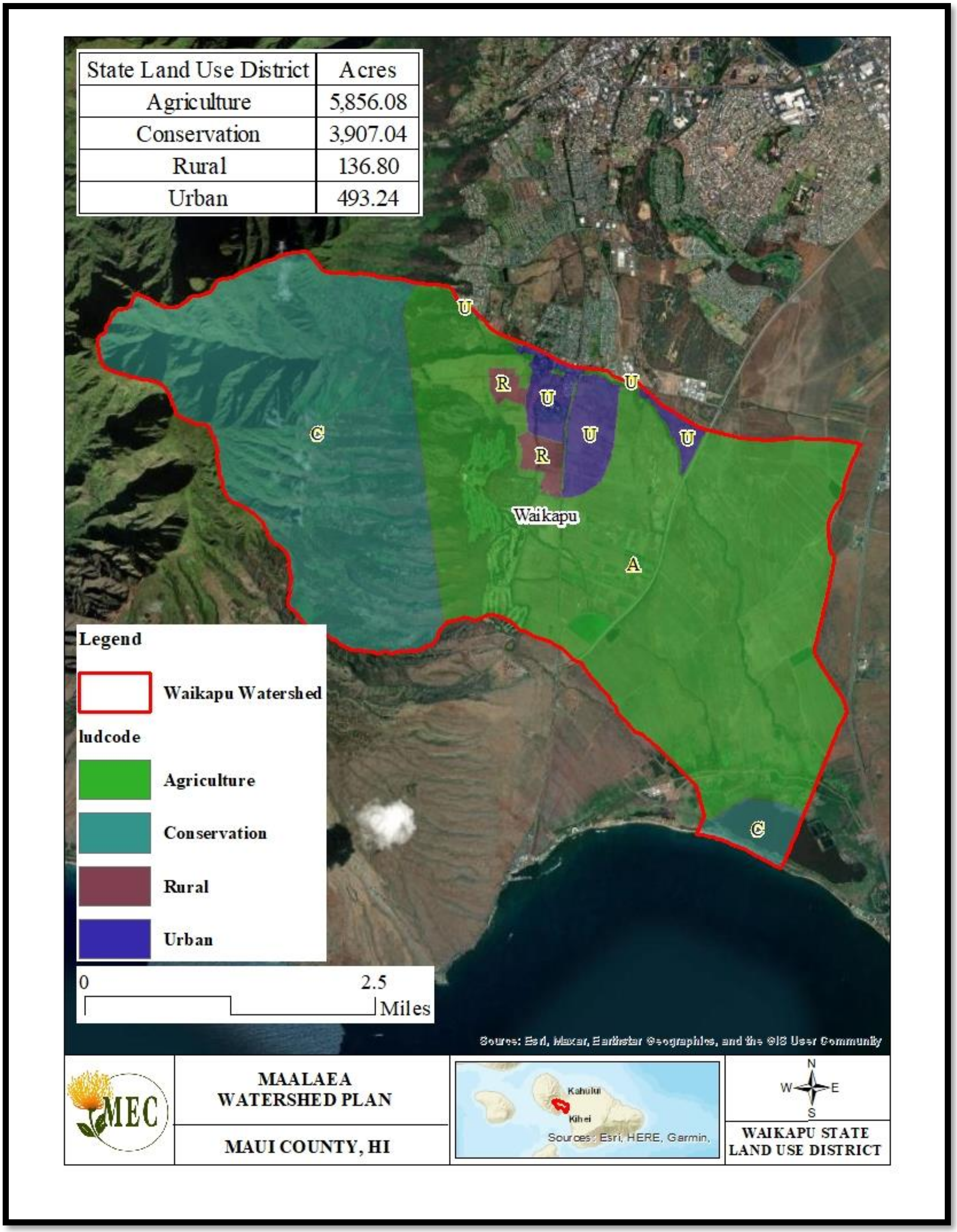


Figure 28. Waiakoa State Land Use Districts Map

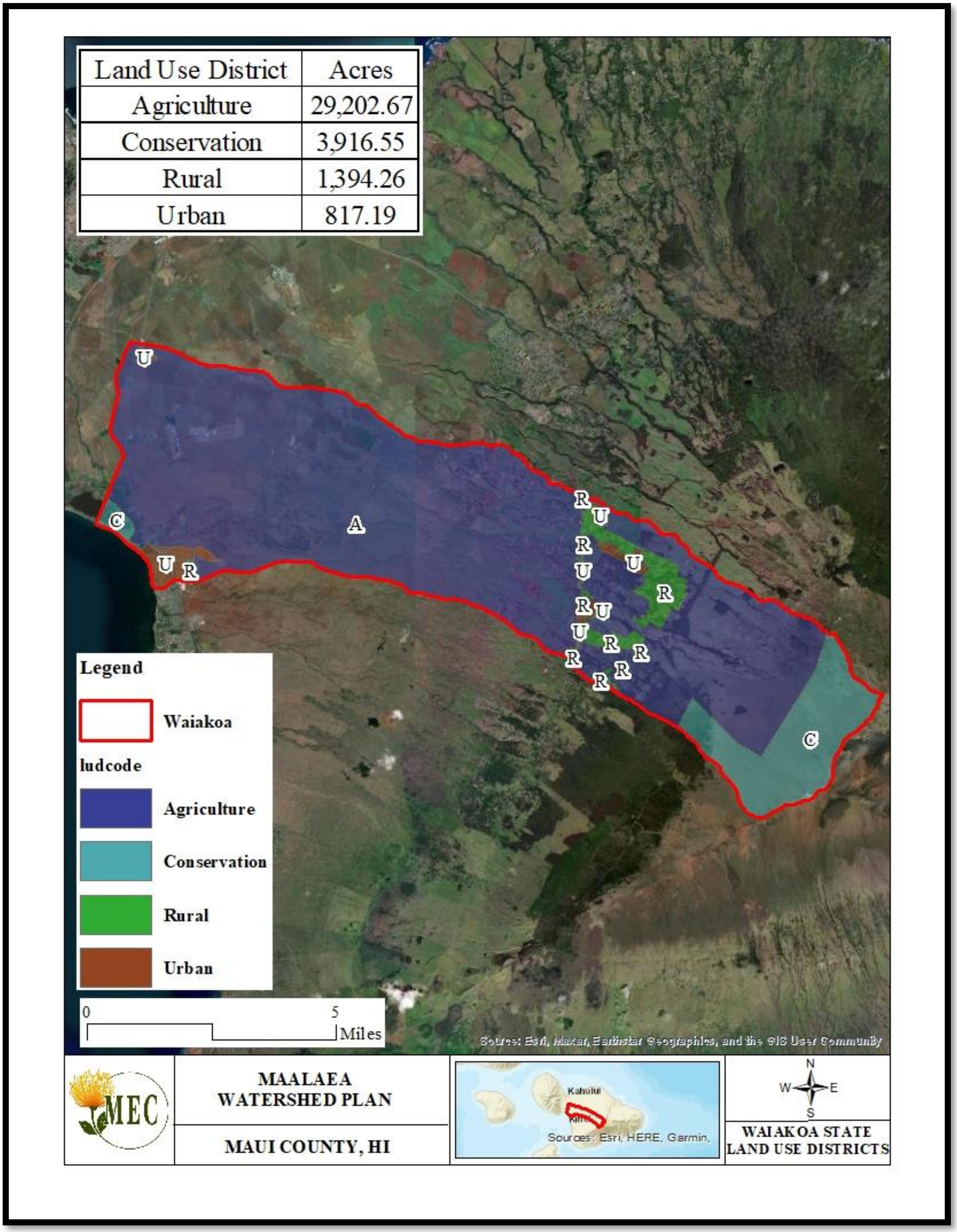


Figure 29. Waikapū State Land Use Classifications Map

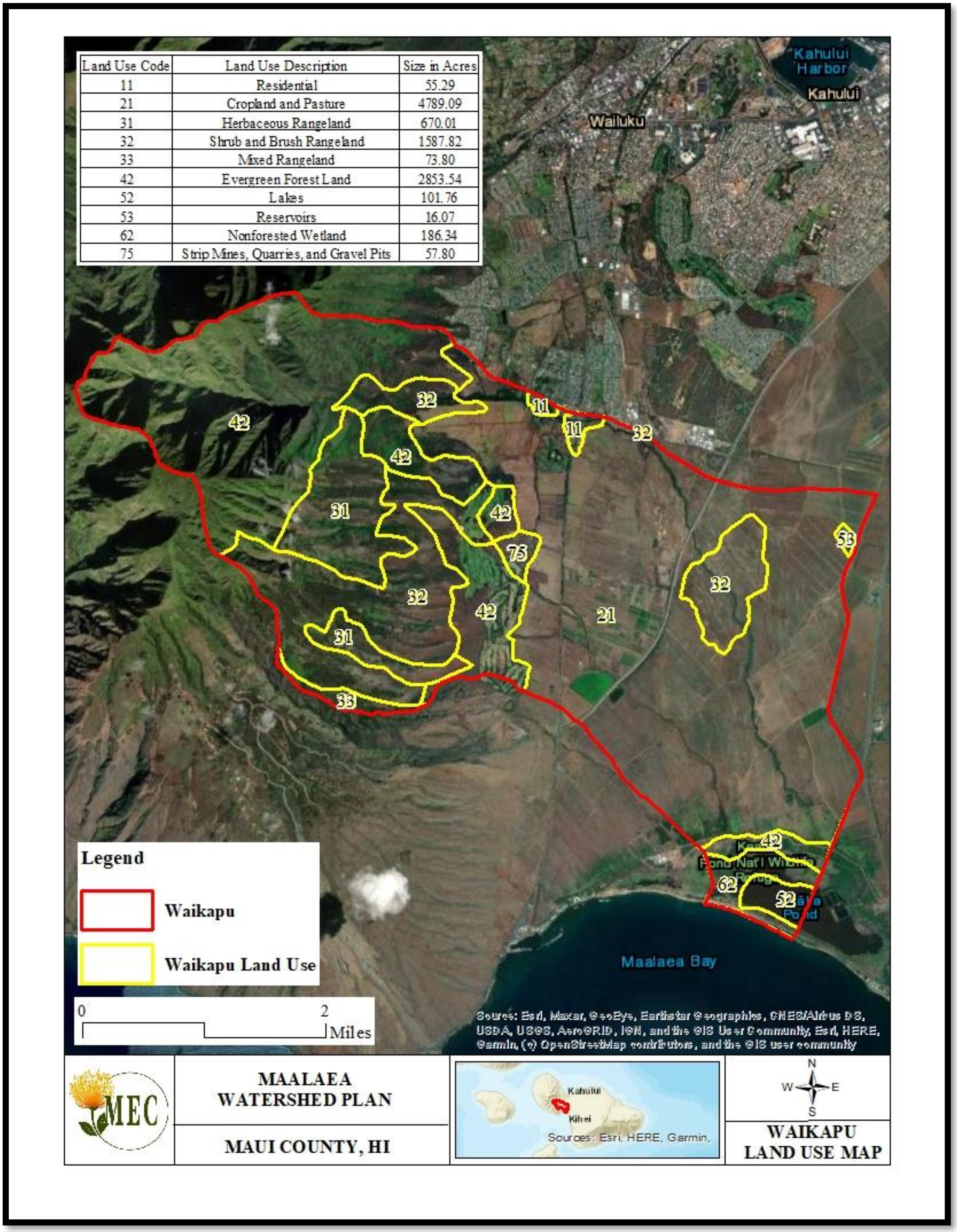
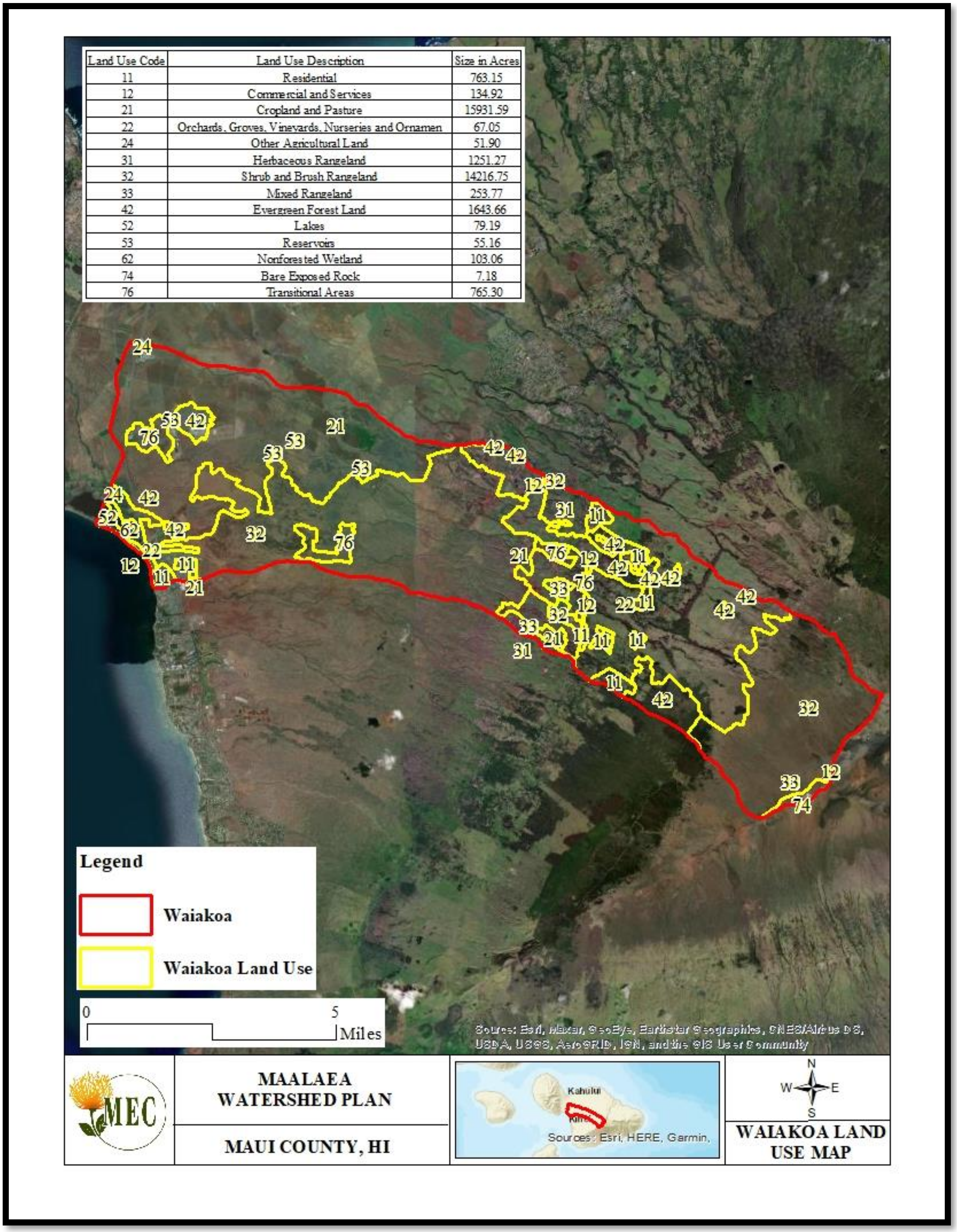


Figure 30. Waiakoa State Land Use Classifications Map



Land Use Code	Land Use Description	Size in Acres
11	Residential	763.15
12	Commercial and Services	134.92
21	Cropland and Pasture	15931.59
22	Orchards, Groves, Vineyards, Nurseries and Ornamen	67.05
24	Other Agricultural Land	51.90
31	Herbaceous Rangeland	1251.27
32	Shrub and Brush Rangeland	14216.75
33	Mixed Rangeland	253.77
42	Evergreen Forest Land	1643.66
52	Lakes	79.19
53	Reservoirs	55.16
62	Nonforested Wetland	103.06
74	Bare Exposed Rock	7.18
76	Transitional Areas	765.30

4.3 Government and Large Land Ownership

This dataset was created using the TMK Parcel shapefiles from the counties of Honolulu, Kauai, Maui, and Hawaiʻi. The "MajorOwner" field was queried for all private landowners owning a cumulative land area of at least 1,000 acres *per island*, as well as those parcels owned by government agencies (public lands). All landowners with "MajorOwner" = "other" were excluded. Within Waikapū, the largest landowners include Maui County, Mahi Pono, and Wailuku Water Company. Within the Waiakoa planning area, large landowners consist of the State of Hawaiʻi, United States of America, A&B LLC, DHHL, Haleakalā Ranch, Kula Ranch, Māʻalaea C and D Landfill Condominium, and Von Tempsky Ranch (Figure 31. Waikapū Large Landowners Map and Figure 32. Waiakoa Large Landowners Map).

4.4 Impervious vs. Pervious Surface

In 2007, an inventory of impervious surfaces for the island of Maui was produced by the NOAA Coastal Services Center. Impervious surfaces prevent infiltration of precipitation into the soil, disrupting the water cycle, and affecting both the quantity and quality of water resources. Impervious surfaces include manmade features such as building rooftops, parking lots, and roads consisting of asphalt, concrete, and/or compacted dirt. This data set utilized 52 full or partial Quickbird multispectral scenes, which were processed to detect impervious features on the island of Maui (Figure 33. Waikapū Impervious Surfaces Map and Figure 34. Waiakoa Impervious Surfaces Map).

Impervious surface areas, such as those shown in Figures 33 and 34, convey more runoff than pervious surfaces such as lawns, fields, shrub lands, or woods. Areas that become developed and are converted from pervious to impervious surfaces increase surface runoff. Correspondingly, increased impervious surfaces and the channelization of streams due to development convey runoff without infiltration and frequently at high speeds. The transport of water in this manner allows pollutants to be carried and deposited quickly, in large pulses, into receiving water bodies with no opportunity for filtration. The amount of infiltration into groundwater resources is reduced as impervious surfaces are increased.

While much of Waikapū is agricultural and conservation land, some impervious surfaces do exist associated with residential communities. A major development named Waikapū Country Town is to include 1,500 new homes and an additional 146 ohana units, in addition to a school and shops. This development will add to the impervious surfaces already associated with this watershed.

In Waiakoa, most of the impervious surfaces are associated with upcountry residential communities and with industrial uses along Mokulele Highway. Additional residential homes associated with North Kīhei also add to the impervious surfaces in this watershed.

Figure 31. Waikapū Large Landowners

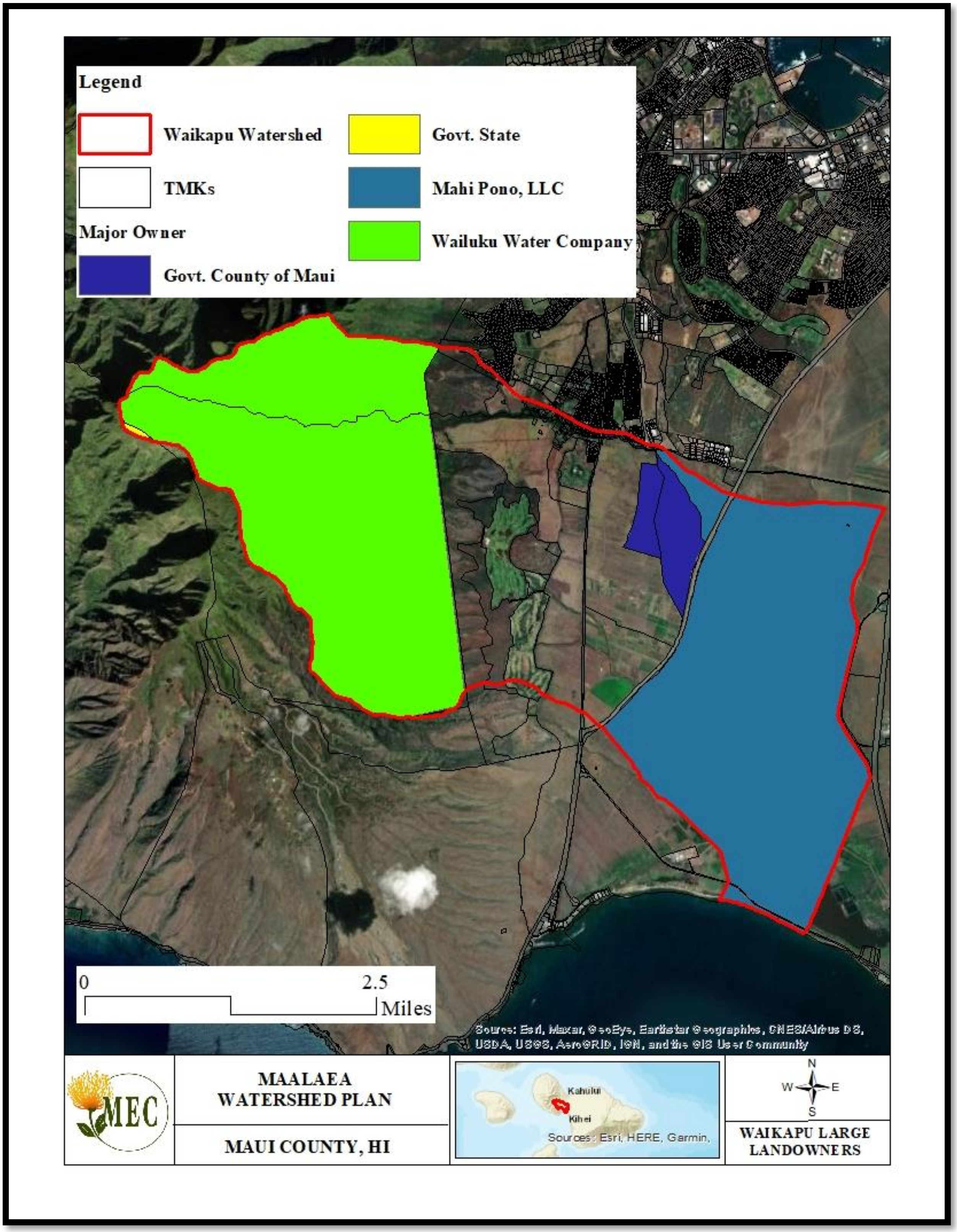


Figure 32. Waiakoa Large Landowners

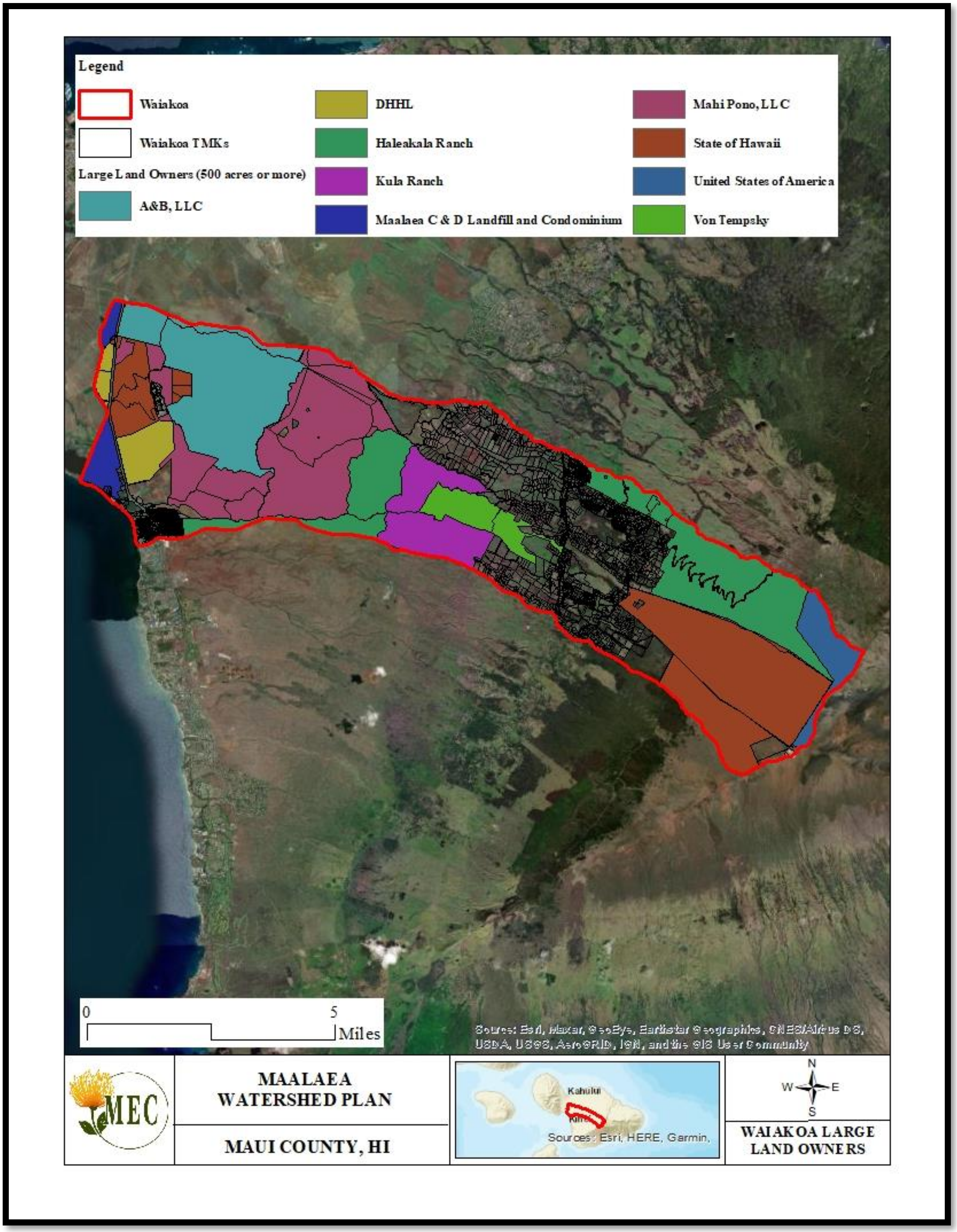


Figure 33. Waikapū Impervious Surfaces

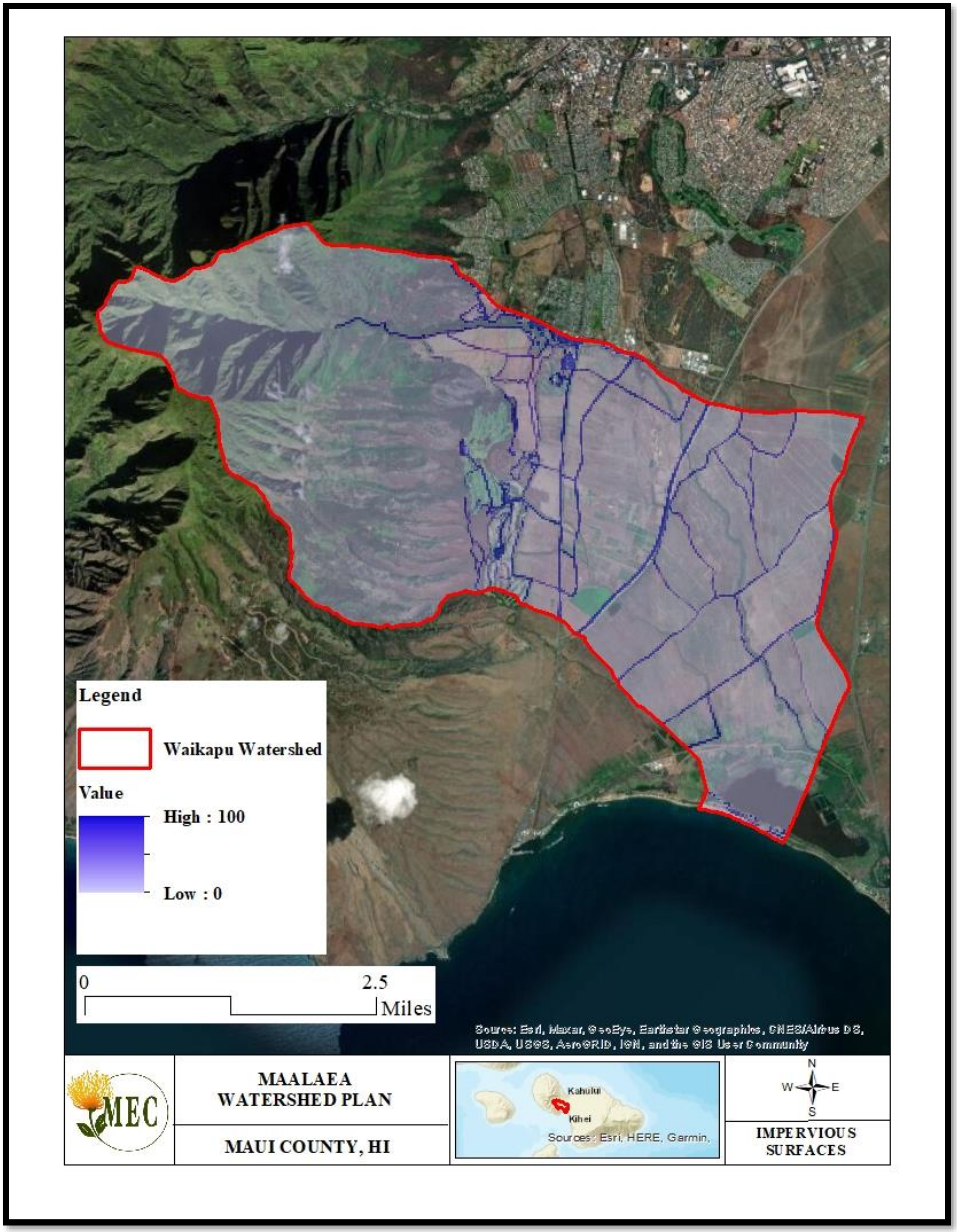
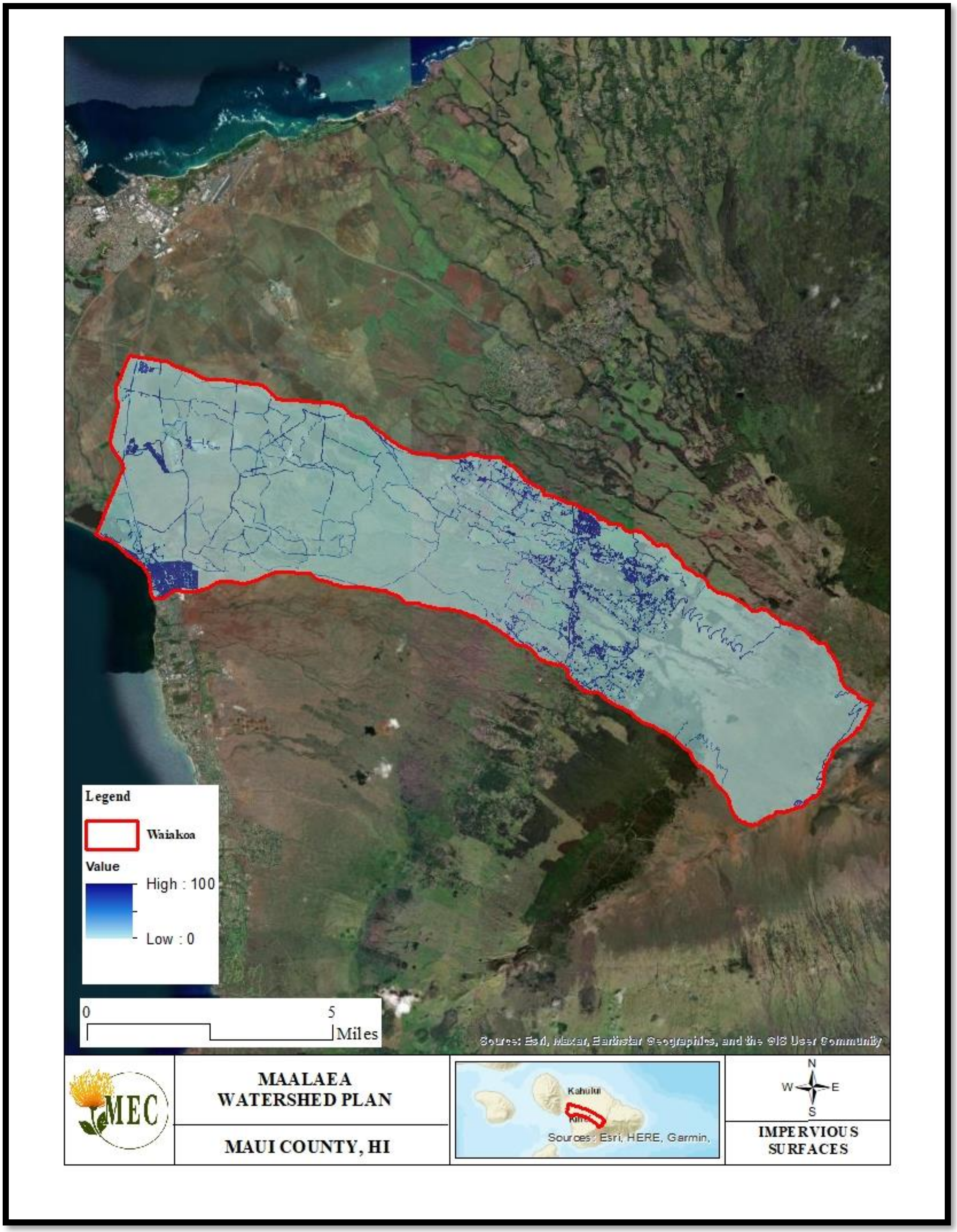


Figure 34. Waiakoa Impervious Surfaces



4.4.1 Planned Development

Planned development within the Māʻalaea Bay Watersheds are notable because such projects increase the amount of impervious surfaces. This may affect the hydrology of the planning area and will likely increase the amount and velocity of surface runoff. It is recommended that all planned developments employ Low Impact Design (LID) technologies. These technologies can include pervious pavement, bioswales, rain gardens, and other LID infrastructure. Helpful island-specific information, guidance, and resources to appropriate LID technologies can be found in the links provided below.

LID Workbook: A Practitioner's Guide

Stormwater Management the Natural Way: Low Impact Design & Development

Stormwater Management in Pacific and Caribbean Islands: A Practitioner's Guide to Implementing LID

Waikapū Watershed has several large development projects planned within its boundaries, including the aforementioned Waikapū Country Town, The Kuihelani Solar Project, and the Central Maui Wastewater Reclamation Facility. The County of Maui Planning Department (COM Planning) reported that there are approximately 1,500 acres of approved development projects and 281 acres of proposed projects within Waikapū Watershed (Figure 35. Waikapū Proposed Development Map).

Within Waiakoa, in the makai portions of the watershed, several projects have either been proposed or are currently under construction. These include DHHL Pūlehunui North and South, the DLNR Industrial and Business Park, the Puunene Heavy Industrial Park, the Maui Baseyard Expansion, and Ohukai Village. In the mauka portions of the watershed, Omaʻopio Estates, Pūlehu Solar, Omaʻopio Ridge, Makani O Kula, and Kula ʻI ʻO have been proposed or are currently under construction (Figure 36. Waiakoa Proposed Development Map).

4.4.2 Historic Population Trends

Residential populations within the Māʻalaea Bay Watersheds are minimal. The Waikapū Watershed boundaries are adjacent to the town of Waikapū, however, the populous residential area is not included within the watershed boundaries. According to the 2020 census, the population of Waikapū is 3,437 (U.S. Census Bureau, 2022). Waiakoa Watershed intersects a small section of the northern-most urban area of Kīhei, and small population clusters exist with the urban and rurual districts of Kula. In 2020 the populations of Kīhei and Kula were 21,423 and 6,942 respectively (U.S. Census Bureau, 2022).

The overall population of Maui Island has increased dramatically in recent decades. In 2000, Maui Island had a population of 117,644, the third-most populous of the Hawaiian Islands, after Oahu and Hawaiʻi. Maui's population has risen to 144,444 in 2010, and to 164,351 in 2022 (U.S. Census Bureau, 2022). According to projections set forth by the County of Maui Planning Department, Long Range Division, the island's population is expected to reach 194,630 by 2030, a 35% increase from 2010 (Maui Island Plan, 2012).

Figure 35. Waikapū Proposed Development Map

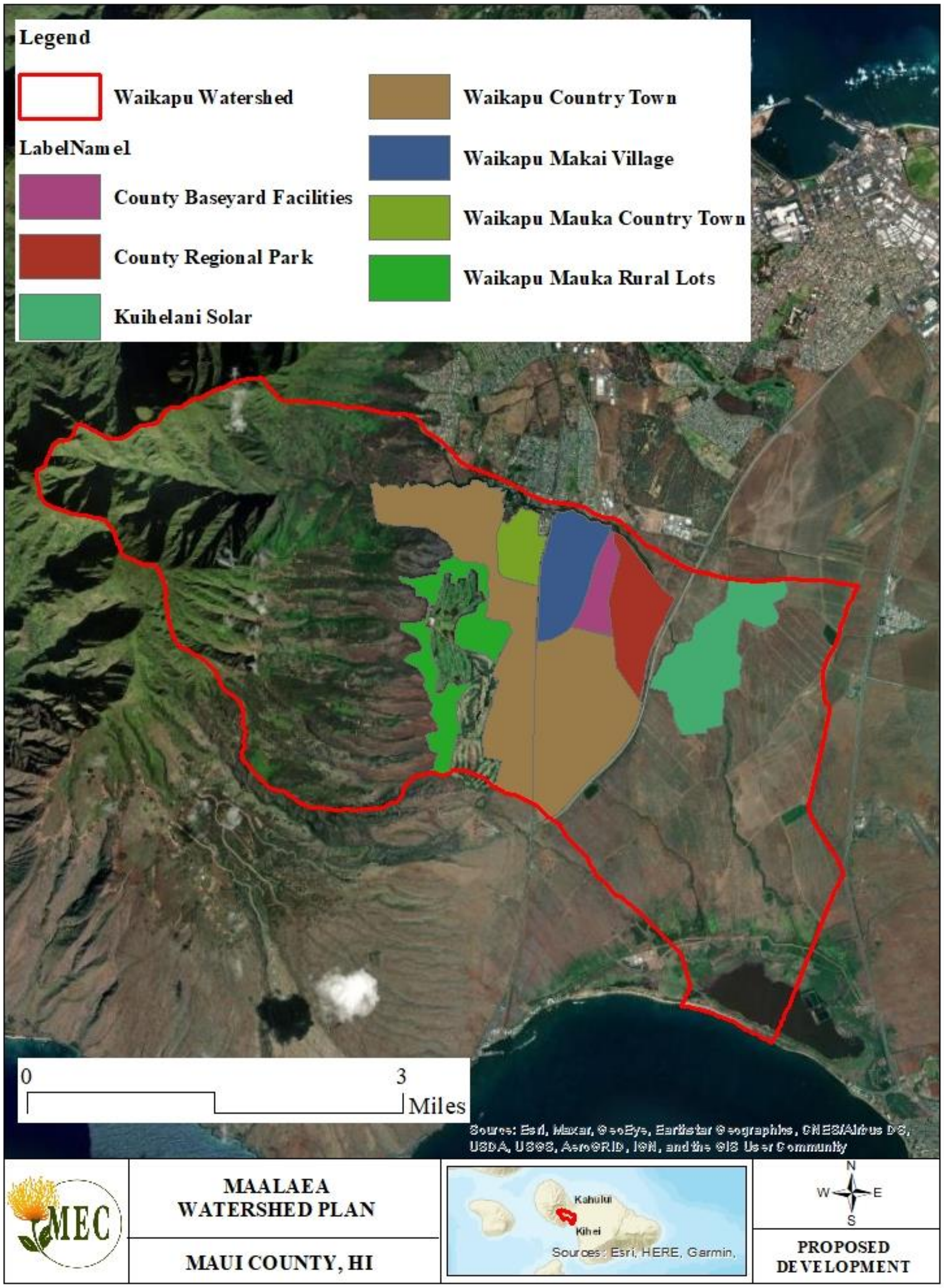
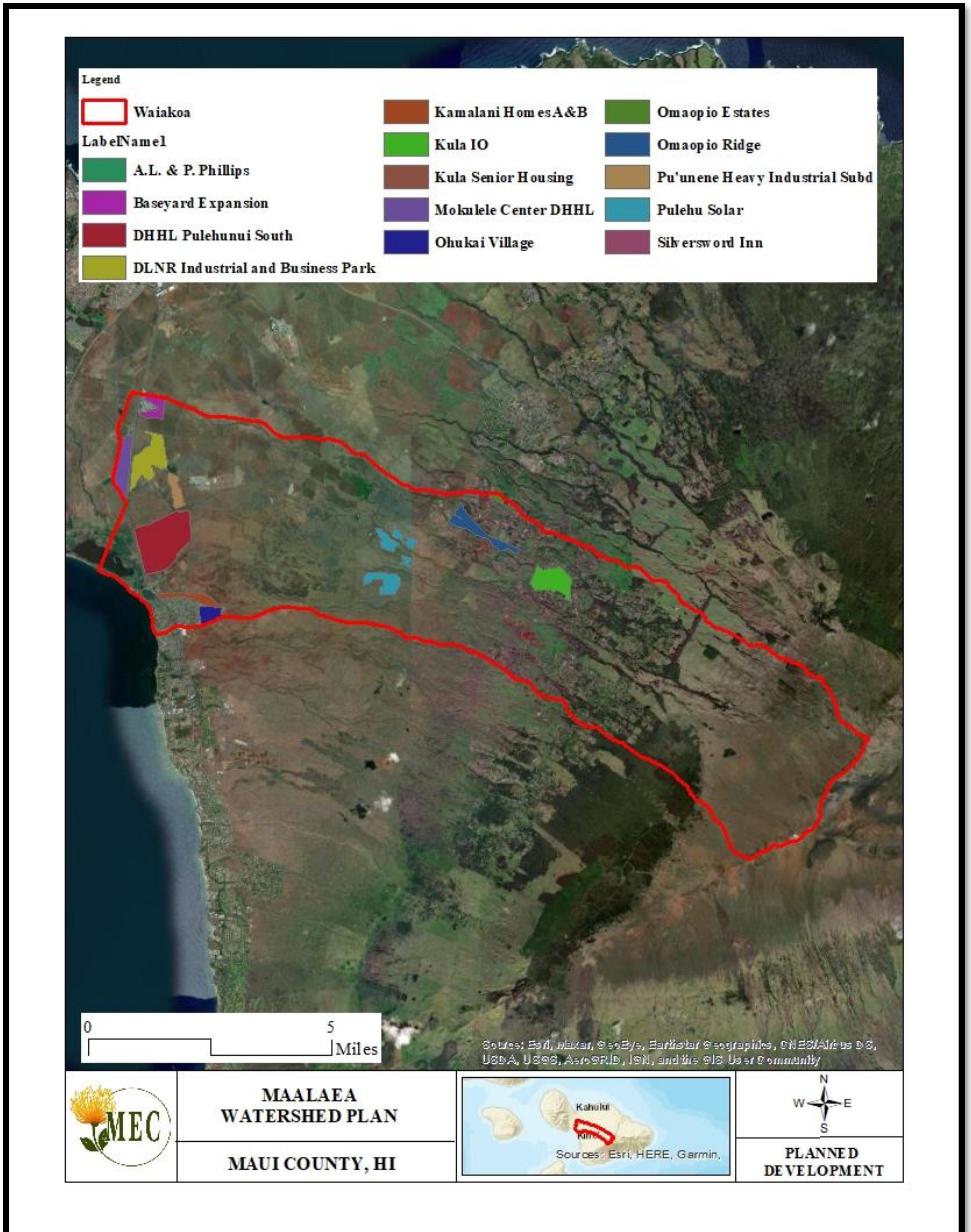


Figure 36. Waiakoa Proposed Development Map



5.0 WATERBODY CONDITIONS

In an effort to identify water quality trends over time, MEC reviewed the Final 2020 and 2022 State of Hawaiʻi Department of Health (DOH) Clean Water Branch (CWB) Integrated Water Quality Report (IR) for water quality data specific to the Māʻalaea Bay Watersheds.

5.1 Applicable Water Quality Standards

Water Quality Standards (WQS) for the State of Hawaiʻi, including designated uses, water quality criteria, and the anti-degradation policy, are found in the Hawaiʻi Administrative Rule (HAR) Chapter 11-54. In the Hawaiʻi regulations, waters are first classified by waterbody type as inland waters, marine waters, or marine bottom ecosystem, and are then further categorized into classes based on ecological characteristics and other criteria. To access (HAR) Chapter 11-54: Water Quality Standards go to:
http://health.Hawaiʻi.gov/cwb/files/2013/04/Clean_Water_Branch_HAR_11-54_20141115.pdf

5.1.1 Waterbody Types and Classes

The three main waterbody types are inland waters, marine waters, and marine bottom ecosystems. Inland waterbody types found within the planning area include intermittent freshwater flowing streams, low wetlands, brackish or saline standing waters, coastal wetlands, and estuaries. Marine waterbody types found within the planning area include open coastal waters, and oceanic waters.

These waterbody types encompass diverse aquatic ecosystems. The uses of these waters will vary along with the type of aquatic organisms each supports. These waterbody types are grouped into classes, and beneficial uses are designated for each waterbody class. Waterbody classes are defined in HAR §11-54-3 and described below.

5.1.2 Designation of Water Class and Beneficial Uses in Hawaiʻi

Specific waterbodies are assigned to classes based on both waterbody characteristics (e.g. fresh or saline, standing or flowing) and other considerations described in the state's anti-degradation policy, such as outstanding natural resource, or important economic or social development. Class determinations are made in accordance with provisions of the water quality law, HAR §11-54. Some waterbodies are specifically named and assigned a class, while for most waterbodies the determination is made based on the class description.

Table 10. Waterbody Classes and Designated Uses

Designated Uses	**Inland Waters**			**Marine Waters**		**Marine Bottom Ecosystem**	
	Class 1a	Class 1b	Class 2	Class AA	Class A	Class I	Class II
Natural Waters							
Native Aquatic Life							
Aquatic Life							
Recreation							
Aesthetics							

Designated Uses	**Inland Waters**			**Marine Waters**		**Marine Bottom Ecosystem**	
	Class 1a	Class 1b	Class 2	Class AA	Class A	Class I	Class II
Wildlife							
Drinking Water							
Food Processing							
Agricultural Water Source							
Industrial Water Source							
Shipping							

*Legend:

Use is designated for class	
Use is not designated for class	

5.1.2.1 <u>Inland Water Classes</u>

Inland waters within the Māʻalaea Bay Watersheds Management Planning area include a perennial stream, numerous ephemeral streams and gulches, as well as Keālia Pond. These streams are designated Class 2, while Keālia Pond is designated as a Class 1 waterbody.

<u>Class 1:</u> Waters must remain in their natural state as nearly as possible with an absolute minimum of pollution from any human-caused source. To the extent possible, the wilderness character of these areas shall be protected.

<u>Class 1a)</u>: The uses to be protected in class 1a waters are scientific and educational purposes, protection of native breeding stock, baseline references from which human-caused changes can be measured, compatible recreation, aesthetic enjoyment, and other non-degrading uses which are compatible with the protection of the ecosystems associated with waters of this class

<u>Class 1b)</u>: The uses to be protected in class 1b waters are domestic water supplies, food processing, protection of native breeding stock, the support and propagation of aquatic life, baseline references from which human-caused changes can be measured, scientific and educational purposes, compatible recreation, and aesthetic enjoyment. Public access to these waters may be restricted to protect drinking water supplies.

<u>Class 2</u>: The objective of class 2 waters is to protect their uses for recreational purposes, the support and propagation of aquatic life, agricultural and industrial water supplies, shipping, and navigation.

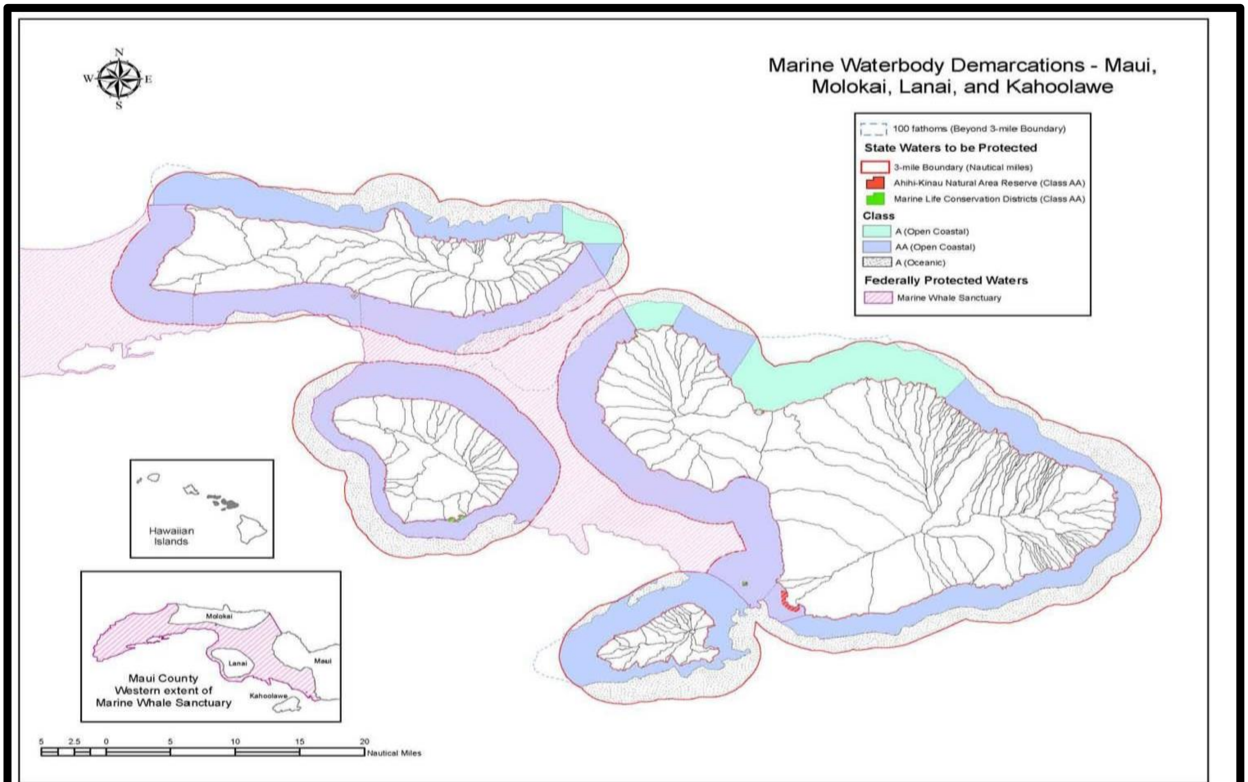
5.1.2.2 <u>Marine Water Classes</u>

The open coastal waters of Māʻalaea Bay are designated as Class AA waters. The receiving waters for drainages from the remainder of the watershed planning area include open coastal and oceanic marine waters within the Hawaiian Islands Humpback Whale National Marine Sanctuary. These waters may be considered Class AA by virtue of being in a Federal Marine Sanctuary (Figure 19. Maui County Marine Water Classes).

<u>Class AA</u>: It is the objective of class AA waters that these waters remain in their natural pristine state as nearly as possible with an absolute minimum of pollution or alteration of water quality from any human-caused source or actions. To the extent practicable, the wilderness character of these areas shall be protected.

<u>Class A</u>: It is the objective of class A waters that their use for recreational purposes and aesthetic enjoyment be protected. Any other use shall be permitted as long as it is compatible with the protection and propagation of fish, shellfish, and wildlife, and with recreation in and on these waters. These waters shall not act as receiving waters for any discharge which has not received the best degree of treatment or control compatible with the criteria established for this class. No new sewage discharges shall be permitted within embayments.

Figure 37. Maui County Marine Water Classes



5.1.2.3 <u>Marine Bottom Ecosystem Classes</u>

For sandy beaches, the Northwest Hawaiian Islands are Class I; all other beaches in the state are Class II.

<u>Class I</u>: It is the objective of class I marine bottom ecosystems that they remain as nearly as possible in their natural pristine state with an absolute minimum of pollution from any human-induced source. Uses of marine bottom ecosystems in this class are passive human uses without

intervention or alteration, allowing the perpetuation and preservation of the marine bottom in a most natural state, such as non-consumptive scientific research, non-consumptive education, aesthetic enjoyment, passive activities, and preservation.

Class II: It is the objective of class II marine bottom ecosystems that their use for protection including propagation of fish, shellfish, and wildlife, and for recreational purposes not be limited in any way. The uses to be protected in this class of marine bottom ecosystems are all uses compatible with the protection and propagation of fish, shellfish, and wildlife, and with recreation. Any action which may permanently or completely modify, alter, consume, or degrade marine bottoms, such as structural flood control channelization, landfill and reclamation, navigational structures, structural shore protection, and wastewater effluent outfall structures may be allowed on securing approval in writing from the director, considering the environmental impact and the public interest pursuant to sections 342D-4, 342D-5, 342D-6, and 642D-50, HRS, in accordance with the applicable provisions of chapter 91, HRS.

5.1.3 Water Quality Criteria

Basic criteria are applied to all classes of waters, and specific criteria are assigned to some, but not all classes. Within a class, the specific criteria may not apply to all waterbody types. The regulations do not provide specific criteria for uses for all waterbody types. Therefore, the regulations provide a nexus between waterbody class and use, but not between use and criteria. An exception is that recreational waters are defined and recreational uses are tied to bacterial criteria in the water quality standards.

5.1.3.1 Basic Criteria

The basic criteria apply to all waters (HAR §11-54-4). These criteria include narrative statements for controlling substances, including materials that settle or float, or that can have toxic or other undesirable effects. The narrative criteria include that all waters should be free of "deleterious substances sufficient to be toxic or harmful to human, animal, plant, or aquatic life, or in amounts to interfere with any beneficial use of the water." A translator for these narrative criteria is contained within the regulation in the requirement that waters be free from pollutants in concentrations exceeding acute and chronic toxicity and human health standards (expressed as average criteria concentrations at specified durations). There are also provisions translating the narrative criteria in terms of toxicity testing (bioassay) results.

5.1.3.2 Specific Criteria

For some waterbody types, there are specific narrative or numeric criteria. There are specific criteria for inland waters (HAR §11-54-5), marine waters (HAR §11-54-6), marine bottom types (HAR §11-54-7), and recreational areas (HAR §11-54-8).

5.1.4 Numeric Criteria for Water Column Chemistry

Numeric criteria for water column chemistry for marine waters are defined for wet and dry conditions as values not to be exceeded by the geometric mean, more than ten percent of the time and more than two percent of the time, respectively. Tables 11 through 16 provide the applicable numeric criteria for water column chemistry in inland waters (streams and estuaries) and marine waters (open coastal and oceanic) within the Māʻalaea Bay Watersheds Management Plan (MBWMP) area (Source HAR§11-54, 2014).

Table 11. Inland Waters - Specific Water Quality Criteria for Streams

Parameter	Hawai'i State Water Quality Standards HAR §11-54-5.2(b)					
	Geometric Mean (Not to Exceed)		Not to Exceed > 10% of time		Not to Exceed > 2% of time	
	wet	dry	wet	dry	wet	dry
Nitrate+Nitrite (as N) (µg/L)	70.0	30.0	180.0	90.0	300.0	170.0
Nitrogen, Total (µg/L)	250.0	180.0	520.0	380.0	800.0	600.0
Phosphorus, Total (µg/L)	50.0	30.0	100.0	60.0	150.0	80.0
Total Suspended Solids (mg/L)	20.0	10.0	50.0	30.0	80.0	55.0
Turbidity (NTU)	5.0	2.0	15.0	5.5	25.0	10.0

Notes: Wet Season = November 1 through April 30; Dry Season = May 1 through October 31;

Table 12. Specific Water Quality Criteria for Estuaries (except Pearl Harbor)

Parameter	Hawai'i State Water Quality Standards HAR §11-54-5.2(d)(1)		
	Geometric Mean (Not to Exceed)	Not to Exceed > 10% of time	Not to Exceed > 2% of time
Nitrogen, Total (µg/L)	200.00	350.00	500.00
Ammonia (as N) (µg/L)	6.00	10.00	20.00
Nitrate+Nitrite (as N) (µg/L)	8.00	25.00	35.00
Phosphorous, Total (µg/L)	25.00	50.00	75.00
Chlorophyll a (µg/L)	2.00	5.00	10.00
Turbidity (NTU)	1.5	3.00	5.00

Table 13. Specific Water Quality Criteria for Embayments

Parameter	Hawai'i State Water Quality Standards HAR §11-54-6(b)					
	Geometric Mean (Not to Exceed)		Not to Exceed > 10% of time		Not to Exceed > 2% of time	
	wet	dry	wet	dry	wet	dry
Nitrogen, Total (as N) (µg/L)	200.00	150.00	350.00	250.00	500.00	350.00
Ammonia (as N) (µg/L)	6.00	3.50	13.00	8.50	20.00	15.00
Nitrate+Nitrite (as N) (µg/L)	8.00	5.00	20.00	14.00	35.00	25.00
Phosphorus, Total (µg/L)	25.00	20.00	50.00	40.00	75.00	60.00
Chlorophyll a (µg/L)	1.50	0.50	4.50	1.50	8.50	3.00
Turbidity (NTU)	1.50	0.40	3.00	1.00	5.00	1.5

Table 14. Specific Marine Water Quality Criteria for Open Coastal Waters

Parameter	Hawaiʻi State Water Quality Standards HAR §11-54-6(b)					
	Geometric Mean (Not to Exceed)		Not to Exceed > 10% of time		Not to Exceed > 2% of time	
	wet	dry	wet	dry	wet	dry
Nitrogen, Total (as N) (µg/L)	150.00	110.00	250.00	180.00	350.00	250.00
Ammonia (as N) (µg/L)	3.50	2.00	8.50	5.00	15.00	9.00
Nitrate+Nitrite (as N) (µg/L)	5.00	3.50	14.00	10.00	25.00	20.00
Phosphorus, Total (µg/L)	20.00	16.00	40.00	30.00	60.00	45.00
Chlorophyll a (µg/L)	0.30	0.15	0.90	0.50	1.75	1.00
Light Extinction Coef (k units)	0.20	0.10	0.50	0.30	0.85	0.55
Turbidity (NTU)	0.50	0.20	1.25	0.50	2.00	1.00

Notes: Wet Season When open coastal waters receive **more** than three million gallons per day of fresh water discharge per shoreline mile; Dry Season = When open coastal waters receive **less** than three million gallons per day of fresh water discharge per shoreline mile

Table 15. Marine Water Quality Criteria for Oceanic Waters

Parameter	Hawaiʻi State Water Quality Standards HAR §11-54-6(c)		
	Geometric Mean (Not to Exceed)	Not to Exceed > 10% of time	Not to Exceed > 2% of time
Nitrogen, Total (µg/L)	50.00	80.00	100.00
Ammonia (as N) (µg/L)	1.00	1.75	2.50
Nitrate+Nitrite (as N) (µg/L)	1.50	2.50	3.50
Phosphorus, Total (µg/L)	10.00	18.00	25.00
Chlorophyll a (µg/L)	0.06	0.12	0.20
Turbidity (NTU)	0.03	0.10	0.20

Table 16. Recreational Criteria for all Sate Waters

Parameter	Hawaiʻi State Water Quality Standards HAR §11-54-8		
	Geometric Mean (Not to Exceed)	Statistical Threshold Value Not to Exceed > 10% of time	Not to Exceed > 2% of time
Enterococcus (cfus/100ml)	35	130	NA

Notes: Enterococcus content shall not exceed a geometric mean of 35 colony forming units (cfu's) per 100 milliliters over any 30-day interval. A statistical threshold value (STV) of 130 colony forming units shall be used for enterococcus. The STV value shall not be exceeded by more than ten percent of samples taken within the same 30-day interval in which the geometric mean is calculated.

5.1.5 <u>Criteria for Marine Bottom Ecosystems</u>

The criteria for Marine Bottom Ecosystems are found at HAR §11-54-7. A major reef tract for Maui begins in Māʻalaea Bay and extends south through North Kīhei. The marine bottoms of the Hawaiian Islands Humpback Whale National Marine Sanctuary may be considered Class I depending on the interpretation of the language, "in preserves, reserves, sanctuaries, and refuges established by the department of land and natural resources under chapter 195 or chapter 190, HRS, or similar reserves for the protection of marine life established under chapter 190, HRS, as amended; or in refuges or sanctuaries established by the U.S. Fish and Wildlife Service or the National Marine Fisheries Service."

5.2 Clean Water Act Sections 303(d) and 305(b)

The Hawaiʻi State Department of Health (DOH) is obligated by the Clean Water Act (CWA) Sections (§) 303(d) and §305(b) to report on the State's water quality on a two-year cycle. The CWA §305(b) requires states to describe the overall status of water quality statewide, and the extent to which water quality provides for the protection and propagation of a balanced population of shellfish, fish, and wildlife, and allows recreational activities in and on the water. The CWA §303(d) requires states to submit a list of waters that do not attain applicable water quality standards, plus a priority ranking of impaired waters for Total Maximum Daily Loads (TMDL) development based on the severity of pollution and the uses of the waters.

The IR informs the public on the status of marine and inland (streams and estuaries) water bodies and serves as a planning document to guide other CWA programs. The Final 2020 IR incorporates data collected from November 1, 2017 to October 31, 2019 to provide an updated snapshot of water body conditions throughout the state and carries over the assessment results from previous IRs. In addition, the Final 2022 IR report incorporates data collected from November 1st, 2019 to October 31st, 2021. These documents can be found on the DOH CWB website:
https://health.Hawaiʻi.gov/cwb/clean-water-branch-home-page/integrated-report-and-total-maximum-daily-loads/

Impaired waters—waters that do not meet the State's water quality standards (WQS)— in the IR may be targeted for further monitoring activities to develop TMDLs, to plan and evaluate CWA §319 nonpoint source (NPS) pollution control projects and set requirements for National Pollutant Discharge Elimination System (NPDES) permits and §401 Water Quality Certifications (WQCs). The IR not only identifies areas in need of restoration but serves as a baseline to validate the State's efforts to improve water quality and eventually delist impaired waters that have been rehabilitated.

5.2.1 <u>2022 State of Hawaiʻi Integrated Water Quality Report - Clean Water Act §305(b) Assessments and §303 (d) List of Impairments</u>

In the most recent finalized Integrated Water Quality Report (Hawaiʻi Department of Health, 2022), three water body sites are listed by the DOH CWB that fall within the Māʻalaea Bay Watersheds boundary. They include Mai Poina Oe Iau Beach Co. Park, Kīhei Coast-Mokulele, and Keālia Pond.

<u>HIW00025 – Mai Poina ʻOe Iʻau Beach Co. Park</u>

Mai Poina ʻOe Iʻau Beach Co. Park is listed in both the 2020 and 2022 Final IR reports for Total Nitrogen, Nitrate+Nitrite, Ammonium, and Turbidity impairments. The site has been given low priority status for the development of a Total Maximum Daily Load (TMDL) for these parameters. No attainment status is offered in either report for chlorophyll-*a*.

<u>HIW00042 – Kīhei Coast-Mokulele</u>

Kīhei Coast-Mokulele is listed in both the 2020 and 2022 Final IR reports for Total Nitrogen, Nitrate+Nitrite, Ammonium, Turbidity, and chlorophyll-*a* impairments. The site has been given low priority status for the development of a Total Maximum Daily Load (TMDL) for these parameters.

<u>HIW00224 – Keālia Pond</u>

Keālia Pond was added as a sample site in the Final 2022 IR report. It was listed for Nitrate+Nitrite, Ammonium, and Turbidity impairments. No attainment statuses were given for Enterococcus or Chlorophyll-*a*. The site has been given low priority status for the development of a Total Maximum Daily Load (TMDL) for these parameters.

Table 17. Māʻalaea Bay Watersheds Assessed Water Bodies and Impairments for the 2020 Final and 2022 Final Integrated Water Quality Reports

Final 2020 Integrated Water Quality Report								
Assessed Water Body	Water Body ID	Water Quality Parameters						
		Enterococcus	TN	Nitrate + Nitrite	Ammonium	TP	Turbidity	Chlorophyll-*a*
Waiakoa Watershed								
Mai Poina ʻOe Iʻau Beach Co. Park	HIW00025	A	**<u>N</u>**	**<u>N</u>**	**<u>N</u>**	**<u>A</u>**	N	-
Kīhei Coast-Mokulele	HIW00042	-	N	N	**<u>N</u>**	**<u>A</u>**	N	N
Final 2022 Integrated Water Quality Report								
Assessed Water Body	Water Body ID	Water Quality Parameters						
		Enterococcus	TN	Nitrate + Nitrite	Ammonium	TP	Turbidity	Chlorophyll-*a*
Waiakoa Watershed								
Mai Poina ʻOe Iʻau Beach Co. Park	HIW00025	A	N	N	N	A	N	-

Kīhei Coast-Mokulele	HIW0 0042	**<u>A</u>**	N	N	N	A	N	N
Waikapū Watershed								
Keālia	HIW0 0224	-	**<u>A</u>**	**<u>N</u>**	**<u>N</u>**	**<u>A</u>**	**<u>N</u>**	-

N indicates that the water quality standard was not attained
A indicates that the water quality standard was attained
- indicates insufficient data
*Site is not currently sampled and data have been carried over from previous reports
Changes in attainment status from previous years are bolded and underlined

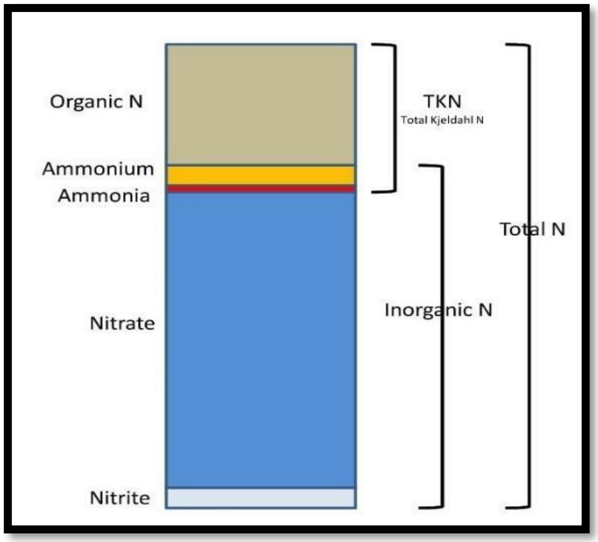
Turbidity measurements in exceedance of water quality standards can be caused by sediment laden water discharging from freshwater streams and/or from the resuspension of sediment caused by tidal or wave action within coastal waters. Increased sedimentation and nutrient loading on the extensive offshore reef complex threaten the health of the reef ecosystem. Sediments deposited by one storm event can be subsequently re-suspended. Recent studies have demonstrated that increases in sediment discharges from watersheds associated with poor land-use practices can impact reefs over 100 km from shore, and that ecosystem-based management efforts that integrate sustainable activities on land, while maintaining the quality of coastal waters and benthic habitat conditions, are critically needed if coral reefs are to persist (Richmond, et al., 2007).

In addition to nutrient testing, DOH tests for algae in coastal waters. Testing for algal growth is conducted by measuring chlorophyll-*a* concentrations in the water. Chlorophyll-*a* is the most abundant type of chlorophyll within photosynthetic organisms and gives plants their green color. Higher concentrations generally indicate poor water quality. Abundance of algal growth is maintained by high nutrient concentrations.

Total nitrogen is equal to the sum of organic nitrogen, ammonia, and inorganic nitrogen. It should be noted that the term ammonia refers to two chemical species which are in equilibrium in water (NH3, un-ionized and NH4+, ionized). Ammonia and ammonium forms of N are usually only elevated near sources of human or animal waste discharges. Nitrate + nitrite nitrogen is also known as inorganic nitrogen. Inorganic nitrogen is typically associated with the use of fertilizers for agricultural operations, golf courses, and residential lawn maintenance. Organic nitrogen can originate from various sources including organic fertilizers, detritus, human and animal waste, and algae in the water column (Wall, 2013). When too much nitrogen is present in water, algae blooms can occur. These blooms reduce dissolved oxygen that fish and other aquatic and marine organisms need to survive. In addition, high levels of nitrates in drinking water can cause illnesses such as blue baby syndrome in infants and can even result in death (Beaudet, et al., 2014)

In most surface waters, the dominant forms of Nitrogen (N) are Nitrate and Organic Nitrogen. Where streams occur near agricultural production or biological wastewater treatment facilities, the Nitrate form of N is usually substantially higher than organic N. Nitrate levels are typically low in forested and grassland environments, therefore organic N is typically found in much higher amounts than Nitrates in more natural landscapes. Ammonia and ammonium forms of N are usually only elevated near sources of human or animal waste discharges (Wall, 2013).

Figure 38. Total Nitrogen and Nitrogen Components in Surface Water



Total phosphorus is found in agricultural fertilizers, manure, and organic wastes in sewage and industrial wastewater. An abundance of phosphorus in surface waters can lead to an abundance of plankton and algae that consume large amounts of dissolved oxygen and may ultimately lead to eutrophication within the system. Too much phosphorus can also be detrimental to human health, causing kidney damage and osteoporosis. Phosphorus and orthophosphates are not typically very mobile in stormwater. Phosphorus fertilizers typically enter streams with sediment transport and increase as TSS increases (Oram, 2014).

Cesspools, feral ungulate feces, human feces, decomposing vegetation, agricultural fertilizer, golf courses, and other sources of nutrients may be causing or contributing to the high nutrient concentrations observed in Māʻalaea Bay. Section 14.0 of this document entitled Monitoring Program for Evaluating Implementation Project Success provides methods for determining the source of these nutrients in the stormwater. Specifically, by distributing testing locations throughout the watershed at locations where pollutants are believed to originate, and by testing groundwater, stormwater, and coastal surface water, this plan aims to tease out the various sources of pollutants entering Keālia Pond and Māʻalaea Bay. In addition, by testing for a suite of nutrient species, the origin of these pollutants can be better understood as discussed in detail above.

6.0 Element A – SOURCES AND CAUSES OF POLLUTANTS

Primary sources of water pollution in the Māʻalaea Bay Watersheds are nutrients and sediment. Nutrients may enter coastal waters through various mechanisms including shallow wastewater injection wells, malfunctioning septic systems, cesspools, and the improper use of fertilizers on agricultural lands, golf courses, residential lawns and resort landscapes. An injection well can be considered a point source, whereas discharges from cesspools and septic systems are usually accounted for as nonpoint sources of pollution. Stormwater runoff from conservation lands; agricultural or industrial land uses; and urban, resort, and rural development can transport nonpoint source pollution to the ocean.

Information on both permitted sources of pollution and non-point source pollution in the Waikapū and Waikaoa Watersheds was collected by MEC through literature and data review, sediment and nutrient delivery models, field assessments, and discussions with the community. Previous water resource reports, maps and shapefiles, and environmental assessments were utilized to better understand pollutant sources and pollutant transport pathways at a landscape level throughout the Māʻalaea Bay Watersheds.

6.1 Point Sources

6.1.1 National Pollutant Discharge Elimination System

The discharge of pollutants from point sources is generally regulated through the National Pollutant Discharge Elimination System (NPDES). The Clean Water Act prohibits discharge of pollutants to Waters of the US except in compliance with an NPDES permit. The Hawaiʻi Department of Health, Clean Water Branch is delegated authority for issuance of general and individual NPDES permits. The NPDES program requires permits for the discharge of "pollutants" from any "point source" into "waters of the United States." The terms "pollutant", "point source", and "waters of the US" are found in the Code of Federal Regulations (CFR) Chapter 40 Part 122.2. Point source means any discernible, confined, and discrete conveyance, including but not limited to, any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, landfill leachate collection system, vessel, or other floating craft from which pollutants are or may be discharged. This term does not include return flows from irrigated agriculture or agricultural stormwater runoff (See §122.3).

There are two types of NPDES permits: Individual Permits and General Permits. Individual Permits are facility-specific permits that are issued to a specific permittee and include conditions and requirements that are applicable to that specific facility. The State's General NPDES Permits are not issued to a specific permittee and are instead written to address a specific type of activity or discharge. Activities covered under a General NPDES Permit include stormwater runoff associated with construction activity at construction sites greater than one acre, stormwater runoff associated with industrial activity, and other regulated discharges to State waters. Table 18 below lists the active NPDES permits that exist within the Māʻalaea Bay Watershed boundaries, all of which lie within the Waiakoa Watershed Boundary. No active NPDES permits exist within the Waikapū Watershed Boundary. This data was pulled from the Hawaiʻi Department of Health Environmental Health Portal Water Pollution Control Viewer (https:// wpc-viewer.doh.hawaii.gov/).

Table 18. Active NPDES Permits within the Māʻalaea Bay Watersheds

Polynesian Adventure Tours Bus Yard - Waiakoa	HIR10G977	182 Nopu Street, Puunene, HI 96784.	Notice of General Permit Coverage	Form C: Storm water associated with construction activity	10/14/2022	2/8/2024
Kula I'o Residence, Lot 26 - Waiakoa	HIR10H038	126 Kula I'o Road, Kula, HI 96790	Notice of General Permit Coverage	Form C: Storm water associated with construction activity	12/8/2022	2/8/2024

This study did not review water quality data associated with individual NPDES permits or their associated discharges within the watershed as these entities are actively regulated by the HDOH and permit exceedances have been developed by the regulatory agency to ensure Hawaiʻi water quality standards are being adhered to. As a condition of their NPDES permit, these entities are required to report any exceedance of their permit limitations.

6.1.2 Injection Wells

An injection well (IW) is a bored, drilled or driven shaft, or a dug hole, whose depth is greater than its largest surface dimension; an improved sinkhole; or a subsurface fluid distribution system used to discharge fluids underground (40 CFR Part 144.3). Injection wells and cesspools are regulated by the USEPA under the authority of the Underground Injection Control (UIC) program, as provided by Part C of the Public Law 92-523, the Safe Drinking Water Act (SDWA) of 1974. DOH administers a separate UIC permitting program under state authority that controls the location, construction, and operation of injection wells so that the injected fluids do not migrate and pollute underground sources of drinking water.

Seven active injection well UIC permits exist within the Māʻalaea Bay Watersheds, all of which lie within the Waiakoa Watershed boundaries (Figure 40. Waiakoa NPDES – UIC – Cess Pool Map). Of these, four are used for sewage, one is used for industrial wastewater, and two are used for stormwater runoff. The table below lists these wells and provides information on their permit number, operator and location within the Māʻalaea Bay Watersheds (Table 19. UIC Permits Within Māʻalaea Bay Watersheds).

Table 19. UIC Permits within the Māʻalaea Bay Watersheds

Permit Number	Operator/Facility	TMK	Discharge Type	Well Classification	Location
UM-2678	Ilima Houselots	2-3-9-028-039	Storm Runoff	Class V, Subclass C	Kenolio Rd and Kuilima PL, Kīhei
UM-2192	Central Maui Baseyard	Not Listed	Sewage	Class V, Subclass AB	Not Listed
UM-2933	Pūlehunui Industrial Park	2-3-8-008-019	Industrial	Class V, Subclass AB	Puunene, Wailuku, Maui
UM-1442	Kaiola Heights Subdivision	2-3-9-035-048	Storm Runoff	Class V, Subclass C	Between Kenolio Rd. & Kaiola Place, Kīhei, Maui 96753
UM-2670, 2876	Kula Elementary School	2-2-2-014-002	Sewage	Class V, Subclass E	500 Kula Highway, Kula, HI 96790
UM-2164	Kula Experiment Station	2-2-2-011-033	Sewage	Class V, Subclass A	424 Mauna Place, Kula, HI
UM-2700, UM-2803	Haleakalā National Park	2-2-3-005-001, 2-2-3-005-024	Sewage	Class V, Subclass A	Haleakalā National Park Summit

6.2 Estimating Nonpoint Source Pollutant Loads

6.2.1 INVEST Modeling

InVEST®: **https://naturalcapitalproject.stanford.edu/software/invest** is an informative geospatial tool developed by the Natural Capital Project for watershed managers and planners (Natural Capital Project, 2022). It is a GIS-based application with several different models. To estimate and identify potential water-quality impacts from nonpoint source pollution and erosion in the Waikapū and Waiakoa watersheds, MEC staff utilized the Sediment Delivery Ratio and Nutrient Delivery Ratio models. MEC ran the InVEST model for sediment, nitrogen, and phosphorus delivery throughout the Waikapū and Waiakoa Watersheds. The models provide estimates of both accumulated sediment and nutrients in the gullies and gulches making their way towards the ocean and localized sediment and nutrient contributions based on the model inputs listed above.

The objective of the InVEST Sediment Delivery Ratio (SDR) model is to quantify and map overland sediment generation and delivery to the stream. For the SDR model, inputs include the following:

1. 30m Digital Elevation Models (DEMs) from the United States Geological Survey (USGS)
2. An erosivity raster file, which is a map of rainfall erosivity (R-factor), reflecting the intensity and duration of rainfall in the area of interest
3. A soil erodibility raster file, which is a map depicting the susceptibility of soil particles to detach and transport by rainfall and runoff
4. Coastal Change Analysis Program (CCAP) land cover - each land cover type has an associated impervious surface co-efficient.
5. A biophysical table organized in Xcel. This table maps each LULC code to biophysical properties of that LULC class, including USLE c and p values
6. A watershed vector map
7. Threshold Flow Accumulation value
8. Borselli K Parameter value
9. Maximum SDR value as a function of soil texture
10. Borselli IC0 Parameter value
11. Maximum L value, which is the maximum allowed slope length

The objective of the InVEST nutrient delivery ratio model (NDR) is to map nutrient sources from watersheds and their transport to the stream. For the NDR model, inputs include the following;

1. 30m Digital Elevation Models (DEMs) from the United States Geological Survey (USGS)
2. Coastal Change Analysis Program (CCAP) land cover - each land cover type has an associated impervious surface co-efficient.
3. A Nutrient Runoff Proxy, which is a map of runoff potential, the capacity to transport nutrients downslope
4. A watershed vector map
5. A biophysical table organized in Xcel. This table maps each LULC code to biophysical properties of that LULC class, including usle c and p values
6. Subsurface Critical Length for Nitrogen
7. Subsurface Maximum Retention Efficiency
8. Threshold Flow Accumulation value
9. Borselli K Parameter value

It should be noted that geospatial models like InVEST have known limitations with accuracy and precision when modeling for erosion in wet, steep slopes like those in the upper reaches of the Waikapū and Waiakoa Watersheds. This is due, in part, to a lack of available data collection from inaccessible mountainous areas. Inputs to InVEST, such as rainfall days and soil erosion factors, are often very different throughout the landscape being modeled and may not be accurately represented by the input data. In addition, general CCAP designations can skew data. As an example, CCAP data used in this effort designates the fallow sugar cane fields as “Cultivated Land” and does not consider that while this land is agricultural, portions of the watersheds are not actively being farmed. MEC recognizes that there are other models available, and that there are trade-offs between cost-efficiency and higher accuracy (more robust modeling methods and procedures can be costly and time-intensive).

Within InVEST, the NDR model has a small number of parameters, and outputs generally show a high sensitivity to inputs. This implies that errors in the empirical load parameter values will have a large effect on predictions. Similarly, the retention efficiency values are based on empirical studies, and factors affecting these values (like slope or intra-annual variability) are averaged. These values implicitly incorporate information about the dominant nutrient dynamics, influenced by climate and soils. The model also assumes that once nutrient reaches the stream it impacts water quality at the watershed outlet, no in-stream processes are captured.

Among the main limitations of the InVEST SDR model is its reliance on the Universal Soil Loss Equation (USLE) (Renard et al., 1997). This equation is widely used but is limited in scope, only representing overland (rill/inter-rill) erosion processes. Other sources of sediment include gully erosion, streambank erosion, and mass wasting from landslides or rockfalls, and glacial erosion. A good description of the gully and streambank erosion processes is provided by Wilkinson et al. 2014, with possible modeling approaches. Mass movements (landslide) are not represented in the model but can be a significant source in some areas or under certain land use change, such as road construction.

Given the simplicity of the SDR and NDR models and low number of parameters, outputs are very sensitive to most input parameters. Errors in the empirical parameters of the USLE equations will therefore have a large effect on predictions. Sensitivity analyses are recommended to investigate how the confidence intervals in input parameters affect the study conclusions (Natural Capital Project, 2022).

Tables 20 and 21 list the quantitative data resulting from the INVEST modeling effort. In addition, the results of the INVEST modeling exercises for localized sediment, nitrogen and phosphorus are included as figures below (Figures 39-44). These figures are offered as qualitative data serving as visual representations of the various sediment and nutrient sources that are exported from their origin to the actual streams as predicted by the InVEST model.

The Waikapū and Waiakoa Sediment Export Maps (Figure 39 and 40) depict several areas within the watershed where sediment transport (tons per pixel) is particularly high. The INVEST model predicts heavy amounts of localized sediment for land uses at higher elevations where mountain slopes are fairly steep. This is especially true within the Waikapū Watershed, where the model shows the highest amount of sediment export occurring at the upper reaches of Mauna Kahālāwai. InVEST depicts the lowest sediment export to be associated with Mahi Pono and other agricultural lands east of Honoapiʻilani Highway.

According to the model, localized sediment export is significantly lower within the Waiakoa Watershed. As with Waikapū, sediment export is highest near the summit of Haleakalā and is directly correlated with steeper slopes. In the lower reaches of the watershed, where the slope changes from being extremely steep into the gulches and gullies within the coastal floodplain, localized sediment availability is also relatively high. At the upper reaches of the watershed, portions of State lands as well as Haleakalā Ranch depict higher sediment transport. Within the central and lower portions of Waiakoa higher sediment transport is depicted within A&B and Mahi Pono properties.

As stated previously, the InVEST pollutant models are limited by the datasets that go into the model. The sediment values depicted in steeper areas may be overestimated because the soils are quite rocky and are largely covered by dense grasses. InVEST values for annual sediment export to streams equaled 4,314 tons in the Waikapū Watershed and 7,068 tons in the Waiakoa Watershed.

Table 20. InVEST Sediment Delivery Ratio Results

InVEST Sediment Delivery Ratio Results (Annually)			
Watershed	Total amount of potential soil loss as calculated by the USLE equation (Tons)	Sediment discharge into stream (Tons)	Total amount of sediment deposited on the landscape in each watershed, which does not enter the stream
Waiakoa	55,527	7,068	17,174
Waikapū	35,120	4,314	9,765

The InVEST Nitrogen and Phosphorus Maps generated by the NDR model for nutrient concentrations report high amounts of nutrient export in those land uses associated with ranching and agriculture and in areas with steep slopes. As stated above, the InVEST model does not consider specific details like herd size, rotational grazing practices, fallow or in-production agricultural land, fertilizing techniques and schedules, etc.

InVEST values for total phosphorus loads in Waikapū and Waiakoa were 676 kg/year and 2,864 kg/year respectively. Total nitrogen loads were 1,395 kg/year in Waikapū and 4,946 kg/year in Waiakoa.

Table 21. InVEST Nutrient Delivery Ratio Results

InVEST Nutrient Delivery Ratio Results				
Watershed	Total phosphorus loads (sources) in the watershed, i.e. the sum of the nutrient contribution from all surface land uses without filtering by the landscape (kg/year).	Total phosphorus export from the watershed by surface flow (kg/year)	Total nitrogen loads (sources) in the watershed, i.e. the sum of the nutrient contribution from all surface land uses without filtering by the landscape (kg/year).	Total nitrogen export from the watershed by surface flow (kg/year)
Waikapū	676	76	1,395	207
Waiakoa	2,864	345	4,946	593

Figure 39. Waikapū Sediment Export Map

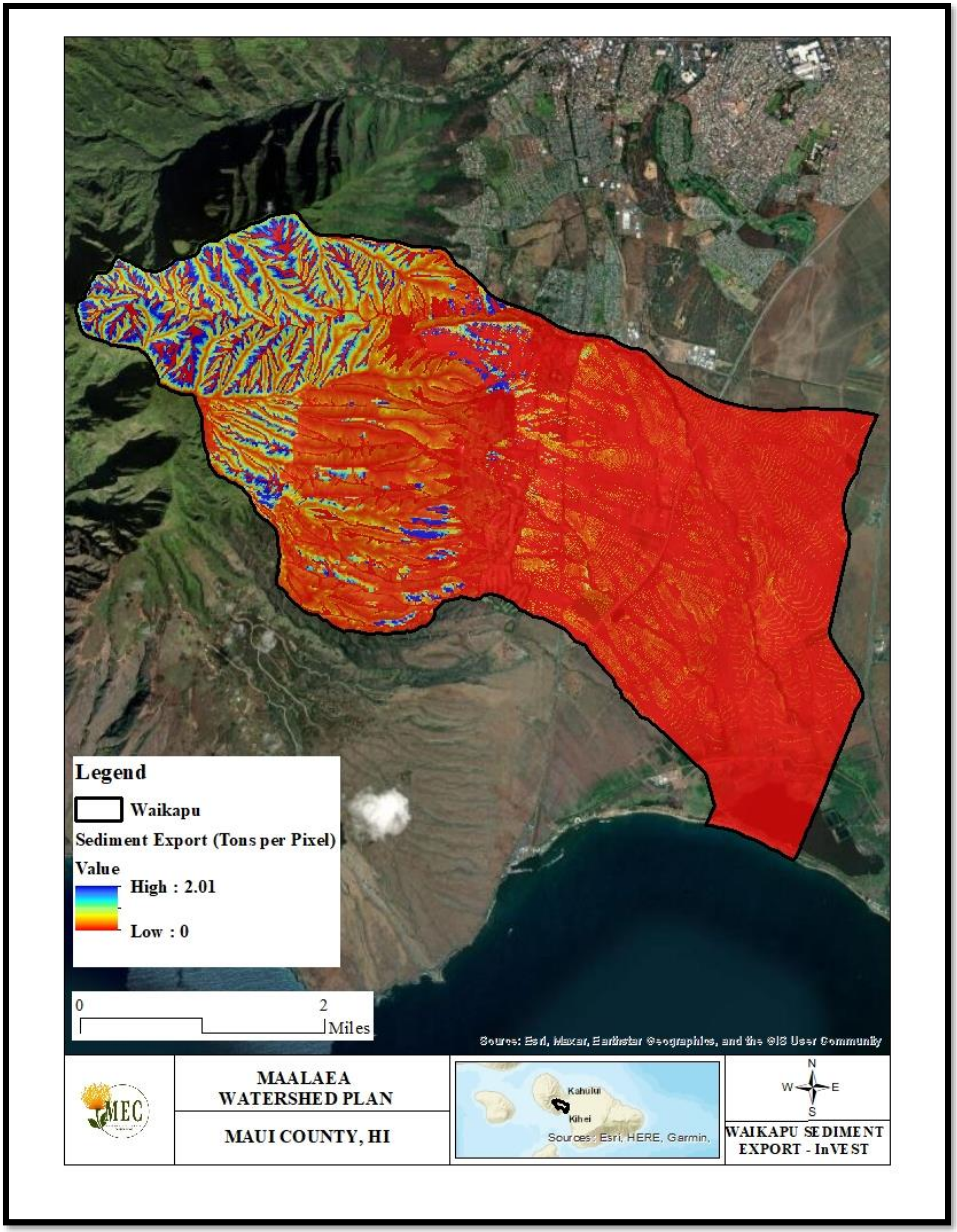


Figure 40. Waiakoa Sediment Export Map

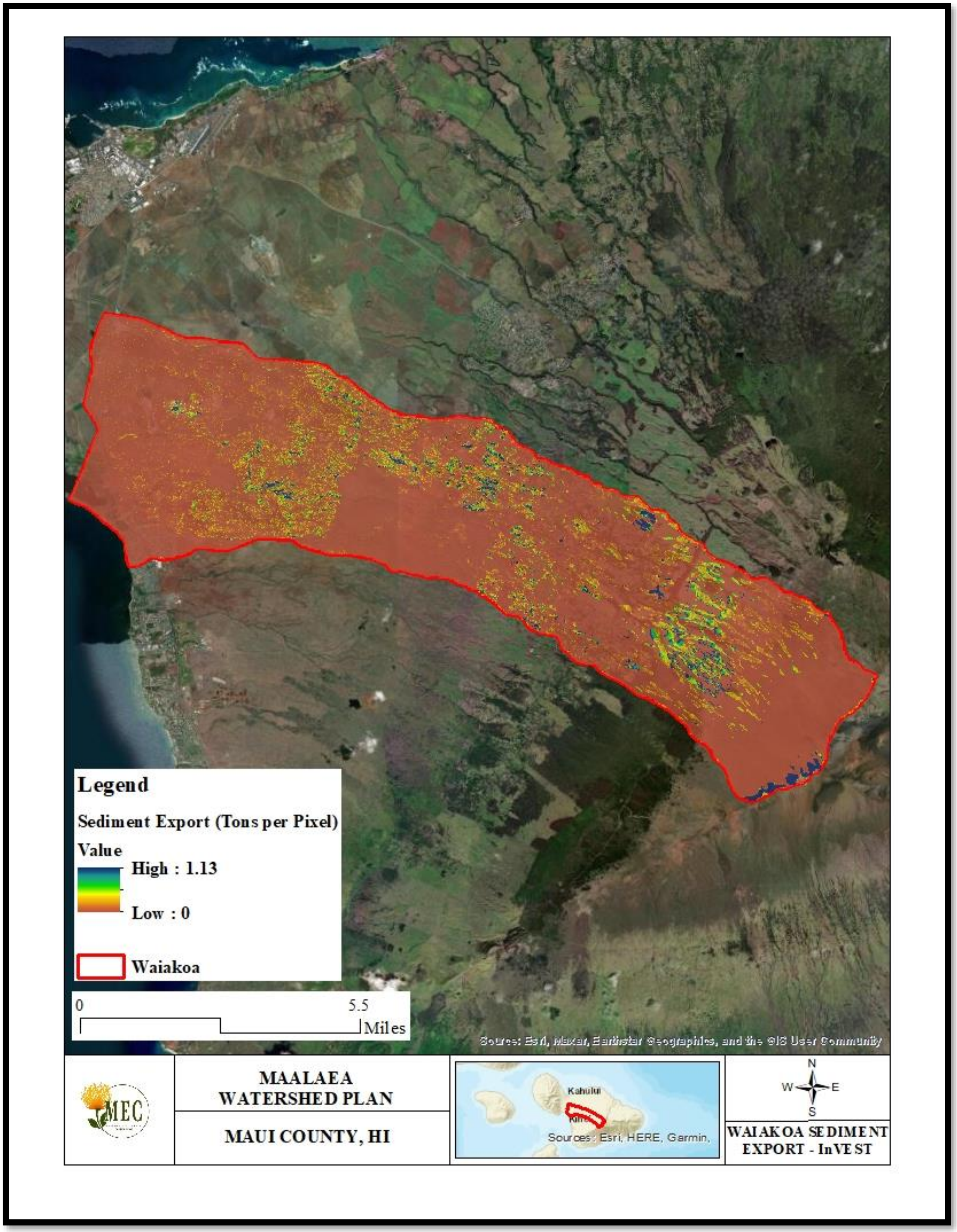


Figure 41. Waikapū Nitrogen Export Map

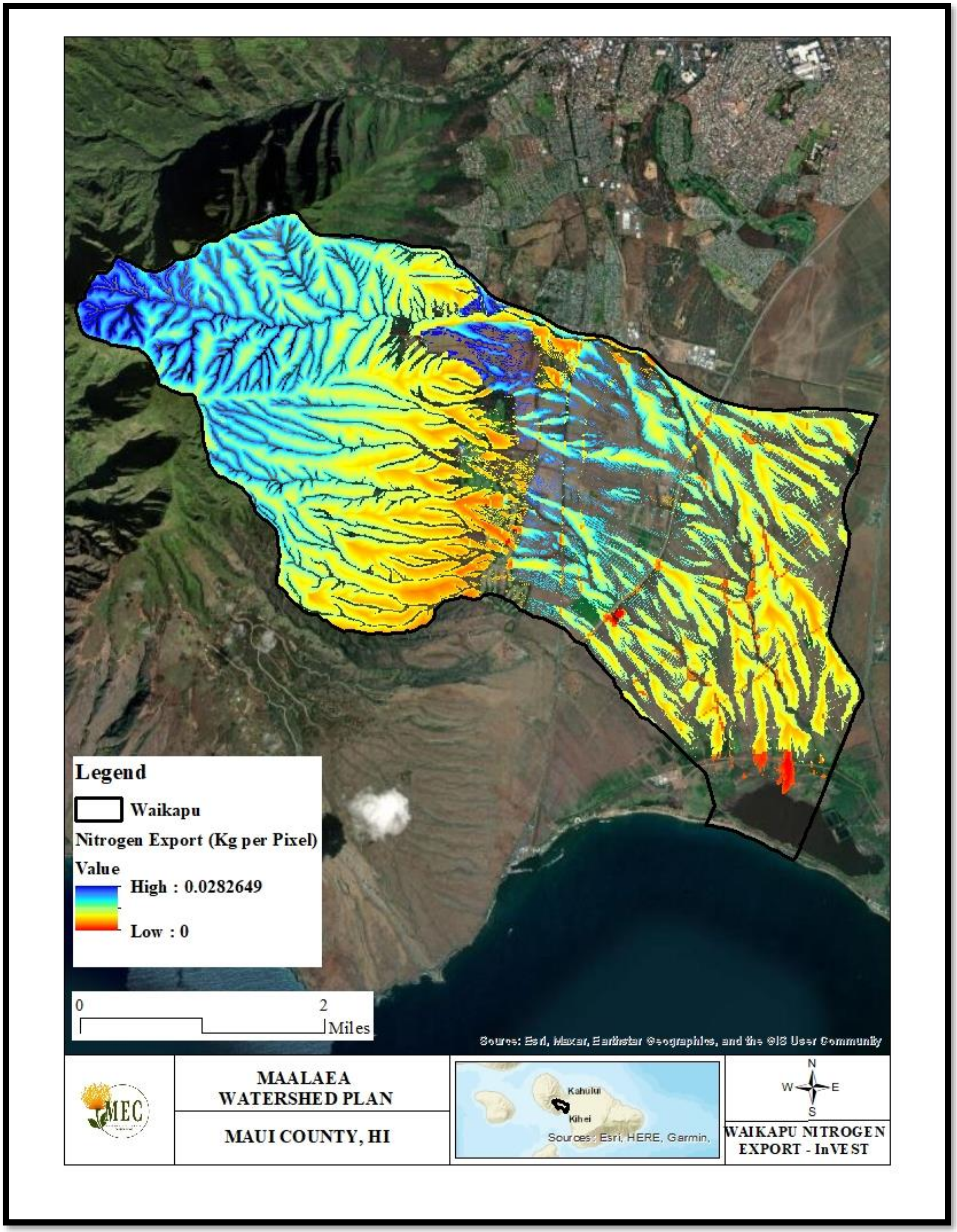


Figure 42. Waikapū Phosphorus Export Map

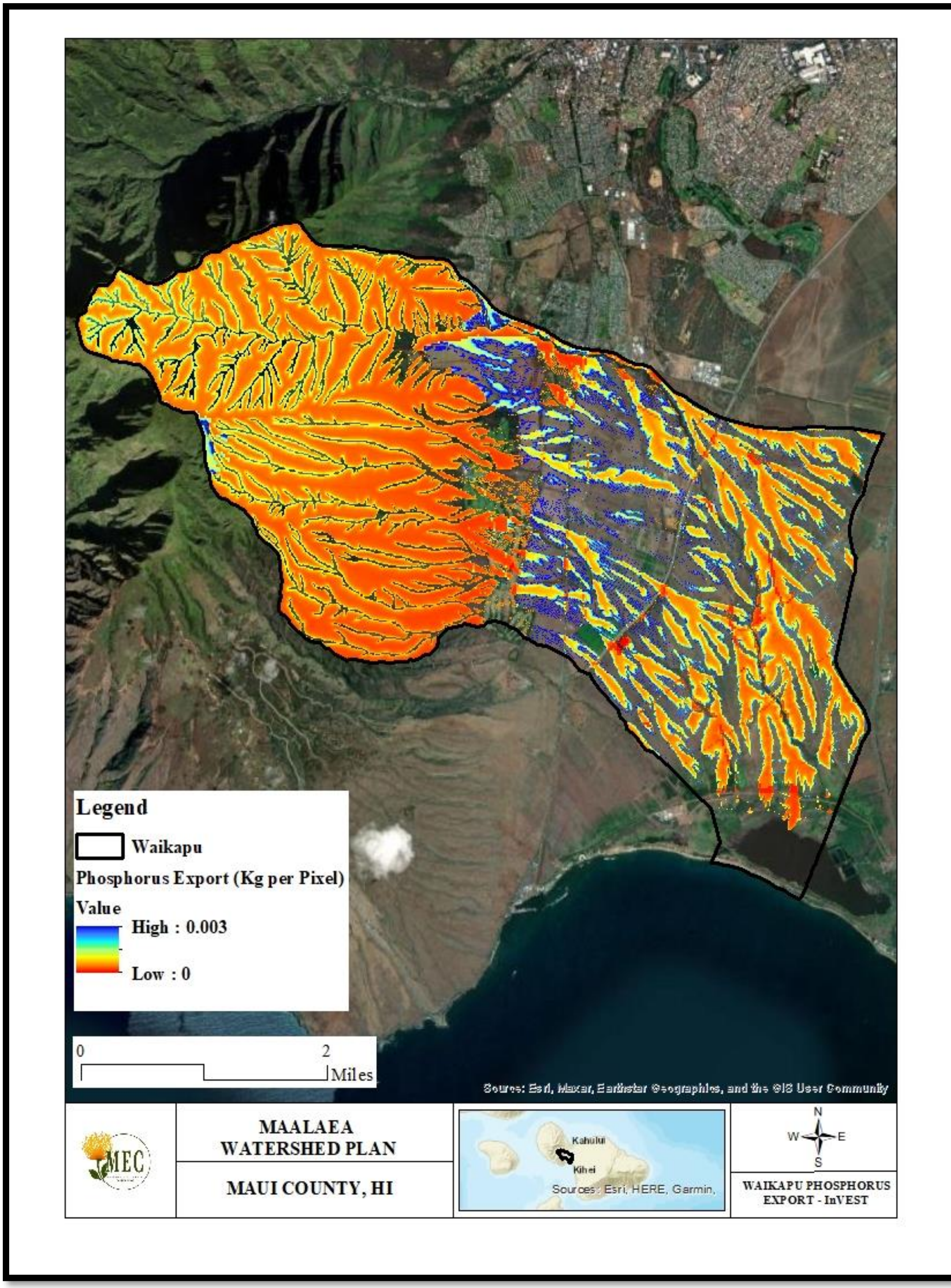


Figure 43. Waiakoa Nitrogen Export Map

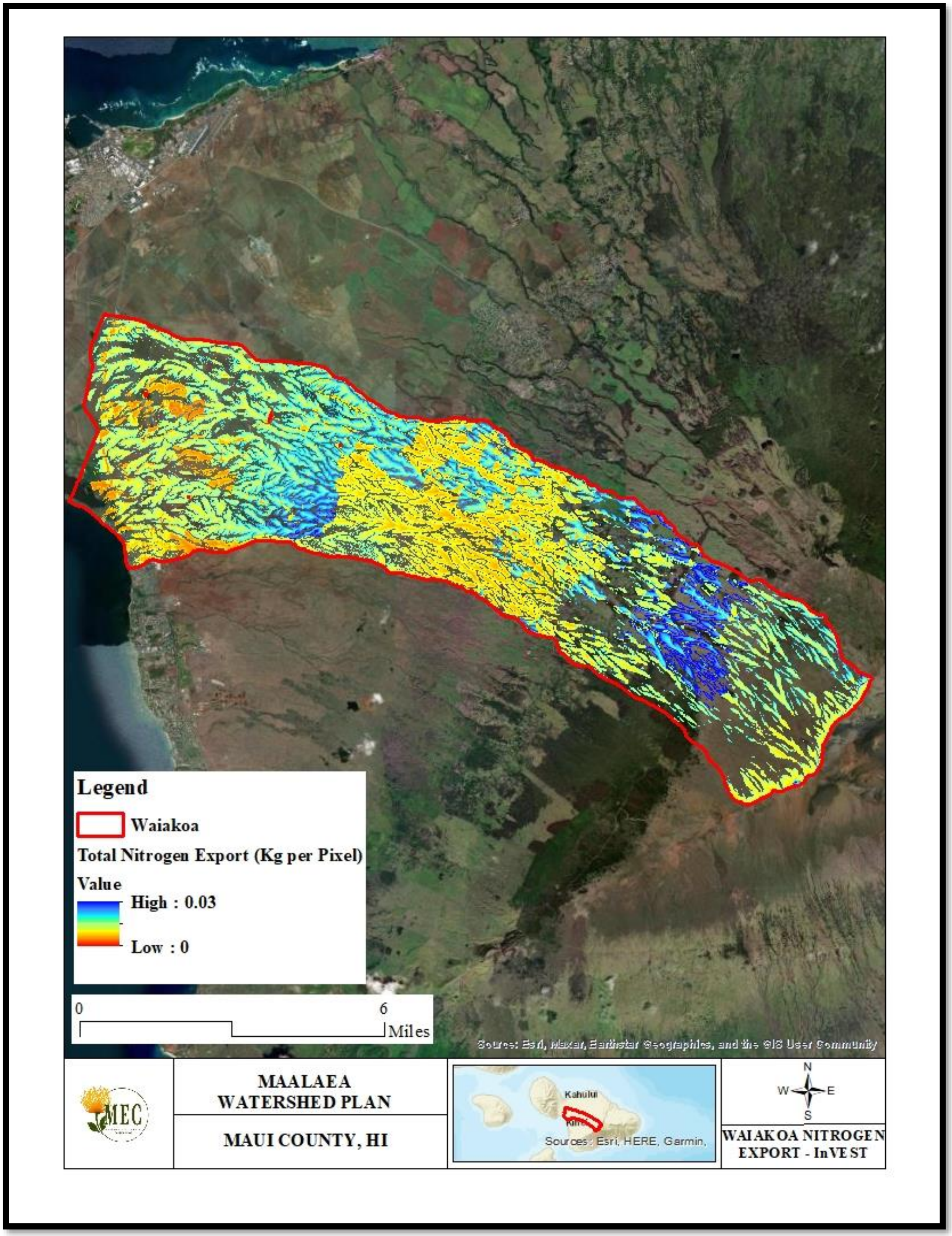
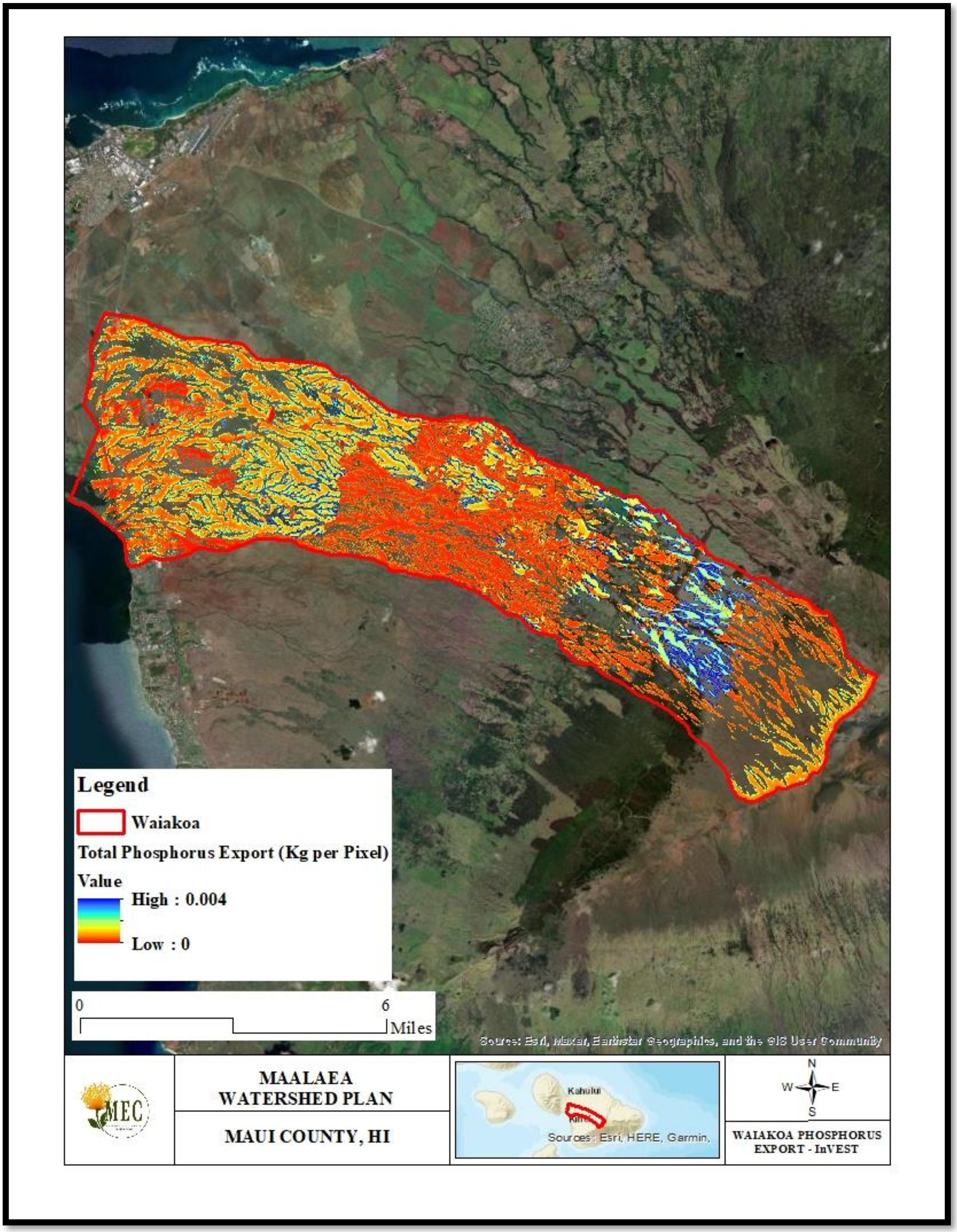


Figure 44. Waiakoa Phosphorus Export Map



6.2.2 STEPL

The EPA has developed the Spreadsheet Tool for Estimating Pollutant Load (STEPL) which employs simple algorithms to calculate nutrient and sediment loads from different land uses and the load reductions that would result from the implementation of various BMPs. STEPL provides a user-friendly Visual Basic (VB) interface to create a customized spreadsheet-based model in Microsoft (MS) Excel. It computes watershed surface runoff; nutrient loads, including nitrogen, phosphorus, and 5-day biological oxygen demand (BOD5); and sediment delivery based on various land uses and management practices. STEPL does not take into account slope and should be considered a very generalized model.

For the Waikapū and Waiakoa Watersheds, annual nutrient loading is calculated based on the runoff volume and the pollutant concentrations in the runoff water as influenced by factors such as the land use distribution and management practices. The annual sediment load (sheet and rill erosion only) is calculated based on the USLE and the sediment delivery ratio. The sediment and pollutant load reductions that result from the implementation of BMPs are computed using the known BMP efficiencies (http://it.tetratech-ffx.com/steplweb/). For Waikapū, the Pōhākea rain gauge was used. For Waiakoa, the average rainfall for Maui was used. These numbers generate the amount of rain days and average amount of rain per event.

Region 5 Model is an Excel workbook that provides a gross estimate of sediment and nutrient load reductions from the implementation of agricultural and urban BMPs. The algorithms for non-urban BMPs are based on the "Pollutants controlled: Calculation and documentation for Section 319 watersheds training manual" (Michigan Department of Environmental Quality, June 1999). The algorithms for urban BMPs are based on the data and calculations developed by Illinois EPA, Region 5 Model. The model does not estimate pollutant load reductions for dissolved constituents.

Cesspool contributions were also accounted for. There are 122 known cesspools in the Waikapū Watershed and 1,838 cesspools in the Waiakoa Watershed. The national average of 2.43 persons per household was used as the number of persons serviced by each cesspool. Table 22 presents the STEPL total load estimates by land use type for Nitrogen, Phosphorus, and Sediment within the Waikapū and Waiakoa Watershed Boundaries. Septic systems and Advanced Treatment Units (ATU’s) that are not properly maintained can contribute nutrient pollution in the same fashion as cesspools. STEPL treats failed septic systems and cesspools equally.

Table 22. STEPL Pollutant Loads by Land Use within Waikapū and Waiakoa

Total Load by Land Use			
Sources	**N Load (lb/yr)**	**P Load (lb/yr)**	**Sediment Load (t/yr)**
Waikapū			
Urban	312.81	48.14	7.18
Cropland	74,446.63	27,039.91	21,032.62
Pastureland	11,871.52	3,018.02	2,144.81
Forest	847.22	351.16	196.87
Cesspools	3,792.76	1,485.50	0.00
Total	91,270.95	31,942.72	23,381.48

Total Load by Land Use			
Sources	**N Load (lb/yr)**	**P Load (lb/yr)**	**Sediment Load (t/yr)**
Waiakoa			
Urban	14,697.78	2,261.89	337.49
Cropland	241,411.82	75,338.96	51,217.04
Pastureland	143,392.88	21,178.32	10,507.92
Forest	674.31	306.70	82.75
Cesspools	57,140.14	22,379.89	0.00
Total	457,316.94	121,465.77	62,145.20

6.3 Waikapū Field Assessments of Nonpoint Source Pollution

Sediment, nutrient, and other pollutant sources associated with the Māʻalaea Bay Watersheds were assessed using field observations. In addition, the Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) Sediment and Nutrient Delivery Ratio models were used to identify pollutant hot spots for the watershed to better understand these sources at a landscape level.

MEC staff canvassed both the Waikapū and Waiakoa Watersheds to identify and photo-document sources of sediment and areas with high erosion potential due to both natural and anthropogenic circumstances. Specifically, when looking for evidence of erosion, MEC recorded observations of head cuts, denuded areas caused by the expanding axis deer population, and rills and channels on the soil surface. In addition, failed Best Management Practices, failed or non-functioning infrastructure, and improper or outdated land management strategies were also documented. These watersheds were divided into four distinct areas including Mauka/Conservation Lands, the Agricultural Lands mentioned above, Commercial and Urban Lands generally occurring in coastal communities, and Keālia Pond.

Within each of these areas, several locations and situations were identified as having appreciable sources of sediment vulnerable to erosion during high stormwater events. While some of the vulnerable areas are present within two or more of the delineated areas, (examples being areas denuded by axis deer and unimproved dirt roads) management actions/recommendations will be similar across the different landscapes, but dictated by specific conditions at each site such as slope, rainfall, water availability, equipment access, etc. The four areas and their respective stormwater management issues for both Waikapū and Waiakoa are discussed below.

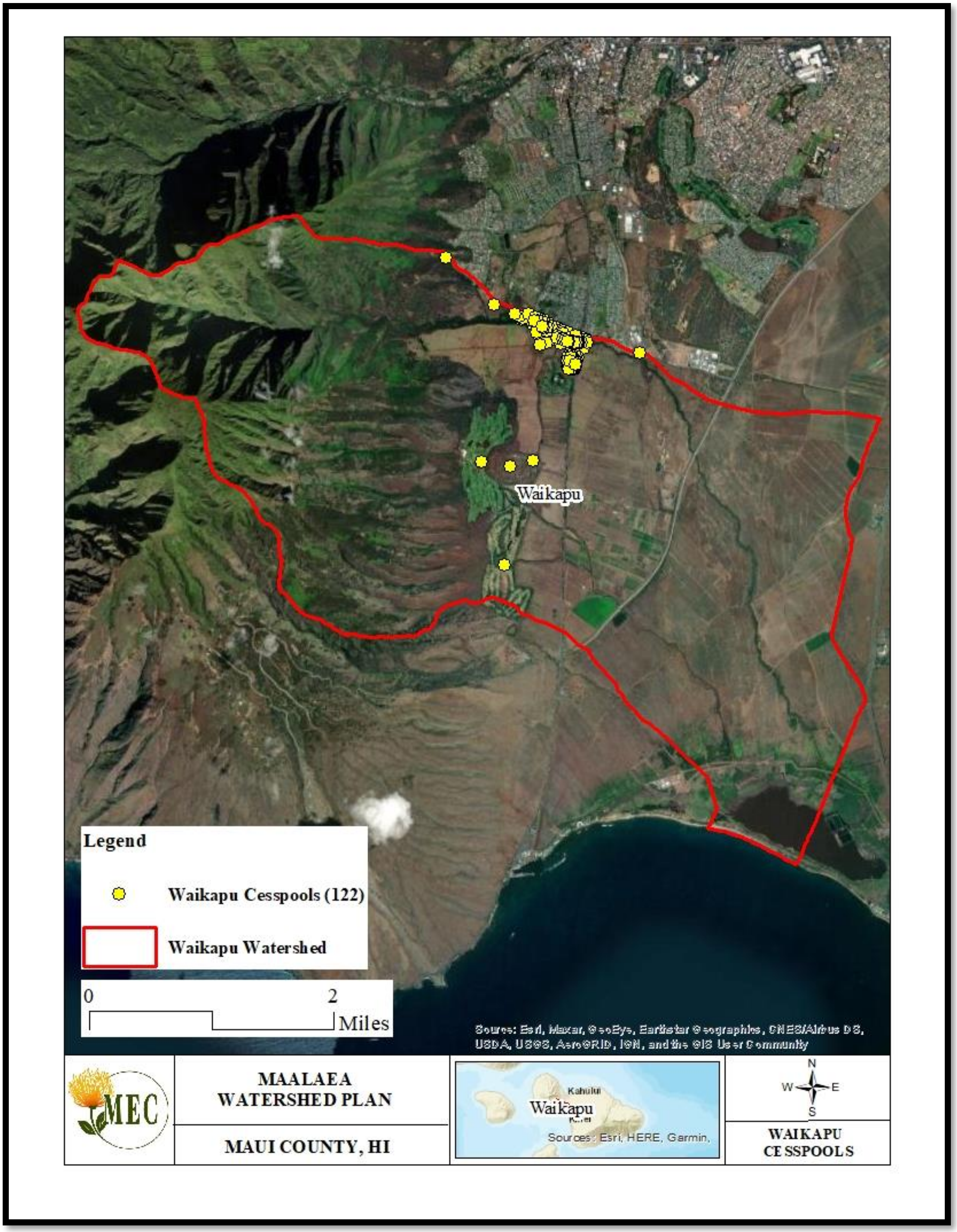
6.3.1 Waikapū Cesspools

Cesspools are of particular concern throughout Maui County. These underground regions are used for the disposal of human waste, where untreated sewage is discharged directly into the ground, leakage from which can contaminate oceans, streams, and groundwater by releasing disease-causing pathogens and nitrates.

Approximately 1,960 cesspools exist in the Māʻalaea Bay Watersheds, with 122 occurring in Waikapū (Figure 45. Waikapū Cesspool Map). Residential areas, including the homes located mauka of Honoapi'ilani Highway in Wailuku are served by onsite waste disposal systems, such as individual residential cesspools or septic tanks. DOH and USEPA databases indicate that the island of Maui has several thousand individual small septic or small cesspool wastewater systems. Figure 45 displays the locations of cesspools within the Waikapū Watershed boundaries.

Leaching from these cesspools may be contributing to the high levels of enterococcus and nutrients observed within Māʻalaea Bay. The coastal waters of Hawaiʻi are naturally low in nutrients, and the marine ecosystems are sensitive to influxes of nutrients. Once in the water, nutrients such as nitrogen and phosphorus can cause algae to bloom as well. As stated earlier, high Chlorophyll-*a* values act as evidence of these algae blooms. According to a report prepared by the HDOH Environmental Management Division, "The cumulative loading of nitrogen and phosphorous from all cesspools in a watershed is delivered to nearshore waters and can result in ecosystem shifts from a coral-dominated ecosystem to one dominated by macroalgae" (HDOH Environmental Management Division, 2017). During large storm events, pathogens from cesspools may enter coastal waters in appreciable amounts.

Figure 45. Waikapū Cesspool Map



6.3.2 Waikapū Mauka/Conservation Lands

6.3.2.1 Axis Deer

Axis deer populations have been exploding in numbers throughout the central valley of Maui. A study conducted in 2022 estimated that more than 46,000 deer exist within the Central Valley (Ulupalakua to Paia) alone, and those numbers are believed to be growing exponentially (Maui Nui Venison, 2022). As deer populations continue to grow, they overgraze and denude landscapes of vegetative cover. The unarmored soils that become exposed are highly susceptible to erosion during storm events. In addition, vital native and endangered vegetation within the conservation lands is lost to these feral ungulates.

6.3.2.2 Ditch System and the Wailuku Water Company

The Wailuku Water Company's Waikapū ditch system diverts water from Waikapū Stream at approximately 1,200 feet in elevation. Water is diverted through open ditches and two tunnels to a reservoir named Reservoir #1. This reservoir has a capacity of 8.1 million gallons. Water is then discharged from Reservoir #1 and distributed to agricultural lands and golf courses via the South Waikapū Auwai. The Palolo Ditch also connects with Waikapū Stream from the north, connecting to several reservoirs just north of the Waikapū Watershed boundary. While this ditch system is likely not a source of pollution, as the only perennial stream in the Waikapū Watershed, water should be sampled above the diversion and throughout the distribution network to capture any nonpoint sources of pollution.

6.3.2.3 Land Slides

Native scrub habitat is being lost as 'mini' landslides occur within the conservation lands in the upper reaches of the Waikapū Watershed and in the surrounding watersheds associated with the eastern range of Mauna Kahālāwai. Steep slopes combined with a groundcover predominance of non-native/invasive plant species have caused structural failures of topsoil layers when the soil becomes over saturated with water and sloughs off the rocky underlying bedrock. A gradual loss of native habitat as non-native species encroach seems to increase this sloughing process leaving behind a series of 'badlands' - areas of exposed bedrock that can support little to no vegetation. Invasive species observed in association with these landslides included Common Ironwood (*Casuarina equisetifolia*), Guinea grass (*Urochloa maxima*), and Molasses Grass (*Melinis minutiflora*). There may be a correlation between these landslides and the presence of Common Ironwood trees. Additional studies should be conducted to identify whether invasive species are contributing to these large losses of soil.

6.3.3 Waikapū Agricultural Lands

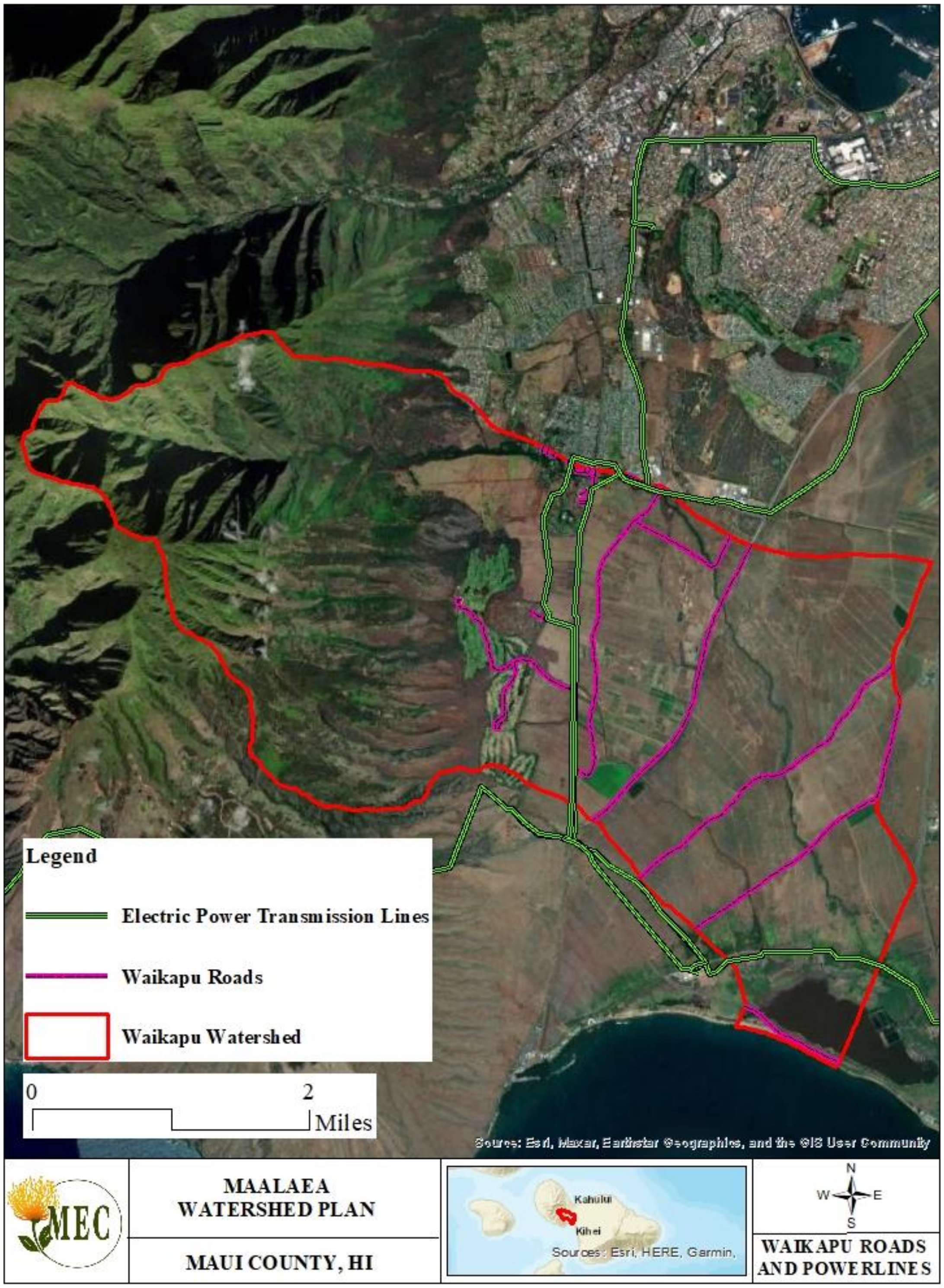
Agricultural lands may provide a nonpoint source for sediment, pathogens, and nutrient pollution. Within the Waikapū Watershed, fallow agricultural plots associated with Mahi Pono and smaller agricultural operations are situated on gently sloping fields throughout much of the watershed, beginning immediately mauka of Keālia Pond and continuing west across Honoapiʻilani Highway to the base of Mauna Kahālāwai. These agricultural lands make up approximately 5,856-acres of the overall watershed. Waikapū streams flow through these agricultural lands. In addition, several dirt roads are located within these fallow fields. Sediment from agricultural fields, and roads can make its way into gulches and ditches during stormwater events, ultimately being transported to Keālia Pond and Māʻalaea Bay. Nutrients used for fertilizer such as nitrogen and phosphorus can be transmitted to coastal waters along with sediment. Likewise, bacteria associated with domestic and feral ungulates can be swept off the landscape by stormwater sheet flow.

6.3.3.1 Powerline Corridors

There are two powerline corridors associated with the Waikapū Watershed. The main powerline corridor runs parallel with Honoapiʻilani Highway. The second transmission line branches off this first line just north of the watershed boundary and runs south, just mauka of the Maui Tropical Plantation, running along an open agricultural ditch before turning back to the east along Golf Course Road and reconnecting with the main transmission corridor (Figure 47. Waikapū Roads and Powerlines Map).

Maintenance of this smaller transmission corridor should be conducted in such a way to ensure clearing of vegetative debris does not enter the open agricultural ditch. In addition, access roads associated with this corridor should be well maintained to ensure dirt is not eroding into the ditch system during stormwater events.

Figure 46. Waikapū Roads and Powerlines Map



6.3.3.2 Landscaped Golf Courses, Resorts and Residential Communities

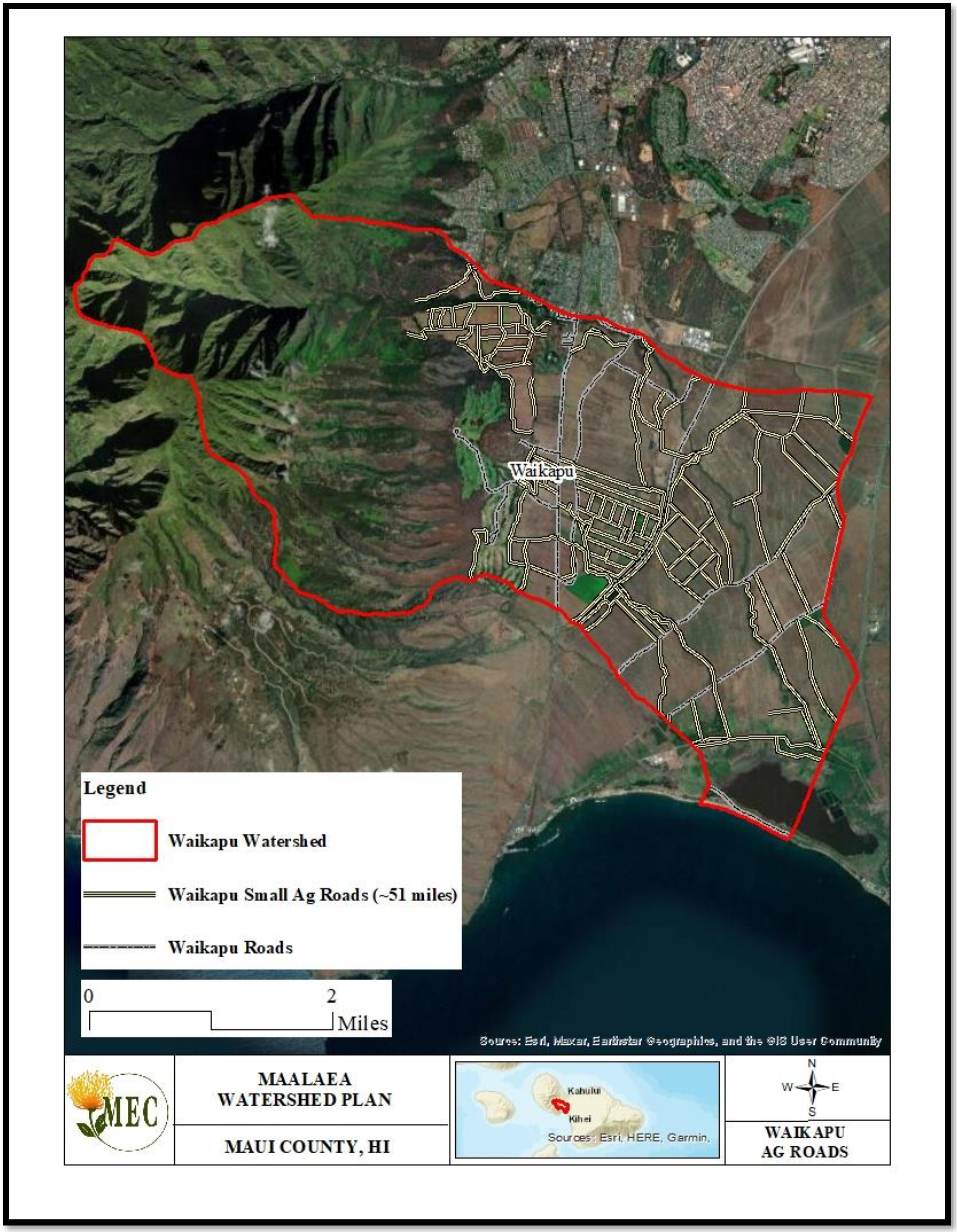
Several landscapes throughout the Waikapū and Waiakoa Watersheds are unnatural, requiring irrigation and fertilizer to exist. The Kahili and Kamehameha golf courses within Waikapū Watershed are likely the best examples of these unnatural landscapes. The resorts and condominiums on the makai side of North Kīhei Road in the Waikapū Watershed are also good examples of unnatural areas. These properties require large amounts of water and fertilizer to remain green. When fertilizers are placed in the soil, they can be transferred to the ocean by both surface water and groundwater. During heavy rainfall, stormwater can carry these nutrients from their source to the ocean through gullies, gulches, stormwater drains and other surface water conveyances. In addition, nutrients can be absorbed into the aquifer and make their way to coastal waters through groundwater flow. The golf courses were not contacted as part of this watershed management plan and any course turf management BMPs that may currently be in use were not evaluated by this Plan.

6.3.3.3 Unimproved Roads

Historic agricultural land uses in this area (primarily sugar production) have left behind a network of unimproved roadways. Many of these roads run parallel to or directly cross the two main stream channels in the Waikapū Watershed. These roads should be maintained to ensure they do not "kickout" into ditches or streams and that they are not providing a source of sediment by eroding into these systems. Often, unused and unmaintained roadways act as stormwater conveyances during rain events and channel stormwater and sediment into adjacent gulches (Figure 49. Waikapū Ag Roads Map).

Figure 47. Example of Unmaintained Dirt Road

Figure 48. Waikapū Ag Roads Map



6.3.3.4 Ditch and Reservoir Systems

In addition to the Wailuku Water Company's Waikapū ditch system, smaller ditches and reservoirs associated with Mahi Pono and other agricultural entities are dispersed throughout the Waikapū Watershed (Figure 50. Waikapū Streams, Ditches and Wetlands Map). Water distributed by this ditch and reservoir system is brought over from Waiheʻe, Waiehu, ʻĪao, and Waikapū within Mauna Kahālāwai. In addition to this water, ditch systems associated with windward Haleakalā stream diversions also convey water into the central valley.

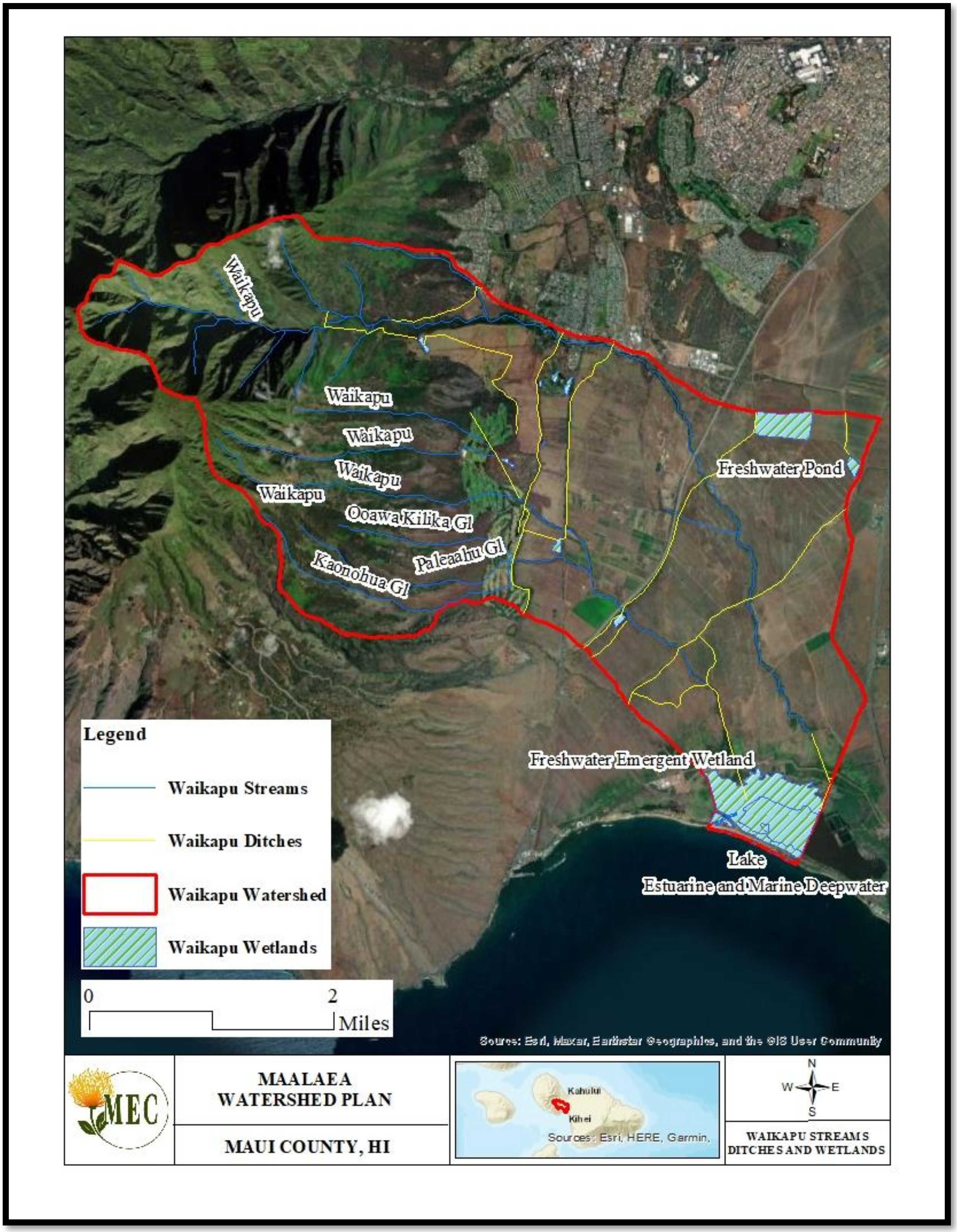
6.3.3.5 Kuihelani Solar

The Kuihelani Solar Project, which is currently under construction will utilize 450-acres of land leased from Mahi Pono. This solar farm will produce 60 MW of alternating current and provide 240 MWh of battery storage. Large solar farms consisting of ground-mounted solar panels have the potential to produce large volumes of stormwater runoff, as each individual panel is an impervious surface. To avoid erosion issues, subsoil compaction should be avoided during construction and installation to allow for natural stormwater infiltration. In addition, rows of panels should be installed with sufficient distance between rows to allow for groundcover vegetation to grow.

6.3.3.6 Central Maui Wastewater Reclamation Facility

The Central Maui Wastewater Reclamation Facility will be located on a 14.9-acre parcel within a larger 209.4-acre parcel (TMK (2)3-8-005:023). The recycled water from this facility will comply with HDOH requirements for R-1 recycled water and can be used to irrigate agricultural fields, parks, schools, and other areas. R-1 water from this facility should also be used to mitigate axis deer damage in locations where groundcover vegetation has been denuded. R-1 water should also be used to establish native vegetation in riparian corridors.

Figure 49. Waikapū Streams, Ditches and Wetlands Map



6.3.4 Waikapū Urban Areas

While the Waikapū Watershed does not currently have an urban area, the Waikapū Country Town is slated for development. This residential mixed-use community will be located on 499-acres of land surrounding the existing Maui Tropical Plantation. This development will include 1,433 residential units, plus about 146 ʻOhana' units, retail and commercial buildings, and a school. This development will generate additional impervious surfaces and the appropriate stormwater infrastructure should be implemented to ensure stormwater is detained on site. Additionally, reef-friendly landscaping and agricultural practices should be employed. These practices include a buffer between landscaped and farmed areas and gulches and streams, a reduction in the amount of fertilizers used, and the use of R-1 water whenever it is accessible. The Final Environmental Impact Statement for this development does include Low Impact Development (LID) techniques to reduce runoff volumes, promote stormwater infiltration, and remove pollutants.

6.3.5 Keālia Pond

Keālia Pond National Wildlife Refuge (KPNWR) is a natural 704-acre pond located along the coast between north Kīhei and Māʻalaea. All the streams and ditches from both Waikapū and Waiakoa watersheds historically discharged into Keālia Pond. This refuge is home to two endangered waterbirds, the ae'o (Hawaiian stilt) and the ʻalae keʻokeʻo (Hawaiian coot), and provides habitat for one of the largest migratory bird populations in the State of Hawaiʻi. Along the beach, the refuge provides nesting habitat for the threatened honu (Hawaiian green sea turtle), the endangered honuʻea (hawksbill sea turtle), and the ʻuaʻu kani (wedge-tailed shearwater).

Currently, little to no surface water flows from Waikapū and Waiakoa Watersheds into Keālia Pond. During large storm events, KPNWR staff have reported receiving stormwater from Waikapū Stream as well as from Keahuaiwi and Waiakoa Gulches as they flood their banks and fan out across the coastal floodplain associated with North Kīhei Road.

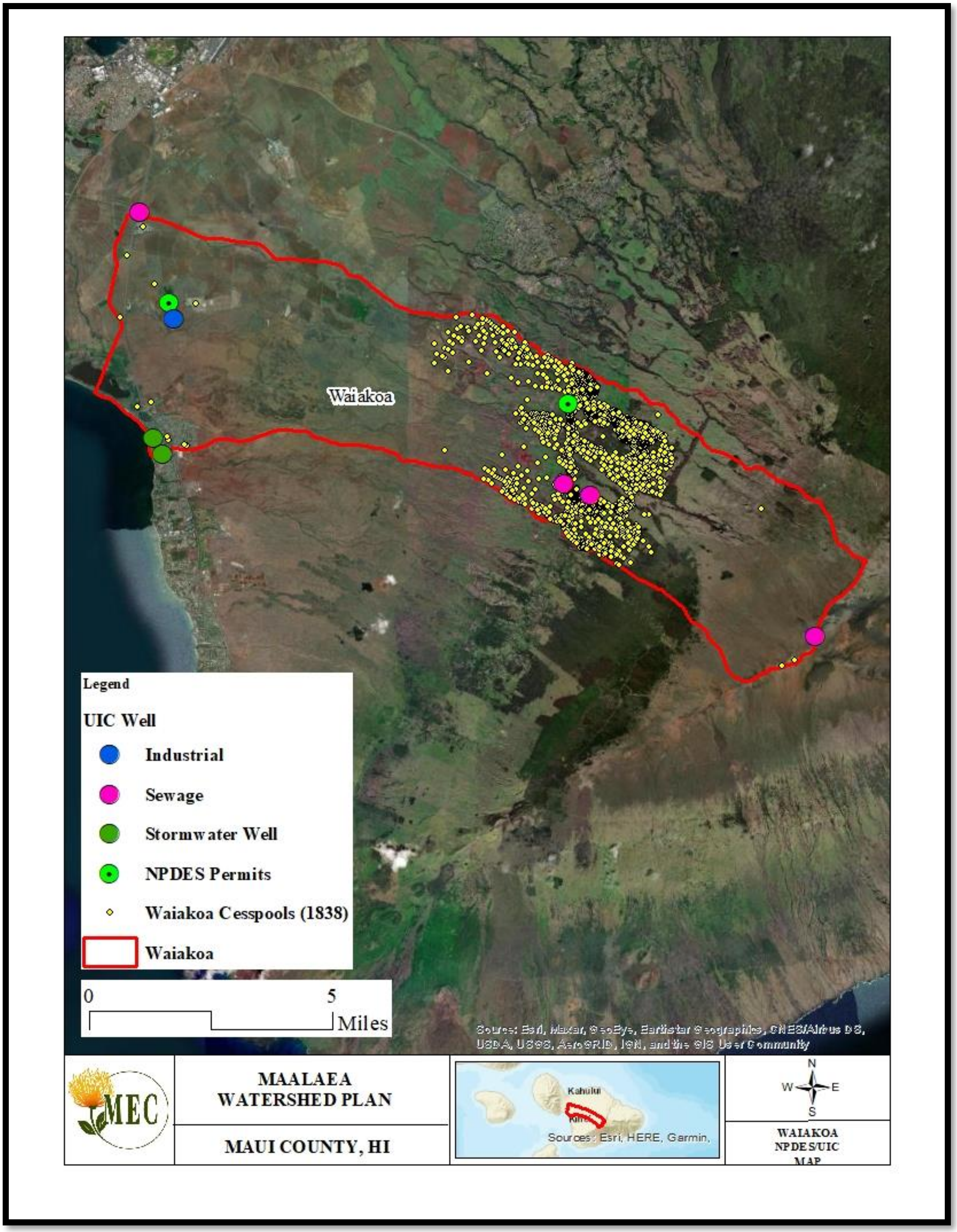
While Waikapū Stream is perennial, surface water from this stream does not reach Keālia Pond. This lack of surface water connection has caused portions of Keālia Pond to become hypersaline, especially in smaller ponds that were historically used for aquaponics. During the dry summer months, as the pond evaporates, these hypersaline conditions cause fish (mainly invasive tilapia) to die in large amounts. Fish die offs can cause eutrification of the entire pond, creating ideal conditions for avian botulism. Currently, ground water is pumped into the pond when water levels are low and to dilute hyper saline conditions. Land managers should ensure surface water flows from Waikapū Stream are reaching Keālia Pond.

6.4 Waiakoa Field Assessment of Nonpoint Source Pollution

6.4.1 Waiakoa Cesspools

Of the approximately 1,960 cesspools that exist in the Māʻalaea Bay Watersheds, 1,838 occur in Waiakoa (Figure 50. Waiakoa NPDES – UIC – Cesspool Map). Residential areas, including the homes located upcountry in Kula are served by onsite waste disposal systems, such as individual residential cesspools or septic tanks. DOH and USEPA databases indicate that the island of Maui has several thousand individual small septic or small cesspool wastewater systems. Figure 50 displays the locations of cesspools within the Waiakoa Watershed boundaries. Leaching from cesspools may be a contributing facture to high enterococcus and nutrients within Māʻalaea Bay, especially during large storm events.

Figure 50. Waiakoa NPDES – UIC - Cesspool Map



6.4.2 Waiakoa Conservation Lands

Conservation lands exist from the summit of Haleakalā to approximately 8,000 feet. This area includes portions of Haleakalā National Park, State of Hawaiʻi, and Haleakalā Ranch lands. Soils in this section of the watershed are extremely rocky with a high runoff potential. In addition, slopes are steep. Because of the elevation, vegetation is also sparse, creating ideal conditions for sediment transport during stormwater events. These areas should continue to be protected with feral ungulate fencing, invasive plant and animal species removal, and the planting of native plant species.

6.4.3 Agricultural Lands

Within the Waiakoa Watershed, agricultural lands make up almost 83 percent of the total land area with approximately 29,202-acres. At the lower part of the watershed, agricultural lands begin immediately mauka of Keālia pond, continuing eastsoutheast towards the summit of Haleakalā. These agricultural lands are interrupted briefly in Kula where rural and small pockets of urban landuse exist. Beyond the upcountry communities, agricultural lands continue, primarily owned by the State of Hawaiʻi and Haleakalā Ranch, ending just before the summit of Haleakalā where a band of conservation land exists.

At the lower portions of these agricultural lands, most of the area is currently fallow, with smaller farming operations being conducted by Bayer and Mahi Pono. In the mauka portions, pasture and rangeland dominate most of this land use designation. The lower portions of the Waiakoa Watershed are extremely dry and prone to wildfires.

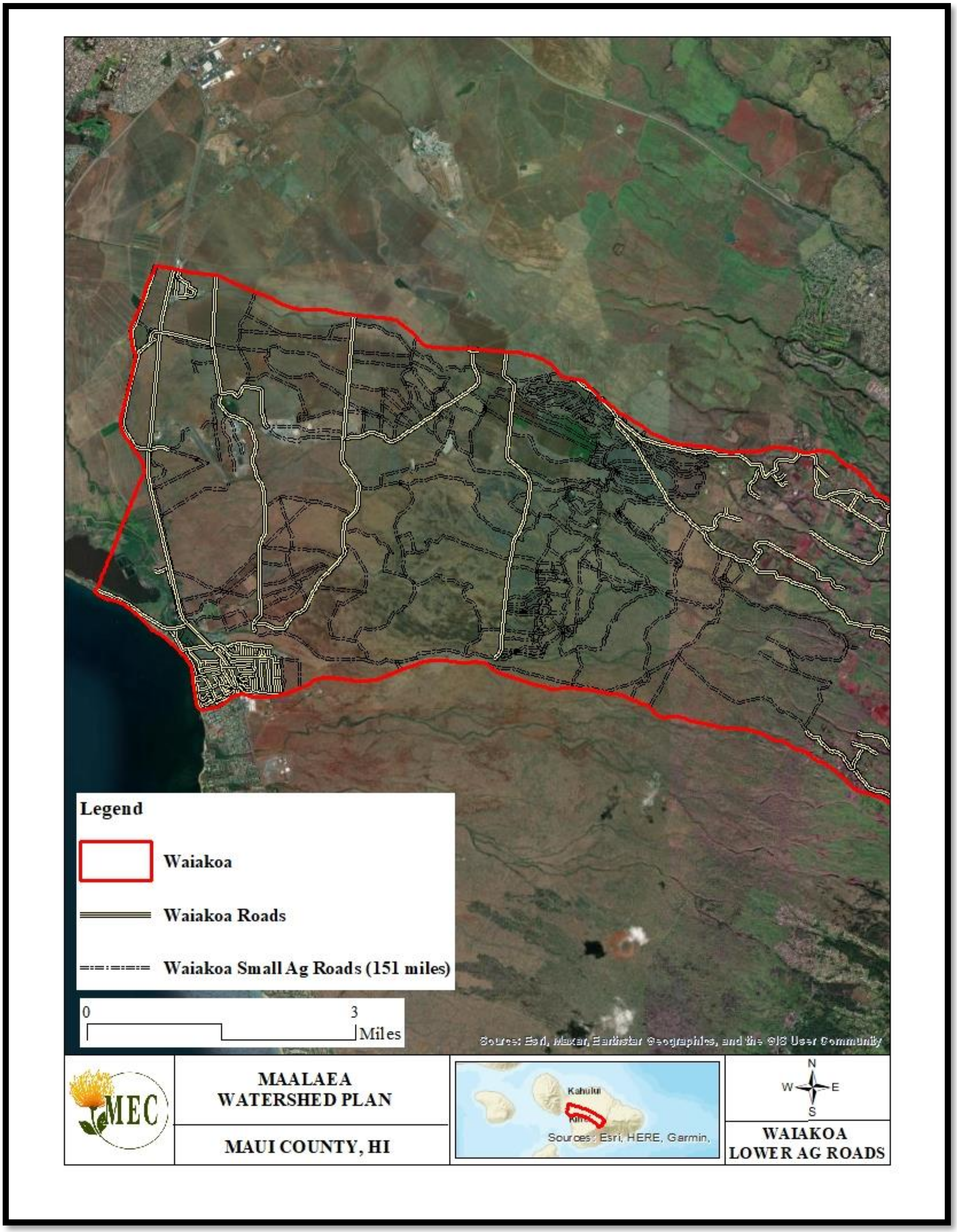
6.4.3.1 Axis Deer

Large axis deer populations exist within Waiakoa Watershed (an estimated 46,000 deer are present within the central valley of Maui), and much of the landscape has been denuded of vegetation. Axis deer are likely the main cause of sediment pollution in the Waiakoa Watershed. During storm events, soils within these agricultural areas are easily eroded, causing sediment deposition at the outfalls of Waiakoa and Keahuaiwi Gulches in North Kīhei, and within the ditch and reservoir systems that ultimately lead to Keālia Pond. Feral ungulate fencing is needed to create management units within these agricultural lands. Once in place, these management units will provide a way to control axis deer populations by limiting herd migrations and by allowing for controlled removal of this highly invasive species.

6.4.3.2 Agricultural Roads

As with Waikapū Watershed, agricultural operations have left behind a network of unimproved roadways. These include what are referred to as the Upper and Lower Kīhei Road, Ah Yen Road, Keahua Road, and Waiakoa Road. In addition to the larger unimproved roads, many smaller roads associated with farming and ranching exist. These roads should be maintained to ensure they do not "kickout" into ditches or streams and that they are not providing a source of sediment by eroding into these systems. Often, unused and unmaintained roadways act as stormwater conveyances during rain events and channel stormwater and sediment into adjacent gulches (Figure 51. Lower Waiakoa Ag Roads Map).

Figure 51. Lower Waiakoa Roads and Ag Roads Map



6.4.3.3 Nutrients and Fertilizer

Both Mahi Pono and Bayer have agricultural operations within the agricultural lands associated with the Waiakoa Watershed. Fertilizer used in these operations has the potential to be swept away with surface water sheet flow, erosion, or leached into groundwater. In addition to these potential sources of nutrient pollution, feces from the growing axis deer population have the potential to raise nitrogen and phosphorus levels in the watershed.

6.4.3.4 Industrial Operations

Hawaiian Cement and the Puunene Heavy Industrial Park are located within the Agricultural State Land Use District. In addition, a portion of the Maui Base Yard also exists within the Waiakoa Watershed (this area has been designated urban but has been included here). Sediment along with petrochemicals and other pollutants have the potential to be swept into Kolaloa Stream, which is located just south of the Hawaiian Cement and Puunene Heavy Industrial Park. Pūlehu Gulch flows just south of the Maui Base Yard. Best Management Practices should be employed to ensure that sediment remains in place and that petrochemicals and other toxins are stored properly so as not to enter the watershed during storm events. In addition, these entities may need to apply for a Notice of General Permit Coverage (NGPC) under the National Pollution Discharge Elimination System (NPDES) program as an industrial discharger.

6.4.4 Upcountry Urban and Rural Communities

This portion of the Waiakoa Watershed is associated with the Kula community, largely located between Kula Highway and Kekaulike Avenue. Flooding has damaged portions of Kekaulike Avenue as debris conveyed by stormwater collects on the upstream side of bridges, causing streams to back up. Stormwater then overtops these bridges and culverts, causing flooding and damaging infrastructure.

Figure 52. Clogged Drainage Infrastructure and Flooding Impacts on Roadways

6.4.4.1 Invasive Plant Species

Invasive species such as black wattle (*Acacia mearnsii*), which was historically used in the hide tanning industry, have since taken over pastures and gulches throughout much of the upcountry community. Wattle grows in dense stands, chocking out shrub and groundcover species. This leaves the soil within these stands of trees barren, allowing for erosion during storm events.

6.4.4.2 Axis Deer

Axis deer are also a major concern in the upcountry community. In addition to the damages inflicted upon small farmers and larger agricultural operations such as the Kula Ag Park, the ever-expanding axis deer population has denuded the landscape of both native and non-native plant species, leaving soils highly vulnerable to erosion.

6.4.4.3 Drought Resilience

Upcountry residents have expressed interest in watershed projects that capture stormwater while providing drought resilience. Discussions are ongoing and include lined retention basins that divert stormwater from gulches and store it as a resource to be used by agricultural operations. Sediment captured in these basins could also be used as soil amendments.

6.4.5 Urban Communities Associated with North Kīhei

The urban community of North Kīhei has been largely affected by stormwater flooding and sediment deposition. Both the Waiakoa and Keahuaiwi Gulches discharge into North Kīhei, just south and east of Keālia Pond. Both of these streams are ephemeral, only flowing occasionally each wet season. While this flooding has been documented for some time, in recent years the stormwater has become saturated with sediment. This sediment is deposited onto roads, houses, and other vital infrastructure associated with the urban community, before ultimately discharging into the ocean, where it causes major brown water events. Sediment deposited into nearshore coastal waters settle on coral reefs, degrading marine habitat.

Figure 53. Sediment built up along the banks and within Waiakoa Gulch

6.4.5.1 Impervious Surfaces

The roads, parking lots and buildings associated with the North Kīhei community, including homes, roads, oceanfront resorts, and condominiums represent a significant area of impervious surface. Urban runoff from these areas increases the volume of stormwater reaching the ocean, and is a significant contributor of sediment as well as petrochemicals, heavy metals, trash, and other pollutants. There are likely additional sources of nutrient pollution associated with landscaped portions of the urban corridor.

6.4.5.2 Urban Debris

Urban debris from illegal dumping and homeless encampments is widespread throughout the Kīhei Community. As stormwater moves through the watershed, it collects this debris, which is then deposited on the upstream side of culverts and bridges. Once this debris becomes lodged in place, stormwater infrastructure becomes clogged, and flooding occurs as stormwater is forced out of gulches and into upland areas. Debris not captured by stormwater infrastructure is discharged out into the Pacific Ocean, where it becomes a hazard to both water quality and marine life.

6.4.5.3 Wetland Losses

Wetland losses in the coastal communities of Kīhei, Wailea, and Makena are well documented. According to data presented by Terrell Erickson (Erickson, NRCS 2002), Hawaiʻi has lost tens of thousands of acres of wetlands. USFWS estimated 31% of the coastal wetlands were lost during the 1970's to 1990's. Wetlands in Kīhei were determined to have decreased from 199 acres in 1965 to 83 acres in 2001 (including 7.3 acres of mitigation). These wetland losses occur due to development and from aquifer drawdown.

Historically, streams such as Waiakoa and Keahuaiwi likely fanned out into muliwai, or small estuaries during large storm events. Even today, these streams connect with Keālia Pond to the north when flooded. This is evident at the intersection of North and South Kīhei Road, where flooding and sediment deposition has been frequent in recent years.

6.4.6 Keālia Pond

As noted above, Keālia Pond and its surrounding wetlands are extremely important for preventing pollution from entering the ocean. The ecological functions of wetlands provide numerous ecosystem services acting as both a nutrient sink and buffer against stormwater runoff. The pond also provides critical habitat for endangered aquatic bird species as well as many other flora and fauna. Pollution entering from the two Waikapū Streams and the five Waiakoa streams is likely contained within Keālia Pond.

Within the wetland, biological processes have the ability to capture and convert dissolved and suspended nutrients contained in stormwater into harmless atmospheric nitrogen gas. While there are certainly limits to the capacity for Keālia Pond to handle large amounts of sediment and stormwater pollutants, it is fortunate that Waikapū and Waiakoa streams discharge into the pond instead of directly into the ocean. That said, it is likely that sediment deposits in Keālia are gradually filling in the pond, and further study of the sediment dynamics of the system is warranted. Sediment laden stormwater captured in Keālia is discharged at the pond's outfall into Māʻalaea Bay and the ocean during large stormwater events.

7.0 GOALS AND MANAGEMENT RECOMMENDATIONS

The Waikapū Watershed consists of two major drainage ways, both of which are referred to as Waikapū Stream on maps provided by the Hawaiʻi Department of Land and Natural Resources Division of Aquatic Resources. The northern-most Waikapū Stream is considered perennial and originates at approximately 3,300 feet in the West Maui Mountains with several smaller tributaries flowing into it at upper elevations. Rainfall in the upper reaches of Mauna Kahālāwai is greater than 120-inches per year while in the agricultural lands nearest Keālia Pond, less than 15-inches of annual rainfall are typically recorded. The southern Waikapū Stream is considered non-perennial, and the tributaries associated with it include Ooawa Kilika, Paleaahu, and Kaonohua Gulches. Because the streams flow through agricultural fields for much of the watershed, management recommendations for the Waikapū Watershed to reduce sediment and nutrient loading include unimproved road stabilization, riparian buffer protection and rehabilitation, as well as reef friendly landscaping for the Kahili and Kamehameha golf courses. Also, vital native forests in conservation lands at the upper reaches of the Waikapū Watershed should be fenced off from feral ungulates, and non-native plant and animal species removal should continue.

The Waiakoa watershed can be divided into the upcountry portion of the watershed which receives from 25 to over 35-inches of rainfall annually and the makai portion of the watershed which is characterized by long periods with little to no rainfall. Consequently, sediment was determined to be a major pollutant of concern in thi watershed. Management recommendations in the Waiakoa watershed to reduce sediment loading include installation of axis deer fencing to control their populations and grazing patterns. Waiakoa gulches and gullies rarely discharge into the ocean. Unfortunately, when stormwater events do occur, the potential for large stormwater volumes and flash flooding is possible within the watershed. All stormwater mitigation measures and restoration activities must be engineered to handle high flow events that are likely to increase as weather patterns fluctuate in the face of climate change.

Extremely limited water quality data exists for the Māʻalaea Bay Watersheds. As stated earlier, the DOH CWB currently only monitors at one site within the entire 10,393-acre area of the Waikapū Watershed, within the coastal waters immediately off of Keālia Pond. Within the 35,330-acre Waiakoa Watershed, only two sampling sites exist. These include Mai Poina ʻOe Iʻau Beach Co. Park and the Kīhei Coast-Mokulele.

The entire coastline associated with Keālia Pond and Māʻalaea Bay is important for providing public access to fishing, swimming, boating, and other recreational activities. A Māʻalaea Bay Watersheds Water Quality Monitoring Plan was created and is included as Section 14.0 to this watershed plan. At a minimum, if none of the other management projects and strategies listed below are implemented, the Māʻalaea Bay Watershed Water Quality Monitoring Plan (or portions of this plan) should be implemented to narrow existing data gaps in water quality issues, and to better determine where sediment and nutrient pollution is occurring throughout the Waikapū and Waiakoa Watersheds.

The following sections identify implementation projects and other management measures to address specific nonpoint source pollution issues known to occur or that have been observed in the field during this study. Many of the proposed management measures in this report are highlighted in Chapter 5 of the *Hawaiʻi Watershed Guidance* report and are referenced when applicable. Stakeholders in the watershed are encouraged to collaborate on and actively participate in the implementation of these projects and management measures.

7.1 Waikapū

7.1.1 Agricultural Lands and Nutrient Management Plans

Agricultural lands make up 4,789-acres or 46.1 percent of the total land in the Waikapū Watershed. These agricultural lands have the potential to discharge nutrients such as nitrogen and phosphorus into the streams and gulches that flow into Keālia Pond, and ultimately the Pacific Ocean, especially during storm events. Nutrients can cause algal blooms which can cause eutrophication in Keālia Pond and can be harmful to coral reefs. These nutrients don't necessarily need to be transported by surface water but may also find their way into groundwater that eventually seeps toward coastal waters. Agricultural producers should evaluate their fertilizer programs, including the types and amounts of fertilizer used throughout the year, and how these applications apply to water quality data. Whenever possible, these agricultural producers should employ best management practices on their farms, such as those identified in National Management Measures to Control Nonpoint Source Pollution from Agriculture (EPA, EPA-841-B-03-004, July 2003), and Plan Nutrient Management in Hawaiʻi's Soils: Approaches for Tropical and Subtropical Agriculture (James A. Silva and Raymond S. Uchida (Eds.), University of Hawaiʻi at Manoa, College of Tropical Agriculture and Human Resources, 2000). These documents can help agricultural producers develop and implement Nutrient Management Plans to minimize nutrient losses from agricultural lands occurring by edge-of-field runoff and by leaching from the root zone.

7.1.2 Axis Deer Fencing

At a minimum, axis deer fencing should be placed along the conservation land boundary to protect native forests from this invasive species. Working with the Hawaiʻi Department of Land and Natural Resources, Division of Forestry and Wildlife and the Mauna Kahālāwai Watershed Partnership, this project would require a minimum of 15,832 linear feet of fencing.

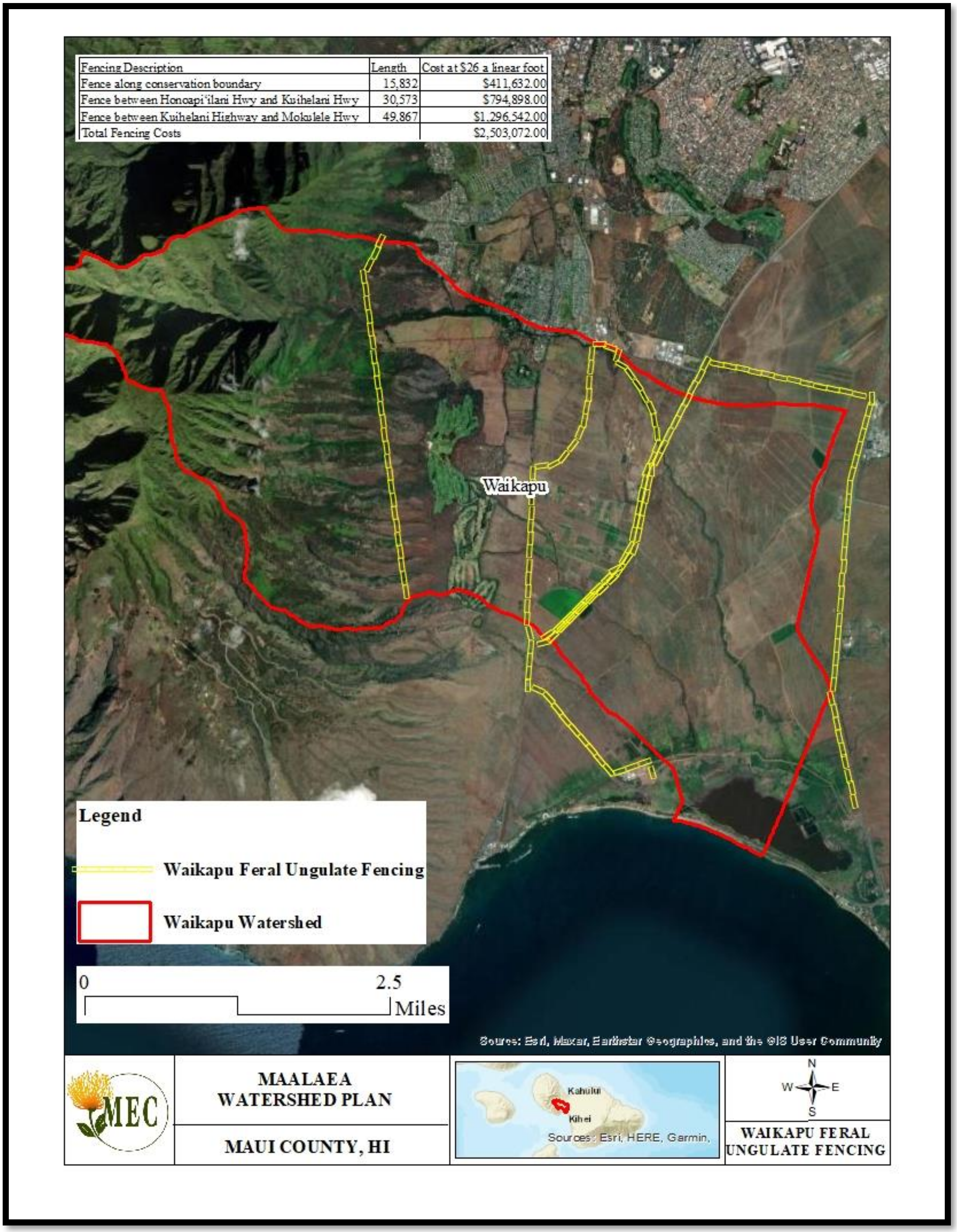
Additional fencing is needed to create axis deer management units (Figure 54. Waiakoa Watershed Feral Ungulate Fencing Map). By creating these management areas, the community can control the migration of axis deer throughout the watershed. While it is believed that axis deer do not typically roam very far, during drought, wildfire, or other pressures such as removal, fencing enables proper management of this invasive species. Due to the amount of agricultural land in production, this watershed plan has suggested additional fencing between Honoapʻilani Highway and Kuihelani Highway to protect this area. Additional fencing has been proposed between Kuihelani Highway and Mokulele Highway, which would tie into the existing feral ungulate fencing already in place around Keālia Pond.

7.1.3 Axis Deer Removal

In concert with fencing, axis deer removal from conservation areas, agricultural areas, and areas in close proximity to highways is recommended. Several options for removal exist and include aerial hunts with helicopters, recreational hunting by the community, and commercialized hunting by organizations with the capability to process meat for sale and consumption.

As stated above, removing all axis deer from conservation lands in the Waikapū Watershed is highly recommended to protect native habitats. Studies have shown that native forest protection and restoration greatly contributes to groundwater recharge, especially in the face of climate change (Brewington et al., 2023). Those areas where axis deer herds are in close proximity to Honoapiʻilani, Kuihelani, and Mokulele Highways should also be considered high priority areas for removal to safeguard the community from collisions with these animals.

Figure 54. Waikapū Watershed Feral Ungulate Fencing Map



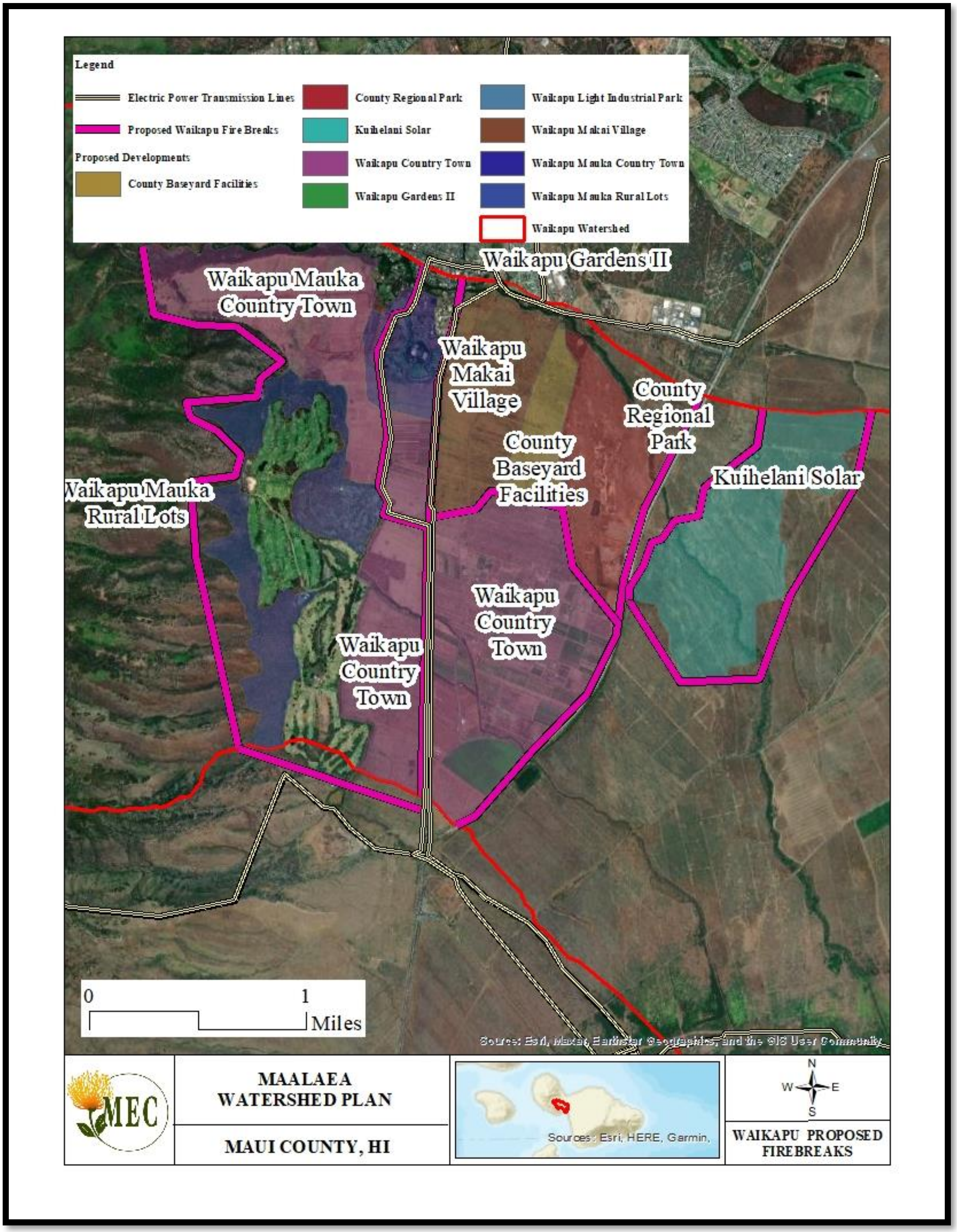
7.1.4 **Wildfires and Fire Breaks**

Waikapū Watershed and the neighboring Pōhākea Watershed are both known for high winds and high wildfire potential. While a wildfire prevention and mitigation strategy is beyond the scope of this document, the loss of vegetation and subsequent erosion resulting from wildfires is directly related to non-point source pollution. In lieu of the devastating August 2023 wildfires that burned Lahaina Town, Olinda, Kula, and Pūlehu, fire breaks should be installed at priority locations throughout the Waikapū Watershed. These fire breaks should run parallel to all electric transmission and distribution powerlines. Firebreaks should also be placed around the Kuihelani Solar project, on both sides of Honoapiʻilani Highway, and placed strategically within and around the Waikapū Country Town development (Figure 55. Waikapū Proposed Firebreak Map). The Western Maui, South Maui, and Upcountry Maui Community Wildfire Protection Plans, are helpful resources that identify wildfire risks and provide prevention, protection, and mitigation strategies. These reports can be found using the following links.
Western Maui Community Wildfire Protection Plan
South Maui Community Wildfire Protection Plan
Upcountry Maui Wildfire Protection Plan

In response to the August 2023 fires that burned through Lahaina, Pūlehu, Kula, and Olinda, on September 11th, 2023 the United States Department of Agriculture, U.S. Forest Service Pacific Southwest Region released the ES4F Burner Area Emergency Response Assessment Technical Report, Hawaiʻi Wildfires (CA-FE9-000005). This report provides a post-fire rapid assessment of damaged areas. Information on post-fire conditions including soil burn severity, soil erosion, hydrology and runoff, geologic hazards, and a summary of post-fire watershed response are discussed. The report can be viewed by clicking on the following link.
September 2023 BAER Report

As stated in Chapter 5 Section 2 of the Hawaiʻi Watershed Guidance report, strategies that minimize erosion potential are important to consider when fire suppression techniques clear vegetated areas. Plowing should be combined with sowing a suitable cover crop. The ideal crop would provide an effective fire break by not creating excessive biomass, be dense growing to prevent invasive species from rooting, and ideally be a nitrogen fixing legume that could nourish degraded soils. Native species such as aweoweo and naio should also be considered for their relatively low pyrophytic ratings. A suitable cover crop or crops should be chosen through collaboration with Natural Resources Conservation Service (NRCS) technical specialists. Guidance for cover crop uses in Hawaiʻi can be found at the link below.
Sustainable and Organic Agriculture Program

Figure 55. Waikapū Proposed Firebreak Map



7.1.5 Unimproved Road Stabilization

Mahi Pono and other agricultural entities should conduct an assessment of the current necessity and future needs of dirt agriculture roads within the Waikapū and Waiakoa Watersheds. Locations where agriculture roads parallel or cross the stream gulches provide areas where erosion can occur and can often act as a sediment source for stormwater moving through the watershed. Several years may pass between major storm events, and these gulches and stream corridors remain dry for long periods of time. Personnel should be educated on best management practices when working in riparian corridors or near wetlands so that when major events do occur, soil loss is not exacerbated by these daily operations or periodic construction activities.

The miles of poorly maintained and disused former agricultural roads are major sources of sediment transfer and pathways for channeling stormwater runoff into stream gulches. Waikapū has approximately 51 miles of unimproved dirt roads (Figure 49. Waikapū Ag Roads Map). Chapter 5 Sections 2 and 3 of the Hawaiʻi Watershed Guidance report states that proper road management and runoff mitigation efforts are important to consider in managing pollution within a watershed. A comprehensive inventory of the Waikapū roads should be conducted to determine stakeholder access needs and to identify those roads that are candidates for decommissioning or repair. Stakeholders should refer to HAR 11-56, Appendix A and "National Management Measures to Control Nonpoint Source Pollution from Agriculture" EPA, EPA-841-B-03-004, July 2003. Closing roads using structural methods (barriers) such rocks, logs, or vetiver plantings can capture sediment and attenuate runoff. In coordination with landowners and potential road users, disused, and unnecessary or redundant roadways should be identified for decommissioning. Any roads likely to stay in use should be improved using water bars, sediment traps and other BMPs to minimize downslope transport of eroded sediments. Several appropriate BMPs can be found in the document entitled: Unpaved Road Standards for Caribbean and Pacific Islands. Common drainage control techniques highlighted in the document include grade breaks, dips and low water crossings, water bars, cross-drains and culverts, ditches, turnouts, sediment traps, geosynthetics, soil and/or aggregate stabilization, and slope stabilization. Examples are displayed below. The example diagrams are courtesy of Brian Kent from the *Gravel Road Maintenance Manual: A Guide for Landowners on Camp and Other Gravel Roads*.

https://www.ncei.noaa.gov/data/oceans/coris/library/NOAA/CRCP/NMFS/OHC/Projects/30033/HorsleyWittenGroup2017_Island_Unpaved_Road_Standards.pdf)

Figure 56. Water Bar Example Diagram

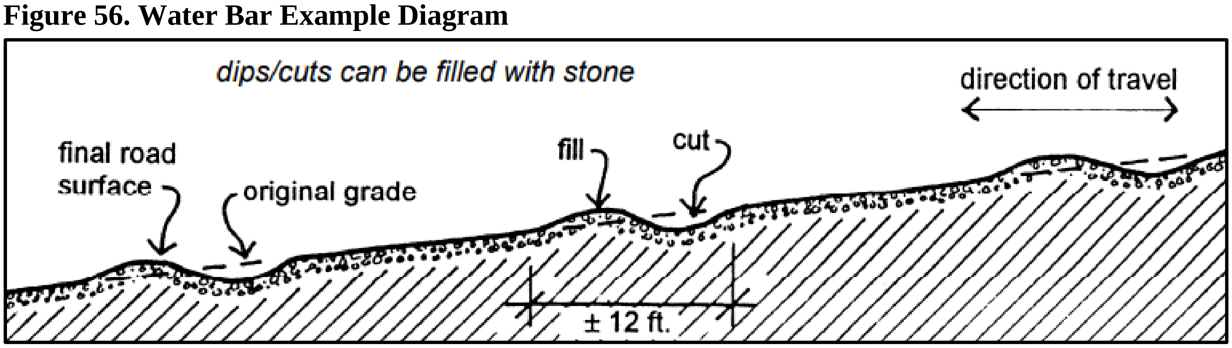
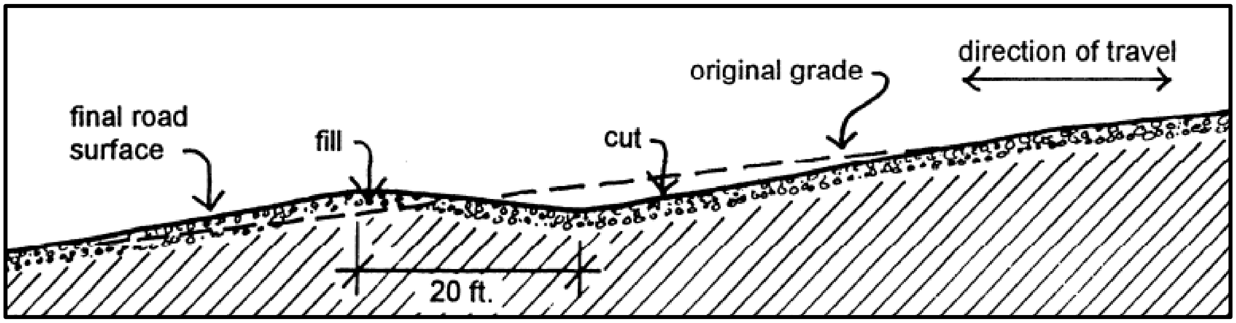


Figure 57. Water Dip Example Diagram



Roads identified for stabilization and/or closure should be prioritized based on 1) utility 2) slope, 3) percentage of sand, silt, clay, and stone, 4) erosion and infiltration rates, and 5) likelihood of transport to streams/gulches based on models developed by Ramos-Scharron in 2009. Other agricultural roads on Maui have been decommissioned based on the following criteria:

1. Roads with high levels of erosion and deep ruts that render them dysfunctional as a road.
2. Those roads which have clearly not been used for at least two years.

Lines of vetiver can be planted on contours across disused roads. These lines serve to interrupt and spread stormwater flows, capture sediment, and infiltrate water safely into the ground. As plants mature, and especially if coupled with stones or other physical barriers, they effectively delineate a road as decommissioned. It is important to conduct stakeholder engagement with any potential road users such as ranchers, fire crews, rangers, illicit dirt bikers, hunters, hikers, etc. to help select appropriate sites, and to ensure the purpose of the road closure is understood and not damaged or tampered with. Signage can be useful to convey this information.

7.1.6 <u>Wetlands and Stream Riparian Buffers and Protection</u>

Riparian buffers along gulches and gullies prevent sediment laden sheet flow from entering flow ways and ultimately discharging into coastal waters. They also offer important habitat for native flora and fauna to inhabit from mauka to makai throughout the watershed. Existing wetlands should be delineated, protected and restored wherever possible. Wetlands have the ability to filter stormwater for sediment, nutrients and pathogens. They provide habitat for native flora and fauna and serve as flood prevention and aquifer recharge locations. Lastly, wetlands represent greenspace within urban communities, offering a place for recreation that can improve the community’s relationship with the natural environment.

The U.S. Army Corps of Engineers (USACE) has regulatory authority over wetlands and other water bodies of the U.S. (WBUS) based on two federal laws. These include Section 404 of the Clean Water Act (CWA) of 1972, and Section 10 of the Rivers and Harbors Act of 1899.

Section 404 of the CWA states that dredged and fill material may not be discharged into jurisdictional WBUS (including wetlands) without a permit. According to 40 CFR 230.3, WBUS subject to agency jurisdiction under Section 404 include navigable waters and their tributaries, interstate waters and their tributaries, wetlands adjacent to these waters, and impoundments of these waters.

A Section 404 permit is required for all fill or discharge activities below the high tide line in tidal waters or below the ordinary high-water mark (OHWM) for non-tidal, non-wetland waters. Corps regulations define the term "ordinary high-water mark" for purposes of the CWA lateral jurisdiction at 33 CFR 328.3(e), which states:

"The term ordinary high-water mark means that line on the shore established by the fluctuations of water and indicated by physical characteristics such as a clear, natural line impressed on the bank, shelving, changes in the character of soil, destruction of terrestrial vegetation, the presence of litter and debris, or other appropriate means that consider the characteristics of the surrounding areas."

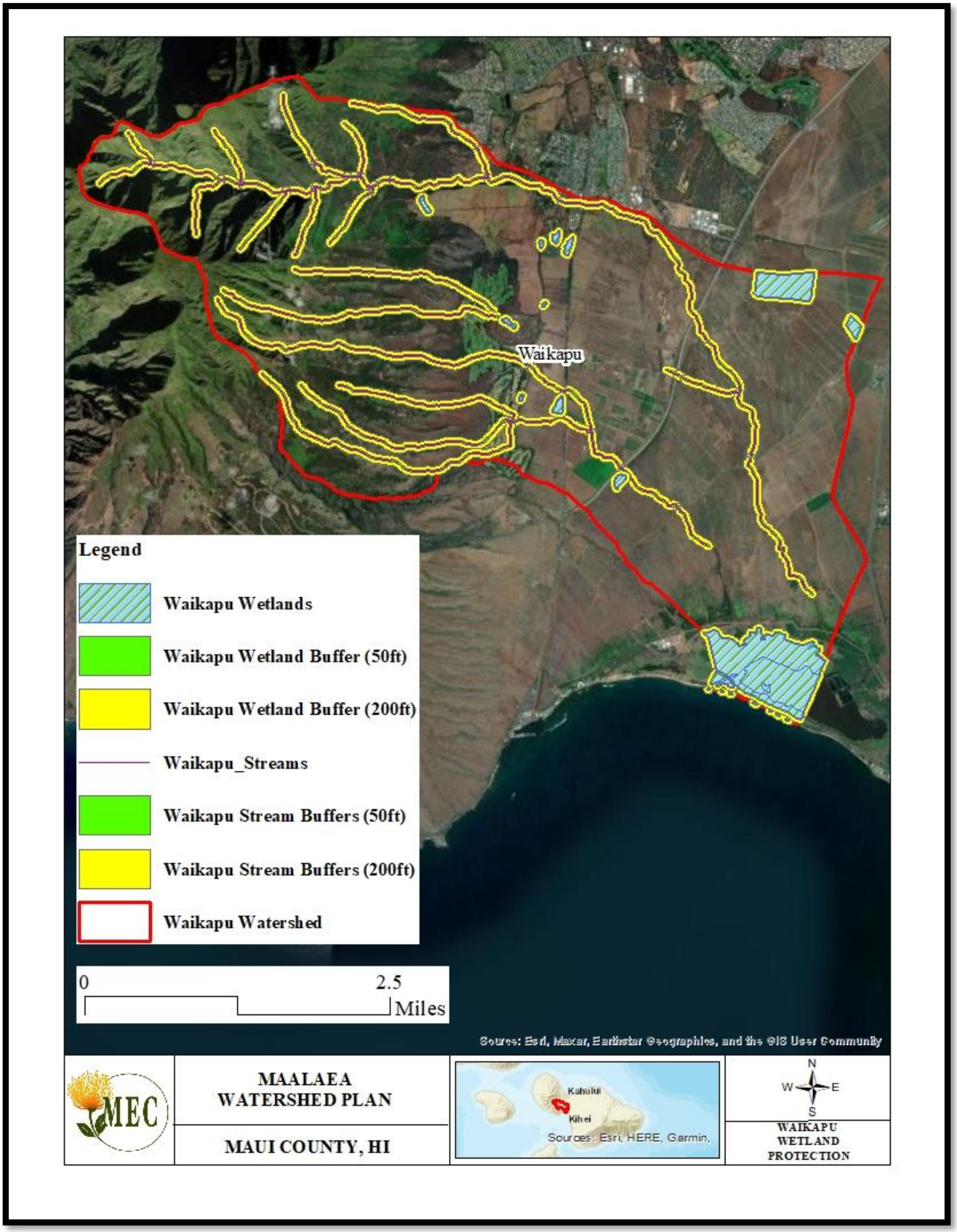
The Rivers and Harbors Act of 1899 prevents unauthorized obstruction or alteration of navigable WBUS. Navigable waters are defined as waters that are "subject to the ebb and flow of the tide and/or presently used, or have been used in the past, or may be susceptible for use to transport interstate or foreign commerce" (33 Code of Federal Regulations [CFR] 325.5(c)(2)). A Section 10 permit is required for non-fill discharging activities proposed in, over, or under WBUS.

In May of 2023, the United States Supreme Court released an opinion in Sackett v. EPA, in which the Court unanimously held that the Environmental Protection Agency (EPA) overstepped its jurisdiction in classifying wetlands on the Sackett property as "waters of the United States" (WOTUS). The court stated: "…the CWA extends to only those wetlands that are "as a practical matter indistinguishable from waters of the United States." This requires the party asserting jurisdiction over adjacent wetlands to establish "first, that the adjacent [body of water constitutes]… 'water[s] of the United States,' (i.e., a relatively permanent body of water connected to traditional interstate navigable waters); and second, that the wetland has a continuous surface connection with that water, making it difficult to determine where the 'water' ends and the 'wetland' begins."

In October of 2022 the Maui County Council passed a bill to protect and restore wetlands (Ordinance 5421). As a requirement of this law, a wetland overlay map is being created. Any wetlands that contain at least two of the three wetland indicators listed by the USACE in their wetland delineation manual and any flow through systems depicting a high-water mark as defined in the 2005 USACE Regulatory Guidance Letter on Ordinary High Water Mark Determination are now considered protected by the bill. County protections may include 50-to-200-foot buffers placed around the wetland edges and stream banks as determined by the Maui County Planning Department. Details of Ordinance 5421 can be found by following this link. Maui County Ordiance No. 5421. Figure 59 below depicts both 50-foot and 200-foot buffers around all streams and wetlands within the Waikapū Watershed.

Figure 58. Landscape denuded by axis deer on the left of the fence compared to rehabilitated riparian corridor on the right side of the fence.

Figure 59. Waikapū Streams and Wetlands with 50-ft and 200-ft Buffers



7.1.7 Golf Course Nutrient Program

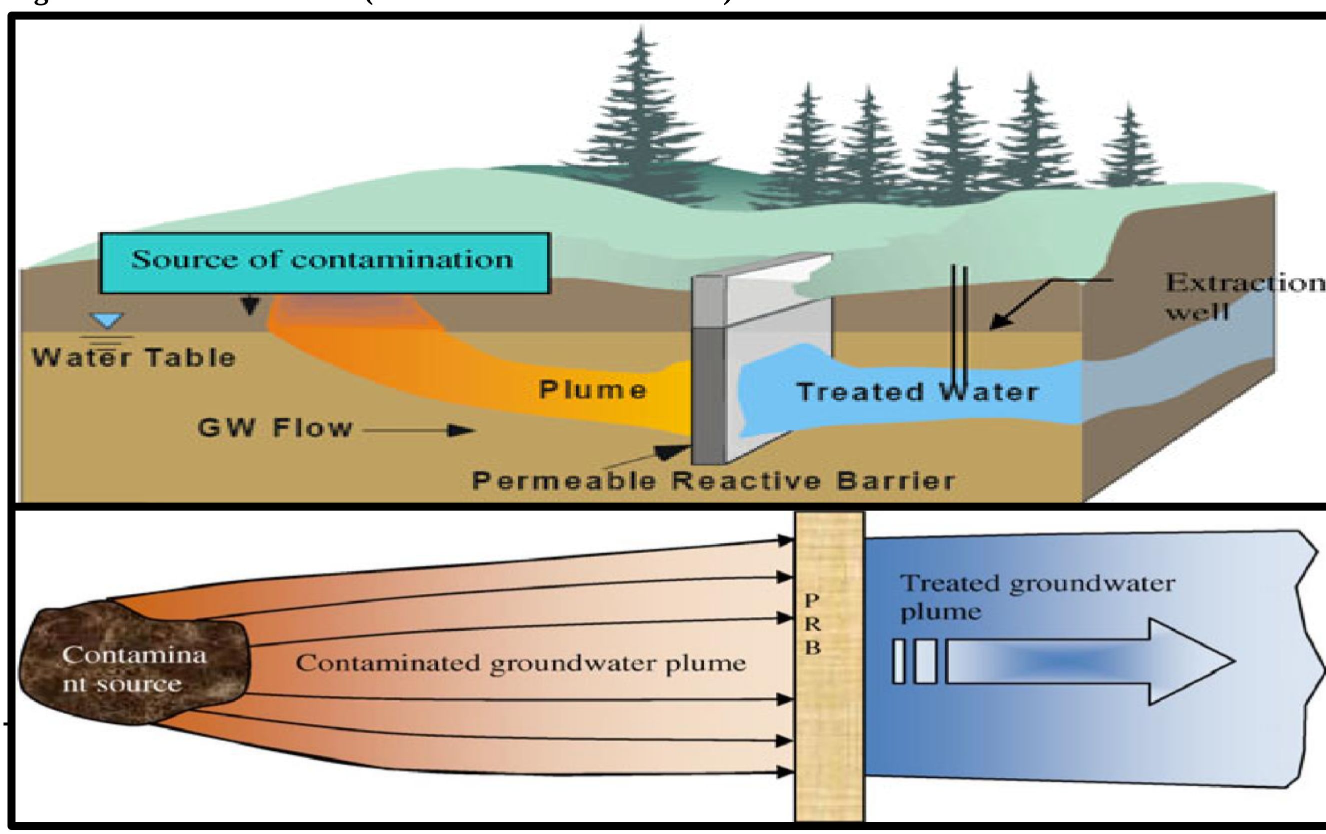
There are numerous turf management BMPs that can effectively reduce nutrient stormwater runoff and groundwater pollution on golf courses. Agricultural ditches run directly downstream and downhill from both Kahili and Kamehameha Golf Courses. This water should be regularly tested for water quality to ensure nutrients and sediment from the golf courses are not being distributed via this irrigation infrastructure. Additionally, agricultural and recreational entities should be in constant discussions with land managers for Keālia Pond National Wildlife Refuge to ensure adequate amounts of surface water is received, and that the water is clean and safe for wildlife that inhabit the refuge.

Golf course management measures have been developed specifically for Hawaiʻi and are included in Chapter 5 Section 3 of the Hawaiʻi Watershed Guidance report. Nutrient management and resourceful irrigation strategies are important to consider. Recent examples successfully piloted throughout Maui include:

7.1.7.1 Nutrient Curtain

A Permeable Reactive Barrier (a.k.a. 'nutrient curtain') is constructed by excavating a trench approximately three feet wide, and four feet deep and long enough to bisect the groundwater moving through the area. It consists of a mix of hardwood chips, sand, sawdust, and activated charcoal (a.k.a. 'biochar'). This precise mixture converts nitrogen pollution contained in the groundwater into atmospheric nitrogen effectively filtering pollutants from groundwater passing through. This process requires no maintenance once installed and has a long effective lifespan because charcoal lasts for hundreds of years when buried in the soil (charcoal makes up a substantial portion of ancient archaeological sites in the Amazon Basin as well as Pacific Islands). There may be a slight loss in nutrient removal efficiency when the woodchips eventually break down (10-15 years), but the system will still function well beyond this time horizon.

Figure 60. Nutrient Curtain (Permeable Reactive Barrier)



7.1.7.2 Floating Treatment Wetland (FTW)

A floating treatment wetland (FTW) can improve the pollution treatment effectiveness of a wet retention pond. An FTW consists of a floating raft of buoyant material that is deployed on the surface of the pond, on which aquatic plants are grown hydroponically. Plant roots take up nutrients to support plant growth. The roots hanging down in the water column provide an ideal habitat for denitrifying bacteria. These bacteria remove nitrogen from the water and convert it into nitrogen gas which bubbles out of the water and is released into the atmosphere.

Figure 61. Floating Treatment Wetland

Costs vary widely depending upon the overall size and complexity of the floating treatment wetland. Assuming volunteer labor is used to assemble the wetland, a small (8' x 8') version of a floating treatment wetland can be constructed for less than $1000. Kamehameha and Kahili Golf Course greens managers should be partnered with to implement this nutrient reduction strategy. Detailed instructions for creating a FTW can be found at the link below.
https://coral.org/wordpress/wp-content/uploads/2017/11/2017_Maui_CaseStudies_FloatingTreatmentWetlands_Final.pdf

7.1.8 Reef Friendly Landscaping

Chemical-free alternatives to synthetic pesticides, herbicides, and fertilizers should be considered to meet landscaping needs. Organic products enhance soil health by restoring the soil microbiome to create ideal conditions that support healthy vegetative growth while fighting against pests and disease. Healthy, biodiverse soils become low-maintenance and cost-saving once established. Maui Nui Marine Resource Council has conducted several pilot projects that demonstrate the success of biological soil amendments. MNMRC has also developed a Reef Friendly Landscaping Certification program, where interested parties

can obtain a free consultation with an organic land care consultant and receive recommendations on products, equipment, and resources to aid in the transition to reef friendly landscaping. Reef-friendly landscaping practices can be adopted by commercial and residential properties alike.
MNMRC's Residential Reef Friendly Landscaping Webpage

Figure 62. MNMRC's Reef Friendly Landscaping Test Plot at Makena Golf and Beach Club

Photo Courtesy of Maui Nui Marine Resource Council.

7.1.9 Land Slides

While the scale of this problem is extensive, attempts to mitigate the loss of topsoil and native vegetation caused by sloughing and mini landslides should be piloted in mauka areas adjacent to major gulches. Landslides are discussed in Chapter 5 Section 2 of the Hawaiʻi Watershed Guidance report, and areas with high erosion potential need to be identified and addressed. Preserving high quality functional, native habitat should be a priority. Drawing upon lessons learned from projects conducted in Hawaiʻi and other high islands in the Pacific, a better understanding of the geologic processes causing this problem is needed. Hillslope stabilization methods could be employed at strategic locations in mauka lands that are vulnerable to landslides.

7.1.9.1 Revegetation

Where soils have been exposed due to land slides, revegetation can help prevent further soil loss and mitigate slope instability. Plants should be selected based on their ability to become quickly established, root structures, nativity, and the hydrological conditions of the area.

7.1.9.2 Fiber Rolls

In areas with high erosion potential, fiber rolls could be placed in intervals along the slope face and/or within stream banks. Fiber rolls are made of straw, coir (coconut fibers), or other biodegradable materials to redirect runoff, decrease stormwater flow velocity, and trap sediment. To maximize effectiveness, fiber rolls should be placed on a level contour in a shallow trench, staked at regular intervals, and tightly abutted to one another. Fiber rolls can also be seeded with native vegetation or coupled with plantings behind it for continued slope stabilization once the roll decomposes. Helpful information about fiber roll installation can be found on the EPA's national menu of BMPs for stormwater (U.S. EPA, 2021). Follow the link below to access the webpage.
Stormwater BMP: Fiber Rolls

7.2 Waiakoa

7.2.1 Detention Basins and Basins in Series

Excavated basins in series, connected by berms or channels for sedimentation and infiltration purposes, have been identified as a management measure to improve water quality in the watersheds. "Excavated basins are often constructed in sequences adjacent to streams, so that excess stormwater flows, from the stream or stormwater channel, can be diverted under gravity to the first basin, then overflows from each basin to the next under gravity, and back to the stream or stormwater channel at the end" (A Handbook for Stormwater Reclamation and Reuse Best Management Practices in Hawaiʻi, December 2008, Commission on Water Reclamation Management).

The Final Report for the Kīhei Drainage Master Plan (KDMP) was released in November of 2016. While several detention basins are proposed in the County plan associated with the Waiakoa drainage area, none are proposed to occur in immediate proximity to Waiakoa Gulch. Figures 63 and 64 below provide examples for a series of basins and a large detention basin associated with Waiakoa Gulch. While the locations of the basins are subject to change, appropriate sites can be found in the watershed gulch systems based on the following criteria:

- Where sufficient undeveloped land exists on the sides of the gulches for the infiltration drain field
- After the convergence of tributaries to maximize efficiency
- Preferably in shallow segments where earth-moving to extract the water can be minimized
- In locations where stormwater intakes can be feasibly installed
- On soils which have adequate permeability

Figure 63. Example of Waiakoa Gulch Basins in Series

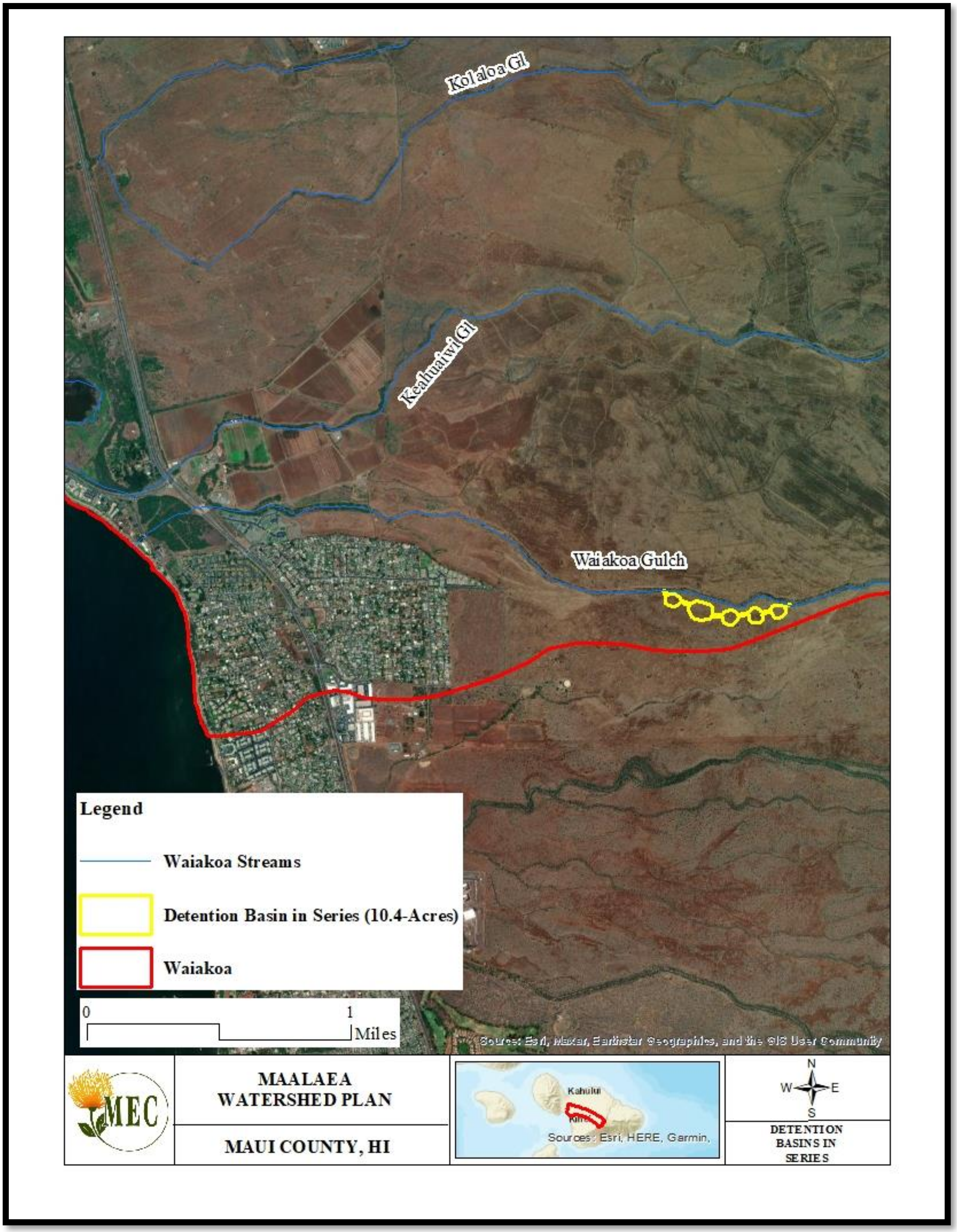
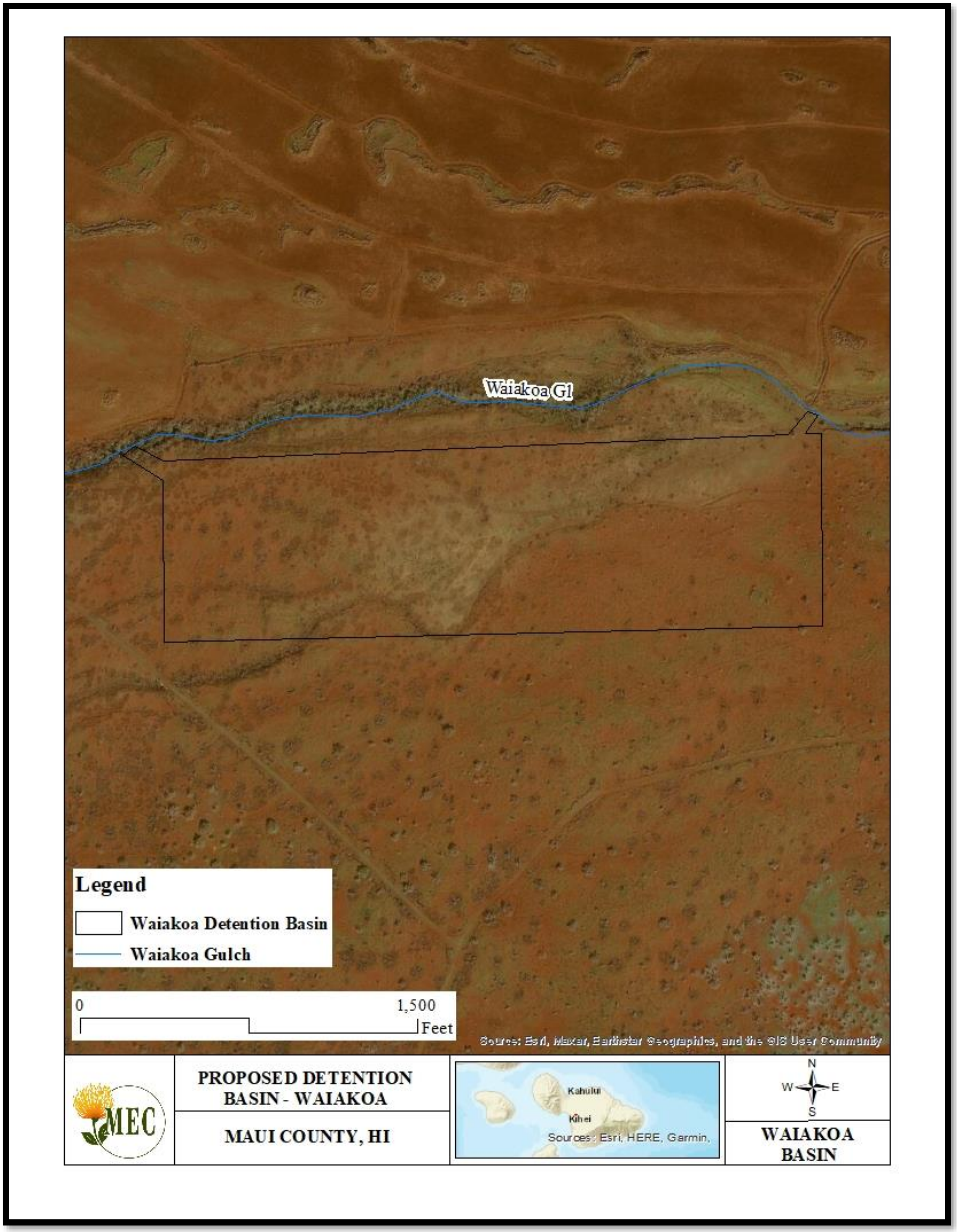


Figure 64. Example of Large Detention Basin in Waiakoa Gulch



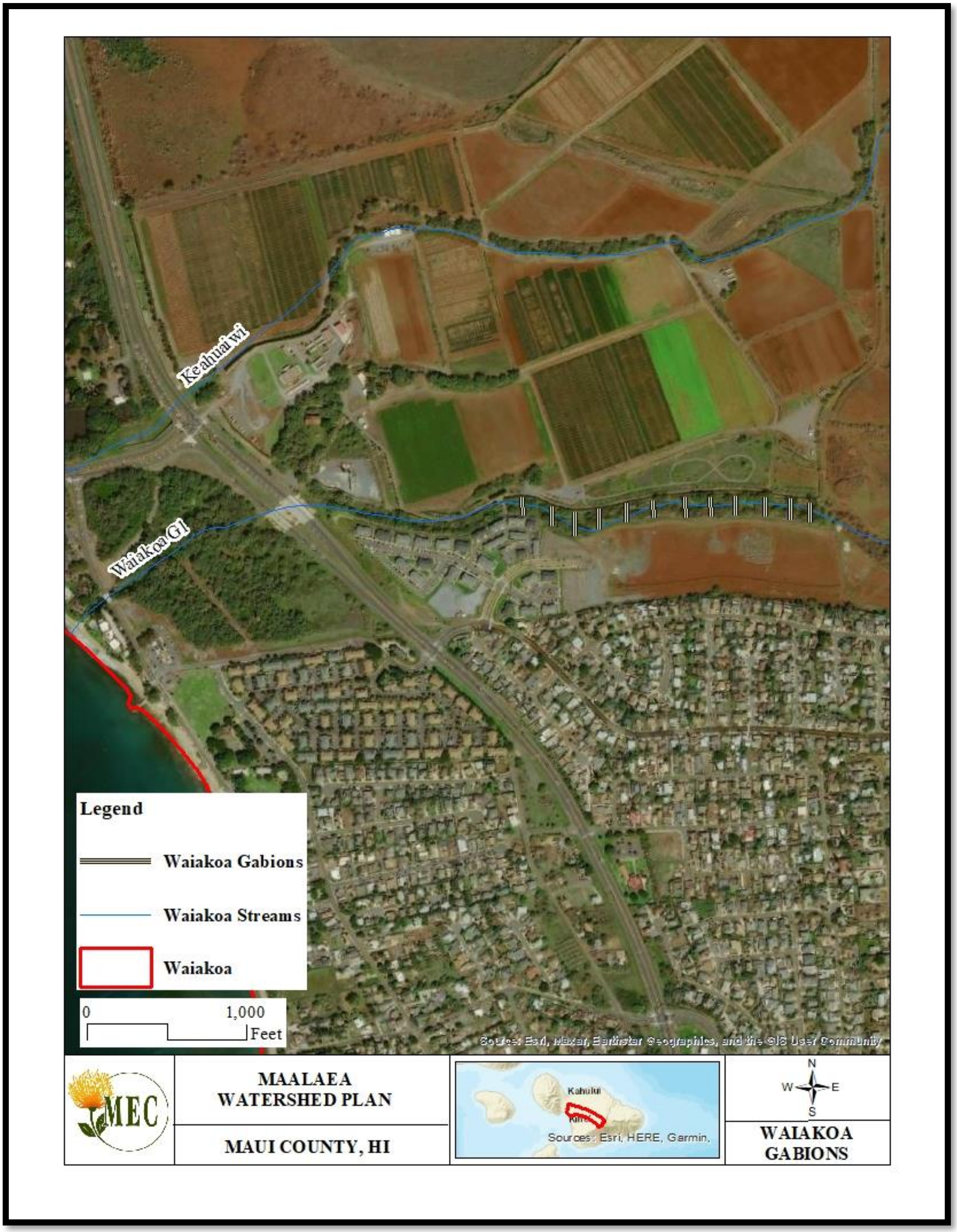
7.2.2 Gabions

Gabions are wire containers filled with rock, gravel, broken concrete, riprap, or other material to create large blocks. These blocks can be placed within stream beds to create small weirs or dams. As stormwater flows down a gulch, it pools behind the gabions, slowing in velocity and losing erosional force. Pools created by these gabions allow sediment in the water to fall out of suspension. When placed in stepped series, these structures can provide flood protection by dissipating energy in flowing systems. Over time the voids fill with sediment and promote vegetative growth, which will further enhance stormwater slowing and sediment trapping capabilities.

Figure 65. Image of Gabion Weirs in Series

The following map provides an example for potential locations for gabion placement in Waiakoa Gulch (Figure 66. Waiakoa Gabions). Actual placement should be determined by topography, access for installation and maintenance, land ownership, and other factors. The life expectancy of gabion is based on the type of wire used to create the cage and not on the material used as filling. Typically, these cages are constructed of galvanized steel wire with a life expectancy of 50 years.

Figure 66. Waiakoa Gabions



7.2.3 Regional Stormwater Management Park

Large detention basins can be engineered to function as recreational facilities or green spaces. The Weinburg Property is located just mauka of South Kīhei Road, immediately above the outfall of Waiakoa Gulch into the Pacific Ocean. This area could be repurposed as a community park with sports fields, community gardens, dog parks, etc.

These stormwater management parks are essentially large, shallow detention basins that collect stormwater and provide flood control, aquifer recharge, stormwater treatment, and wetland protection. All of these benefits are in addition to the recreational opportunities provided by these spaces (Figure 67. Example of a Regional Stormwater Management Park).

Across North Kīhei Road, Keahuaiwi Gulch discharges into a narrow strip of land immediately north of North Kīhei Road, before flowing into Keālia Pond. Adjacent landowners include the State of Hawaiʻi and Mahi Pono. While Keahuaiwi Gulch does not discharge frequently, when it does, it typically floods into the intersection of North and South Kīhei Roads. Like the Weinburg property on the south side of this intersection, the State of Hawaiʻi and Mahi Pono properties should be repurposed to capture flood waters from Keahuaiwi Gulch and properly direct stormwater towards Keālia Pond. Figure 68 below displays potential locations for a regional stormwater management park within Waiakoa Watershed.

Figure 67. Example of a Regional Stormwater Management Park

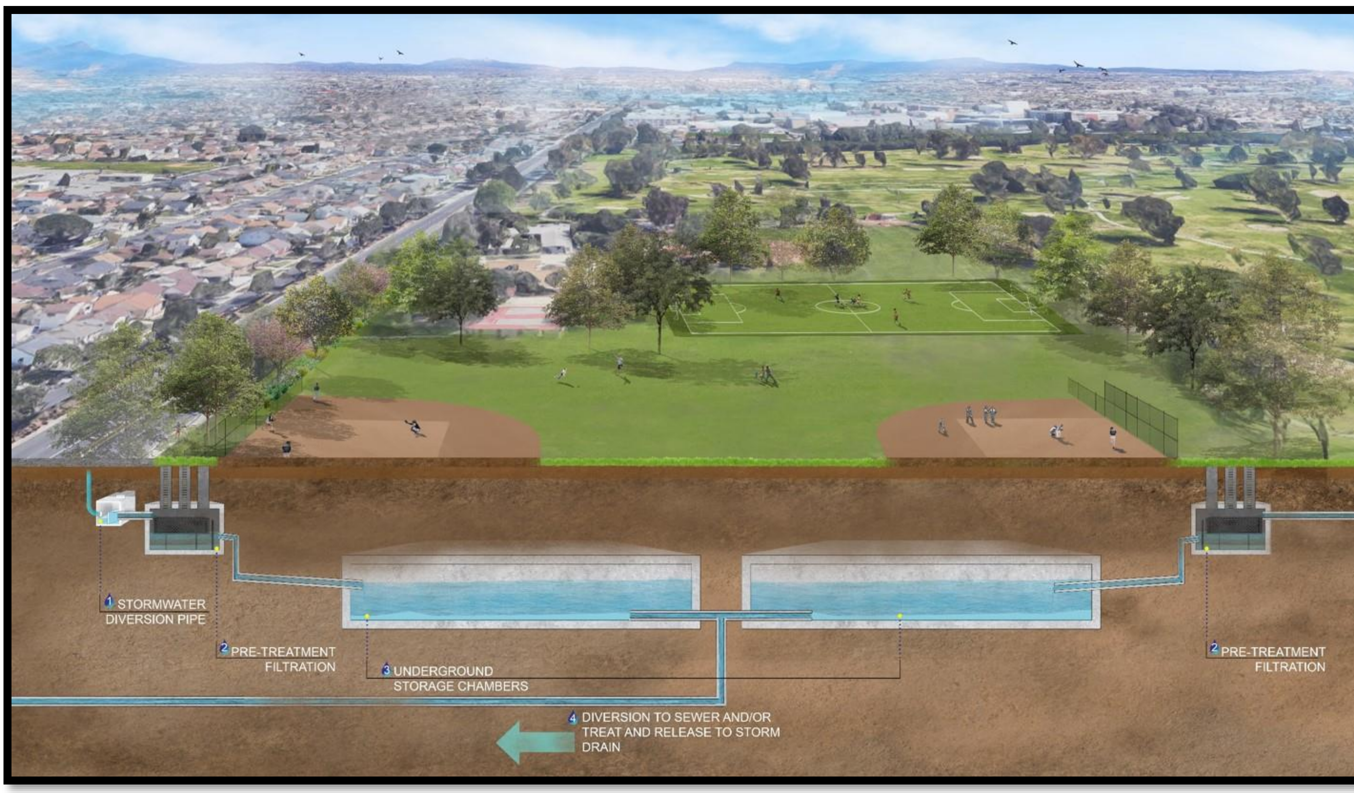


Figure 68. Waiakoa Stormwater Management Park

*The locations depicted are for illustrative purposes and may not represent property owner intentions.

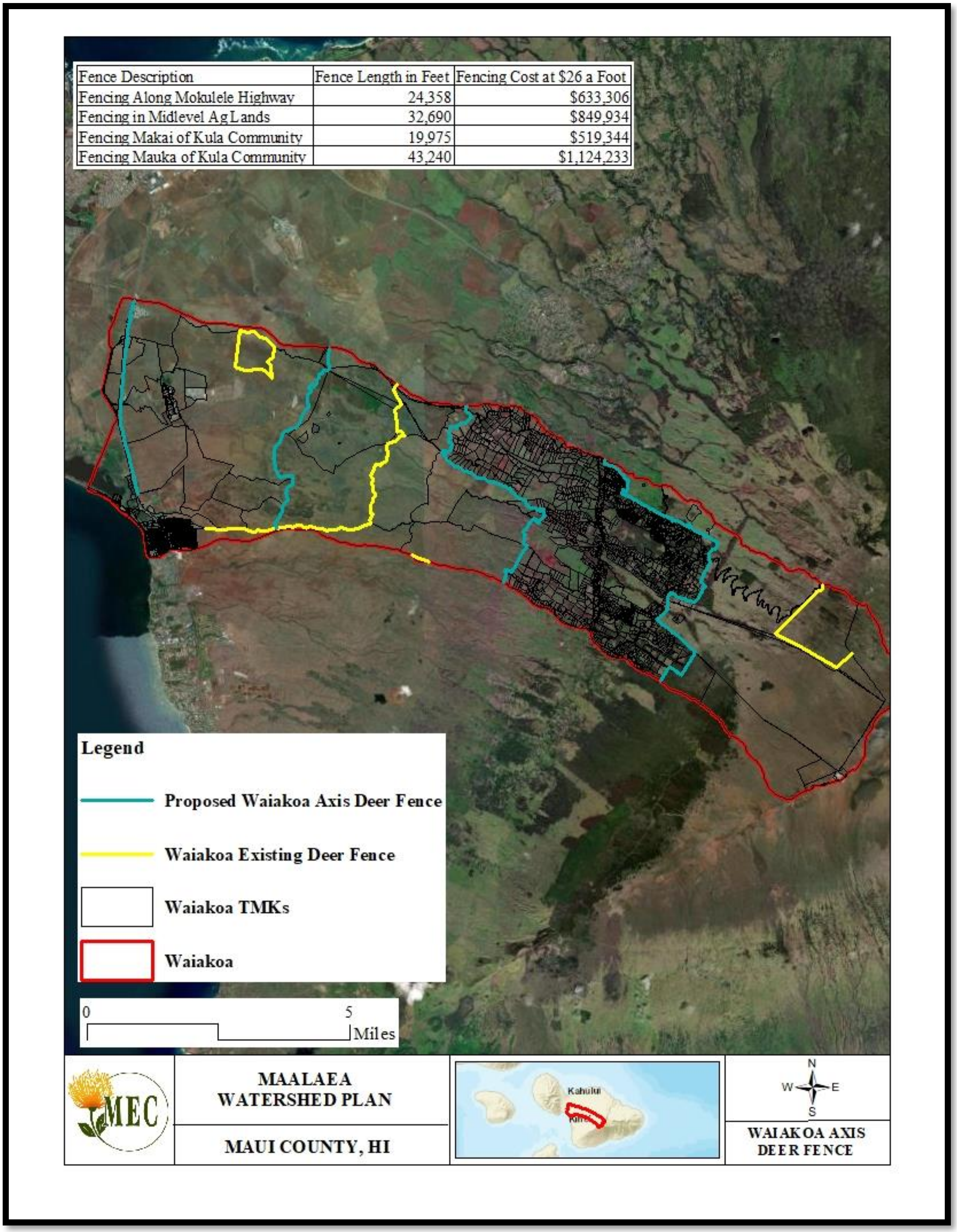
7.2.4 Axis Deer Regional Fencing

As with the Waikapū Watershed, additional fencing is needed to create axis deer management units in the Waiakoa Watershed (Figure 69. Waiakoa Regional Axis Deer Fencing Map). Large herds of deer are regularly observed in the lower, dry regions of Leeward Haleakalā. Substantial vegetation has been lost in the Waiakoa Watershed, leading to sediment laden stormwater discharging into Māʻalaea Bay and vital nearshore marine habitats. Regional axis deer management areas provide the opportunity to control the migration of axis deer throughout the watershed. During drought, wildfire, or other pressures such as removal, fencing enables proper management of this invasive species.

7.2.5 Axis Deer Removal

Fencing provides boundaries in which axis deer can be removed or, at the very least, their populations managed. Options for removal and management include aerial hunts with helicopters, recreational hunting by the community, and commercialized hunting by organizations with the capability to process meat for sale and consumption. It should be noted that private land owners, including Mahi Pono, Haleakalā Ranch, and Kaonoulu Ranch, conduct internal hunting operations within existing fencing boundaries. At present, these efforts are not able to keep up with the growing population of axis deer. Additional resources are needed to alter the trajectory of axis deer populations and their negative ecological impact.

Figure 69. Waiakoa Regional Axis Deer Fencing Map



Fence Description	Fence Length in Feet	Fencing Cost at $26 a Foot
Fencing Along Mokulele Highway	24,358	$633,306
Fencing in Midlevel Ag Lands	32,690	$849,934
Fencing Makai of Kula Community	19,975	$519,344
Fencing Mauka of Kula Community	43,240	$1,124,233

7.2.6 Waiakoa Unimproved Agricultural Road Stabilization

As mentioned in Section 7.1.4, the miles of poorly maintained and disused former agricultural roads are major sources of sediment transfer and pathways for channeling stormwater runoff into stream gulches. Small Waiakoa agricultural roads should be canvassed to see if they require decommissioning or repair. Closing roads using structural methods (barriers) such rocks, logs, or vetiver plantings can capture sediment and attenuate runoff. By reestablishing a dense groundcover like buffelgrass, the potential for soil loss decreases dramatically. In coordination with landowners and potential road users, disused, and unnecessary or redundant roadways should be identified for decommissioning. Any roads likely to stay in use should be improved using water bars, sediment traps and other BMPs to minimize downslope transport of eroded sediments. The lower portions of the Waiakoa Watershed have approximately 151 miles of unimproved agricultural roads (Figure 51. Lower Waiakoa Roads and Ag Roads Map).

7.2.7 Wetland and Stream Riparian Buffers and Protection

As stated earlier, in October of 2022 the Maui County Council passed a bill to protect and restore wetlands (Ordinance 5421). As a requirement of this law, a wetland overlay map is being created. Any wetlands that contain at least two of the three wetland indicators listed by the USACE in their wetland delineation manual and any flow through systems depicting a high-water mark as defined in the 2005 USACE Regulatory Guidance Letter on Ordinary High Water Mark Determination are now considered protected by the bill. County protections may include 50-to-200-foot buffers placed around the wetland edge as determined by the Maui County Planning Department (Figure 70. Waiakoa Streams and Wetlands with 50-foot and 200-foot Buffers). Figure 71 depicts a riparian buffer to protect the riparian corridor along Waiakoa Gulch.

Figure 70. Waiakoa Streams and Wetlands with 50-ft and 200-ft Buffers

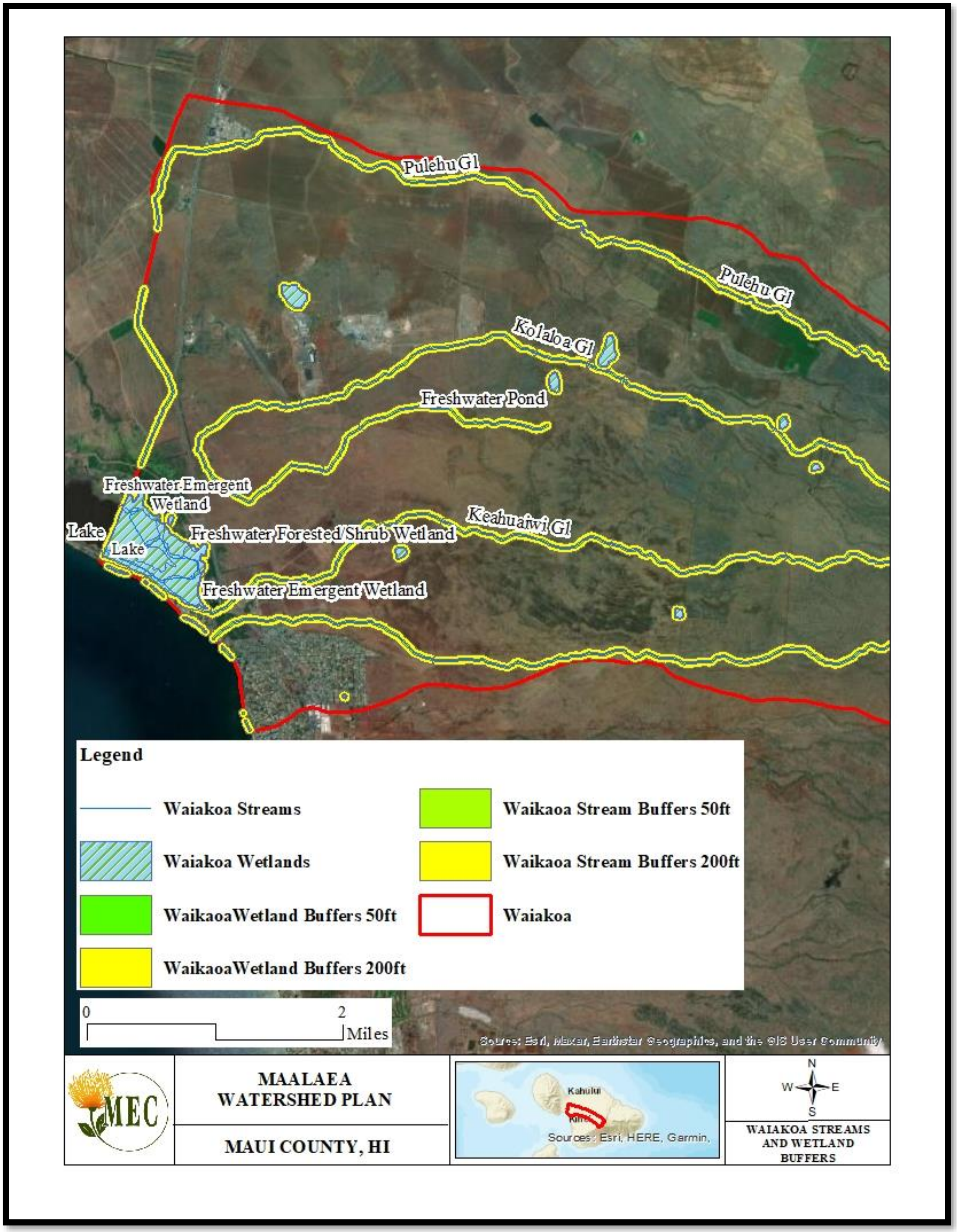
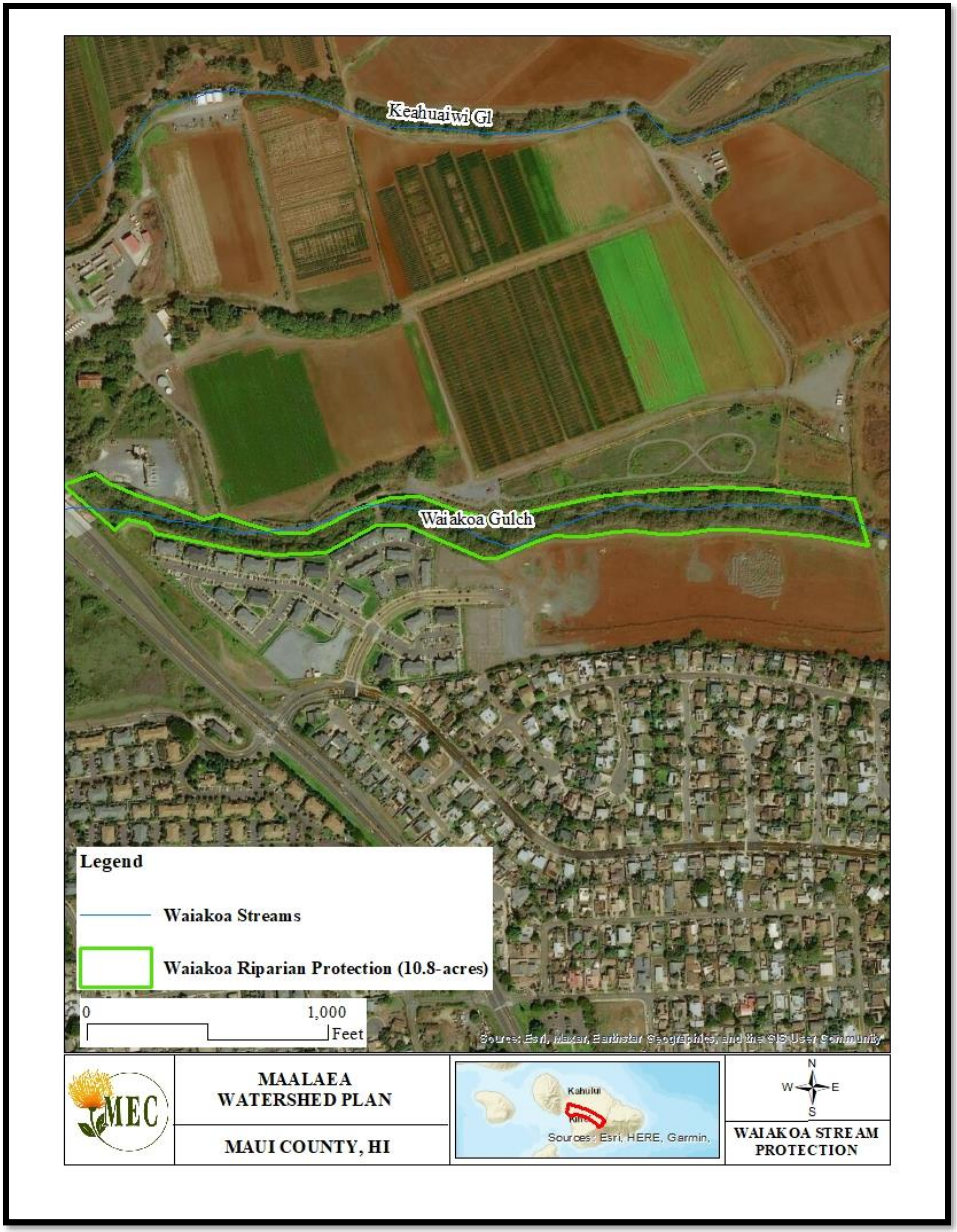


Figure 71. Waiakoa Riparian Protection



7.2.8 Stormwater Infrastructure Damage

Much of the flooding that occurs in the Waiakoa Watershed is due to debris piling up on the mauka side of stormwater infrastructure such as culverts and bridges. The debris clogs drainageways, which then causes stormwater to flood surrounding upland areas as it finds alternative routes downstream within the watershed.

A study should be conducted to identify those portions of the watershed that have inadequate or outdated stormwater infrastructure. Engineers working with the Department of Public Works and affected stakeholders from the community should come together to retrofit this infrastructure with protective devices that allow for stormwater flow to continue even when debris has stacked up in a stream.

Figure 72. Culvert Protection from Debris

7.2.9 Adopt-A-Culvert Program

Suggested by community members at an outreach event, an Adopt-A-Culvert program would provide opportunities for individuals, clubs, nonprofits, and other organizations to take part in improving the environment. Similar to the Adopt-A-Highway program, organizations would "adopt" a culvert of their choice and be responsible for a set number of clean-up events annually. Along with a formal application process and requirements of adoption, adequate safety protocol and procedures would need to be designed. Keeping culverts clear of rubbish and debris remains an effective strategy for flood mitigation and improving water quality.

7.2.10 High Flow Warning System

During community outreach with the Kula Community Association, Dick Mayer proposed the installation of a high flow warning system for the gulches that discharge into the Kīhei, Wailea, and Makena coastal communities. This warning system would consist of flow and stage gauging systems disbursed in gulches makai of Kula and mauka of Kīhei that would send alerts to the community, informing them when stormwater discharge was eminent. This system would provide for flood resiliency by allowing the

Department of Public Works to react in real-time to flooding events. It would also provide the community with a warning system, informing them to stay clear of gulches and to exit the ocean prior to brown water events.

7.2.11 Drought Resilience and Stormwater Reuse

Within the agricultural community of Kula, residents have expressed interest in the construction of retention basins that capture sediment and stormwater for reuse in farming activities. These basins would likely have to be lined to ensure captured stormwater doesn't percolate back into the ground quickly after a storm event. To work properly, at least two basins would have to be constructed. The first basin would not be lined, and its primary purpose would be to capture raw stormwater and allow sediment to fall out of suspension. This basin likely could not be lined because it would require heavy machinery to excavate sediment and other debris captured during stormwater events. Once this water has been allowed to settle, it would be transferred to a second lined basin. This basin would retain water and would be connected to nearby agricultural operations with irrigation infrastructure. This project would benefit the community by dissipating flood energy while also capturing water that could be used in place of potable drinking water to irrigate crops. Sediment captured by this system could also be reused in compost or as aggregate.

7.2.12 Stream Reconnection/Restoration

Many of the streams within the Waiakoa Watershed have been historically impacted by agriculture and urban development. As stated previously, the outfalls for both Waiakoa and Keahuaiwi Gulches have been significantly altered by the construction of the intersection of North and South Kīhei Road. Pūlehu and Kolaloa Gulches are essentially ditched into Keālia pond once they intersect with Mokulele Highway.

All of these streams would be good candidates for stream channel restoration and reestablishment of natural flow regimes. Hydromodifications are discussed in Chapter 5 Section 5 of the Hawaiʻi Watershed Guidance report, and all efforts that improve the overall physical and chemical characteristics of surface waters are supported. Coupled with appropriate infiltration and detention BMPs, restoration of these streams would have a positive impact on the hydrology of Keālia Pond.

Costs vary widely with stream restoration projects, and are most dependent upon site access, proximity and cost of aggregate materials (sand, boulders, etc.), and quantities needed to fill the incised stream channel. A study in North Carolina (an early adopter of stream restoration methods) found an average cost of $242.12 per linear foot of stream restored (Templeton, 2008).

While the costs are likely significantly higher in Maui, this figure is included for illustrative purposes. In many cases, the largest proportion of the costs of stream channel restoration is associated with temporarily diverting stream flow around the area being restored to allow access by heavy equipment. In the case of the streams in the Waiakoa Watershed, the streams are ephemeral, essentially eliminating this expense. This also could allow a longer-term phased approach to restoration activities conducted in the dry stream channels.

7.2.13 Kamehamenui

In 2017, a 3,434-acre parcel in Kamehamenui (TMK (2) 03-005:002) was offered on the open market and threatened with sale and private development. The Trust for Public Land, DLNR, and others collaborated on an offer to purchase this land on behalf of the people of Hawai'i. The Board of Land and Natural Resources (BLNR) approved the purchase on May 8, 2020, with terms and conditions that the land be used for forest restoration, endangered species recovery, and public access. On June 25, 2021, the BLNR set aside the lands as a state Forest Reserve, preserving lands that would have otherwise been sold for private development.

7.2.14 Wetland Protection and Buy Back

The U.S. Army Corps of Engineers (USACE) has regulatory authority over wetlands and other water bodies of the U.S. (WBUS) based on two federal laws. These include Section 404 of the Clean Water Act (CWA) of 1972, and Section 10 of the Rivers and Harbors Act of 1899.

Section 404 of the CWA states that dredged and fill material may not be discharged into jurisdictional WBUS (including wetlands) without a permit. According to 40 CFR 230.3, WBUS subject to agency jurisdiction under Section 404 include navigable waters and their tributaries, interstate waters and their tributaries, wetlands adjacent to these waters, and impoundments of these waters.

A Section 404 permit is required for all fill or discharge activities below the high tide line in tidal waters or below the ordinary high-water mark (OHWM) for non-tidal, non-wetland waters. Corps regulations define the term "ordinary high-water mark" for purposes of the CWA lateral jurisdiction at 33 CFR 328.3(e), which states:

"The term ordinary high-water mark means that line on the shore established by the fluctuations of water and indicated by physical characteristics such as a clear, natural line impressed on the bank, shelving, changes in the character of soil, destruction of terrestrial vegetation, the presence of litter and debris, or other appropriate means that consider the characteristics of the surrounding areas."

The Rivers and Harbors Act of 1899 prevents unauthorized obstruction or alteration of navigable WBUS. Navigable waters are defined as waters that are "subject to the ebb and flow of the tide and/or presently used, or have been used in the past, or may be susceptible for use to transport interstate or foreign commerce" (33 Code of Federal Regulations [CFR] 325.5(c)(2)). A Section 10 permit is required for non-fill discharging activities proposed in, over, or under WBUS.

In May of 2023, the United States Supreme Court released an opinion in Sackett v. EPA, in which the Court unanimously held that the Environmental Protection Agency (EPA) overstepped its jurisdiction in classifying wetlands on the Sackett property as "waters of the United States" (WOTUS). The court stated: "…the CWA extends to only those wetlands that are "as a practical matter indistinguishable from waters of the United States." This requires the party asserting jurisdiction over adjacent wetlands to establish "first, that the adjacent [body of water constitutes]… 'water[s] of the United States,' (i.e., a relatively permanent body of water connected to traditional interstate navigable waters); and second, that the wetland has a continuous surface connection with that water, making it difficult to determine where the 'water' ends and the 'wetland' begins."

In October of 2022 the Maui County Council passed a bill to protect and restore wetlands (Ordinance 5421). As a requirement of this law, a wetland overlay map is being created. Any wetlands that contain at least two of the three wetland indicators listed by the USACE in their wetland delineation manual and any flow through systems depicting a high-water mark as defined in the 2005 USACE Regulatory Guidance Letter on Ordinary High Water Mark Determination are now considered protected by the bill. County protections may include 50-to-200-foot buffers placed around the wetland edges and stream banks as determined by the Maui County Planning Department.

In Fiscal Year 2024, the Maui County Council allocated 5 million dollars for the purchase of wetland resources. This money is intended to protect vital wetlands throughout Maui County. As stated earlier, the USFWS estimated 31% of the coastal wetlands were lost during the 1970's to 1990's. Wetlands in Kīhei were determined to have decreased from 199 acres in 1965 to 83 acres in 2001 (including 7.3 acres of mitigation). Wetlands provide critical habitat for threatened and endangered waterbird species such as the Hawaiian Stilt and the Hawaiian Coot. They capture floodwater and provide treatment, cleaning stormwater before it enters nearshore coastal habitat. They also provide locations for aquifer recharge, recreation, and culture activities.

7.2.15 Powerline Corridors

The extent to which access is needed and vegetation must be controlled or removed from powerline corridors should be assessed (Figure 73. Waiakoa Roads and Powerlines Map). Disused or inactive corridors should be decommissioned, and active corridors managed to minimize disturbance of native vegetation while still maintaining corridor safety and access requirements. An assessment of where utilities can be placed underground should also be conducted.

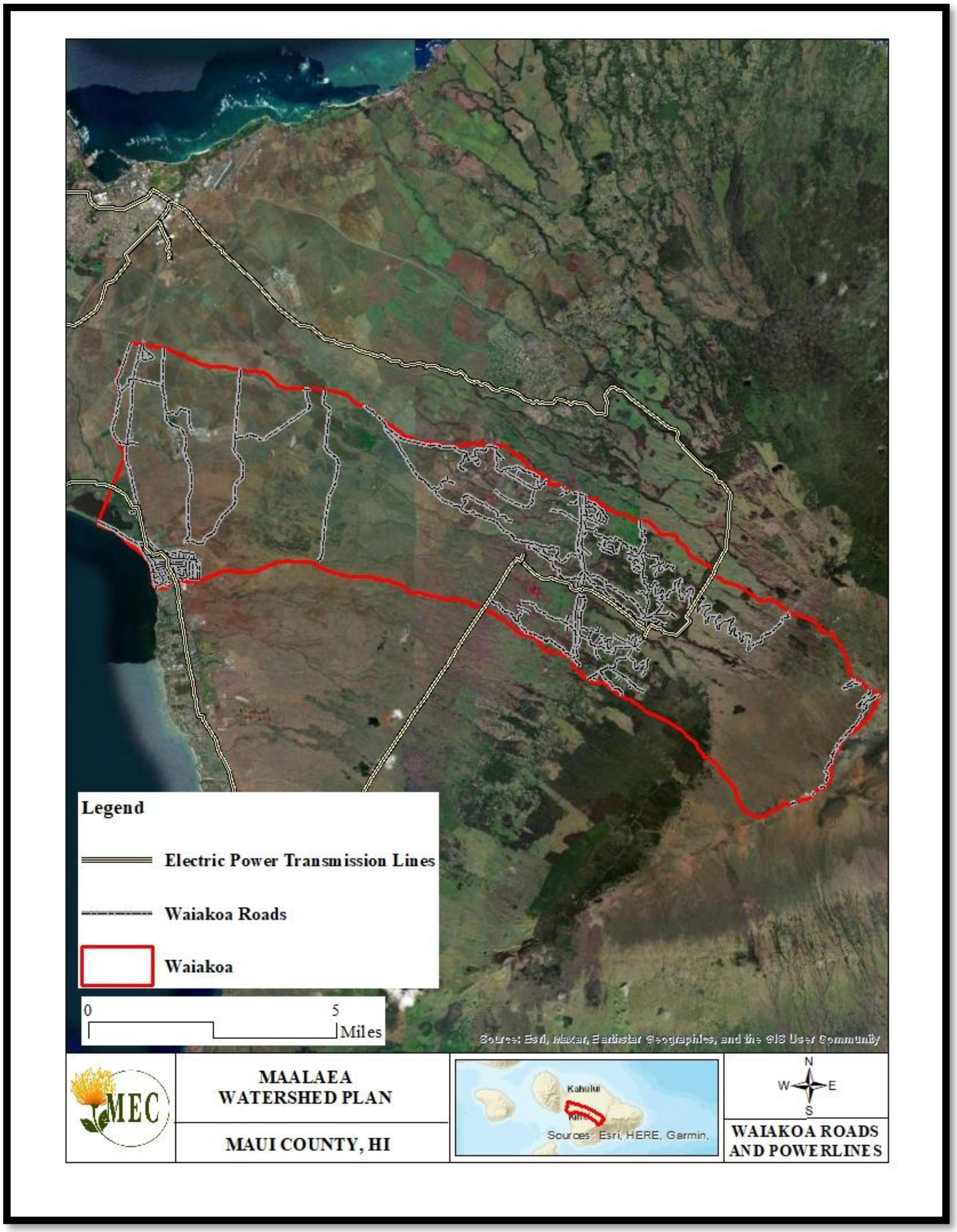
Extreme caution must be exercised when conducting maintenance and repair in transmission and distribution powerline corridors because they are often sited within and adjacent to stream riparian corridors. Grading and grubbing activities must be conducted in a way to ensure that sediment deposits are not left in the regular flow path or floodways of streams to be transported downstream during stormwater events. While riparian corridors may provide linear pathways for utilities offering minimal impacts to available agricultural lands, these same areas are prone to flooding and can cause additional maintenance and safety issues in the long term for utility companies. For example; when utility poles are installed in damp soils, they are more prone to rot and can fall over in high winds or saturated soils.

Relocating this infrastructure away from stream corridors to follow agricultural roads instead will lower maintenance costs for utility companies while enabling farmers to partner with utility companies to share the cost of road maintenance. Wherever possible powerlines should be installed underground. Although initially more expensive, underground utilities are an important part of creating resilient infrastructure as they do not blow over in storms and are less likely to spark wildfires. Underground utilities could also potentially have less impact on sediment transfer as the corridors do not require the same level of vegetation removal and maintenance as above ground lines and poles. Hawaiʻi Revised Statute § 269-27.6 (https://law.justia.com/codes/Hawaiʻi/2013/title-15/chapter-269/section-269-27.6)
requires that new installations of transmission lines are assessed by the Public Utilities Commission (PUC) to determine the merits of underground versus above ground installation. Factors that must be considered in this decision process include:

Overall benefits outweigh costs
Public sentiment
Government requirements
Funds availability
Environmental impacts
Tourism industry impacts

The PUC and the above mechanism could be a potential avenue to explore for lessening the overall negative impacts from sediment transfer caused by improperly placed powerline corridors.

Figure 73. Waiakoa Roads and Powerlines Map



7.2.16 Wildfires

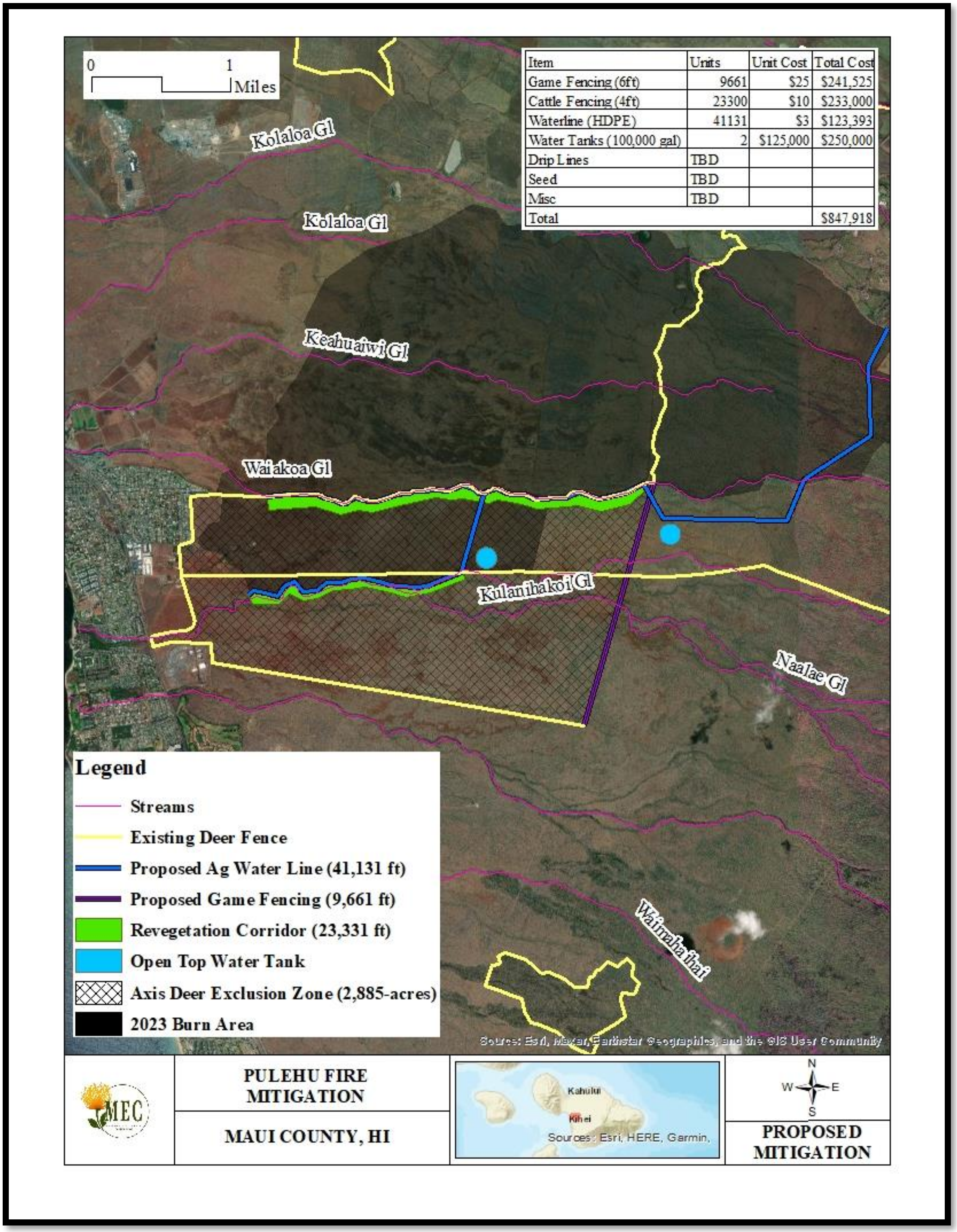
Extremely windy conditions and aging infrastructure make powerline corridors vulnerable ignition sources for wildfires. Fire prevention, revegetation, and stabilization of fire lines and road surfaces are listed as best management practices in Chapter 5 Section 2 of the Hawaiʻi Watershed Guidance report. Wildfires are extremely common in both the Waikapū and Waiakoa Watersheds, especially during the hot, dry summer months. This was made clear during the horrific August 2023 wildfires, which burned through Lahaina Town as well as over 6,000-acres in Pūlehu associated with the Waiakoa Watershed. Additional fires occurred in Kula and Olinda. While a wildfire prevention and mitigation strategy is beyond the scope of this document, the loss of vegetation and subsequent erosion resulting from wildfires is directly related to non-point source pollution. The Upcountry Maui Community Wildfire Protection Plan, developed by the Hawaiʻi Wildfire Management Organization in 2016, identifies and prioritizes wildfire risks and hazards, and recommends wildfire mitigation and prevention practices. The full report can be found by clicking this link: Upcountry Maui Community Wildfire Protection Plan.

Figure 74. Charred Vegetation, Sediment and Ash. Pūlehu Gulch, September, 2023

Regarding the Waiakoa Watershed, flooding and sediment pollution associated with the Pūlehu fire are of particular concern. Waiakoa and Kūlanihākoʻi Gulches flow through the 6,000-acre burn area. These two gulches are both known to flow after Kona storm events, discharging sediment onto infrastructure associated with North Kīhei and into nearshore coastal waters and their associated coral reefs. To mitigate this fire and restore these slopes, Mahi Pono, Haleakalā Ranch, and Kaonoulu Ranch have proposed the following tasks to reestablish vegetation and prevent soil loss (Figure 75. Pūlehu Wildfire Mitigation Strategy Map).

- Installation of 10,000 feet of game fence across Haleakalā Ranch and Kaonoulu Ranch to tie into existing game fences installed by the ranches to create a 2,800-acre Axis Deer Exclusion Zone that includes the Waiakoa Stream and lower Kūlanihākoʻi Gulch systems
- Installation of a water system originating from the Kula Agricultural Park system meters to establish and maintain revegetated corridors of Waiakoa and Kūlanihākoʻi within the exclusion zone
- Installation of open water tanks necessary to support irrigation, helicopters requiring water collection locations, and other regional wildfire suppression needs
- Installation of livestock fence to complement existing game fencing and to manage livestock access to the revegetated corridors for hazard fuel load control
- Installation of drip irrigation and associated practices of establishing appropriate vegetation
- Ongoing management of the area via aggressive deer control and rotational grazing

Figure 75. Pūlehu Wildfire Mitigation Strategy



7.2.16.1 The Kula Community Watershed Alliance

In response to the August 2023 wildfires, upcountry community members formed the Kula Community Watershed Alliance to restore the landscape and improve watershed health. In partnership with NRCS, the community plans to employ slope stabilization techniques to mitigate the negative ecological impacts from the fires. Fallen and invasive trees will be removed, mulched, and deposited onto exposed soils to prevent further erosion. Log terraces will also be installed where possible. Revegetation will utilize site-appropriate native plants to help restore biodiversity. The community is committed to long-term maintenance to ensure longevity of these efforts.

7.2.17 Stormwater Wells

Geology associated with the Waiakoa Watershed has the potential to infiltrate significant amounts of water provided engineered wells and trenches are suitably high enough above underlying groundwater tables and the bottoms of wells and trenches can access enough porous (less dense) strata to allow water to permeate through the soil. Infiltration wells, trenches, or French drains are all designed to convert surface water into groundwater by sinking excess stream flows safely into the ground. Acting like a 'reverse well', this approach has the added benefit of effectively recharging freshwater aquifers. Several stormwater wells already exist within the Waiakoa Watershed (Section 6.1.2).

Department of Health Administrative Rules, Title 11, Chapter 23 provides conditions governing the location, construction, and operation of injection wells so that injected fluids do not migrate and pollute underground sources of drinking water. Section 4 of the Rules gives the criteria for classifying aquifers into those that are designated as underground sources of drinking water and those that are not. The boundary between non-drinking water aquifers and underground sources of drinking water is generally referred to as the "UIC Line". Restrictions on injection wells differ, depending on whether the area is inland (mauka) or seaward (makai) of the UIC line.

7.2.18 Stormwater Infiltration (Dry) Wells

These wells are similar in construction to a cesspool. This open-bottomed well structure is installed surrounded by gravel and wrapped in a geotextile cloth to prevent fine sediment from clogging the well, which would reduce infiltration performance over time. Stormwater is directed into the well where it drains effectively into the ground. Infiltration wells can be as simple as a pit filled with rubble or as complex as a prefabricated concrete structure. UIC permits are typically required for the installation of infiltration wells.

Figure 76. Stormwater Infiltration Well

7.2.19 Infiltration Trench or French Drain

This structure is similar to a well except that it is configured as a long trench filled with gravel or a perforated pipe which spreads water over a larger area. Excess stream water could be directed into a trench, provided the water did not contain significant fine sediment particles which might eventually clog the system.

7.2.20 Cesspools

Cesspools are of particular concern throughout Maui County. These underground regions are used for the disposal of human waste, where untreated sewage is discharged directly into the ground, leakage from which can contaminate oceans, streams, and ground water by releasing disease-causing pathogens and nitrates. Within the Waikapū Watershed there are 122 known cesspools. Within the Waiakoa Watershed, 1,838 cesspools are present. These systems are a known source of nutrient contamination to groundwater and the ocean. All of these wastewater systems should at the minimum be converted to individual waste systems (IWS) such as septic tanks. Injection wells and cesspools are regulated by the USEPA under the authority of the Underground Injection Control (UIC) program, as provided by Part C of the Public Law 92-523, the Safe Drinking Water Act (SDWA) of 1974. DOH administers a separate UIC permitting program under state authority.

Generally, options for upgrade or closure include:

1. Closure and connection to an existing nearby sewer system with available capacity.
2. Closure and connection to a new private or public sewer system.
3. Closure and connection to a community-scale package wastewater treatment system.
4. Upgrade to an onsite septic tank and/or aerobic treatment unit system.

Signed into law in July of 2017, Act 125 requires all cesspools to be upgraded, converted to a septic system, or connected to a sewer system by Jan. 1, 2050. It directs the Hawaiʻi DOH to evaluate residential cesspools in the state, develop a Report to the Legislature that includes a prioritization method for cesspool upgrades, and work with the Department of Taxation on possible funding options to reduce the financial burden on homeowners.

Review and approval of IWS must be obtained through the the HDOH Wastewater Branch. Requirements include design, construction, and site plans as well as maintenance and operation manuals. Routine inspections and pumping, efficient water use, proper disposal of waste, and drainfield maintenance are necessary to ensure proper function and longevity of septic tanks.

7.2.21 Condominium Impervious Surfaces

The condominiums along North Kīhei Road have numerous locations where polluted runoff discharges into stream outfalls and directly into the ocean. Sources observed included; swimming pool backwash water, runoff from parking lots, car wash stations, and tool and equipment wash down sites. A number of potential sites suitable for bioretention or other low impact design (LID) retrofits to treat polluted water were also observed. A full LID assessment of the condos and resorts associated with North Kīhei in the Waiakoa Watershed is recommended to determine those sites best suited for LID retrofits. These projects could be developed and installed in collaboration with condo residents and community groups.

8.0 ELEMENTS B AND C – ESTIMATED LOAD REDUCTIONS FROM NONPOINT SOURCE POLLUTION IMPLEMENTATION PROJECTS

Section 7.0 of this Plan listed goals and recommendations for both the Waikapū and Waiakoa Watersheds. In this section, that broad suite of potential projects has been pared down to include targeted implementation projects proposed to improve water quality. Specifically, the projects listed in Section 8.0 are anticipated to have the greatest benefit to water quality due to estimated load reductions, community feedback and support, field observations, and past successes.

The implementation projects proposed in this Section are outlined below. They include axis deer fencing, riparian protection, road stabilization, excavated detention basins, gabions in series, regional stormwater management parks, culvert protections, LID infrastructure within urban areas, and reef friendly fertilization and landscaping programs. Below we discuss practices that have been deemed the most appropriate for implementation in the near future. Other projects may also be incorporated into the Plan in the future as needs and resources dictate. Appendix A includes "pull sheets" that summarize each of these projects with generalized information on estimated costs, expected load reductions, timelines, and permitting requirements.

In addition to modeling for current pollutant loads within the Waiakoa and Waikapū Watersheds, STEPL is able to estimate load reduction values for individual and combined BMPs implemented within each land use type. The list of BMPs provided in the STEPL model is quite extensive, with over 70 different practices to reduce pollutant loading.

The Revised Universal Soil Loss Equation - Version 2 (RUSLE2) program was developed primarily to guide conservation planning, inventory erosion rates and estimate sediment delivery. Values computed by RUSLE2 are supported by accepted scientific knowledge and technical judgment, are consistent with sound principles of conservation planning, and result in good conservation plans (USDA).

We have included load reduction estimates for each of the proposed implementation projects listed below as modeled using either the STEPL or RUSLE2 programs, as appropriate. When these models were not appropriate, or when actual data exists, we attempted to base load reduction estimates on existing datasets. Some projects lack load reduction estimates, either because of data gaps or because individual project design and implementation will dictate pollutant load reductions. This is the case for Low Impact Design projects, Culvert Protection, as well as Reef Friendly Landscaping projects.

8.1 Axis Deer Fencing

Axis deer populations are growing at an exponential rate in Maui County. These deer are voracious grazers, denuding the landscape of groundcover vegetation. By fencing off larger sections of the Waikapū and Waiakoa Watersheds, natural resource managers can create management units. By creating these management areas, the community can control the migration of axis deer throughout the watershed.

Using the STEPL Heavy Use Area Protection BMP, and for the sake of this modeling effort, we assumed only Pasturelands will be fenced off. This assumption was made because the Heavy Use Area Protection

BMP is specific to the Pastureland land use within the STEPL program and is not an option in either the Cropland or Forest land uses. We believe cropland, forest, and pasturelands should all be fenced off to best control axis deer populations and allow for various management units.

Using a base management unit size of a 100-acre pasture with four linear fencing distances of 2,087 feet of fencing or 8,348 total feet of fencing, this management unit would make up approximately 0.636 percent of the total 15,721.79 acres of pastureland in the Waiakoa Watershed and 4.28 percent of the total 2,331.63 acres in the Waikapū Watershed. At $30 a linear foot, a 100-acre axis deer exclusion area would cost approximately $250,440.00.

Table 23 below depicts the pollutant load reductions for Waiakoa and Waikapū Watersheds per 100-acre Heavy Use Protection BMP. These exclusion management units should be placed in high priority areas where groundcover vegetation has been nearly or completely denuded.

Table 23. Axis Deer Fencing Load Reduction Estimates

Watershed	N Reduction	P Reduction	BOD Reduction	Sediment Reduction
	pounds/year	pounds/year	pounds/year	tons/year
Waiakoa	198.97	37.52	142.43	22.25
Waikapū	137.05	40.76	195.64	30.57

8.2 Pūlehu Wildfire Mitigation Strategy

The Pūlehu Wildfire burned over 6,000-acres in the Waiakoa and Hapapa Watersheds in August of 2023. Waiakoa and Kūlanihākoʻi Gulches flow directly through the burn scar, which has left thousands of acres of land completely devoid of vegetation. These streams already discharge large amounts of sediment onto infrastructure in North Kihei as well as onto coral reefs in the nearshore coastal waters. Working with Mahi Pono, Haleakalā Ranch, and Kaonoulu Ranch, the Pūlehu Wildfire Mitigation Strategy proposes to create a 2,800-acre Axis Deer Exclusion Zone that includes the Waiakoa Stream and lower Kūlanihākoʻi Gulch systems. This exclusion zone will allow for groundcover plant species to recover without pressure from axis deer, locking in soils and reducing erosion potential for the area. Table 24 below displays STEPL pollutant load reduction estimates for the Pūlehu Wildfire Mitigation Project. It should be noted that STEPL estimates are based on the Pastureland land use classification and the software does not take into account for complete loss of vegetative cover within this land use associated with the August 2023 fires.

Table 24. Pūlehu Wildfire Mitigation Strategy

Best Management Practice	Nitrogen Reduction in Pounds per Year	Phosphorus Reduction in Pounds per Year	Sediment Reduction in Tons per Year
Axis Deer Exclusion Zone	10,440.72	1,152.52	652.59
Waiakoa Riparian Protection	487.05	53.76	30.44
Waiakoa Cattle Exclusion	27.6	6.74	4.17
Kūlanihākoʻi Cattle Exclusion	17.25	4.21	2.61
Kūlanihākoʻi Riparian Protection	464.59	68.62	34.05
Totals	11,437.21	1,285.85	723.85

8.3 Protect and Manage Riparian Corridors (Mauka to Makai Connections)

Riparian buffers along gulches and gullies prevent sediment laden sheet flow from entering flow ways and ultimately discharging into coastal waters. They also offer important habitat for native flora and fauna to inhabit from mauka to makai throughout the watershed.

All of the gulches in the Waikapū and Waiakoa Watersheds are now protected by Maui County Ordinance 5421. As a requirement of this law, a wetland overlay map is being created. Any wetlands that contain at least two of the three wetland indicators listed by the USACE in their wetland delineation manual and any flow through systems depicting a high-water mark as defined in the 2005 USACE Regulatory Guidance Letter on Ordinary High Water Mark Determination are now considered protected by the bill. County protections may include 50-to-200-foot buffers placed around the wetland edges and stream banks as determined by the Maui County Planning Department.

Fencing is the primary means of protection, preventing access by hoofed animals. The effectiveness of the removal of sediments and nutrients from stormwater runoff increases with buffer width (see Riparian Buffer Width, Vegetative Cover, and Nitrogen Removal Effectiveness, EPA/600/R-05/118, October 2005). Access crossings through the gulches may be incorporated into the fence design, and stream curtains can be installed to prevent animals from entering the buffers while crossing. These curtains allow stormwater to pass under without destroying the fence.

The Kēōkea Riparian Rehabilitation project is a pilot project funded by the HDOH and Maui County to show the proof of concept of large-scale riparian protection. The project consisted of first protecting the Kēōkea riparian zone with the installation of feral ungulate fencing. Next, R-1 dripline irrigation infrastructure was installed. This infrastructure included over 9,000 feet of dripline and approximately 3,000 emitters. Next, native dryland forest plant species were planted at each emitter. Each plant is watered with one gallon per day. Additional riparian rehabilitation projects are being proposed for streams within the Hapapa Watershed (covered by the Southwest Maui Watershed Plan).

Figure 77. Before and After Pictures from the Kēōkea Riparian Rehabilitation

Included in Table 25 below are the STEPL pollution load reduction estimates for the proposed Waiakoa Riparian Rehabilitation Project described in Section 7.2.5.

Table 25. STEPL Estimated Load Reduction from Riparian Protection and Rehabilitation

N Reduction	P Reduction	BOD Reduction	Sediment Reduction
Pounds/Year	Pounds/Year	Pounds/Year	Tons/Year
10.9	3.4	14.8	2.3

8.4 Excavated Basins

Section 7.2.1 discussed detention basins and their ability to capture sediment laden stormwater. While detention basins have been proposed to be associated with Waikapū Country Town, no dimensions are provided in the master plan available online. Several detention basins were depicted in maps created for Waiakoa. These include basins in series, a large detention basin, and a large regional stormwater management park. While these maps are for illustrative purposes, their sizes were used to generate load reduction estimates using STEPL software – specifically applying values to the Dry Detention BMP within the Urban BMP calculator. This software can be used to generate load reductions for detention basins proposed for the Waikapū Watershed as well.

Table 26. Waiakoa Detention Basin Load Reduction Estimates

Basin	Acreage Based on Map Renderings	Pollutant Load Reduction		
		N Reduction	P Reduction	Sediment Reduction
		lb/year	lb/year	t/year
Waiakoa Basins in Series	10.42	13.54	2.13	0.59
Large Waiakoa Basin	56.40	73.27	11.55	3.19
Regional Stormwater Management Park	45.43	35.69	3.09	1.60

8.5 Unpaved Roads

As discussed in Section 7.1.4, the miles of poorly maintained and disused former agricultural roads are major sources of sediment transfer and pathways for channeling stormwater runoff into stream gulches. A comprehensive inventory of the Waiakoa and Waikapū roads should be conducted to determine stakeholder access needs and to identify those roads that are candidates for decommissioning or repair. In coordination with landowners and potential road users, disused, and unnecessary or redundant roadways should be identified for decommissioning. Any roads likely to stay in use should be improved using water bars, sediment traps and other BMPs to minimize downslope transport of eroded sediments.

Table 27. Comparison of Potential Soil Loss from Ag Roads with Bare Ground vs Dense Grass

Watershed	Unpaved Roads	Bare Ground Soil Loss	Potential Soil Loss in Tons from Unimproved Roads	Dense Groundcover Soil Loss	Potential Soil Loss in Tons if all Unimproved Roads were Grassed Over
	Acres	Tons per Acre per Year		Tons per Acre per Year	
Waikapū	123	4.7	578.1	0.006	0.738
Waiakoa	367	4.7	1724.9	0.006	2.202

To approximate the sediment reduction accomplished by the decommissioning of roads in the Waikapū and Waiakoa Watersheds, MEC used the RUSLE2 program. Several data points were entered into the program, including rainfall of 15-16 inches, major soil types, and a slope length of 1400 feet. Slope steepness was assumed to be approximately 6% based on contours and map measurements. Without any BMPs, soil loss was estimated to be 4.7 tons per acre of road. To calculate areage of dirt roads, the lengths in miles were converted to feet and multiplied by a assumed constant width of 20 feet. Once an area of dirt road was calculated in square feet, it was converted to acres of bare ground dirt road. Because much of the lower agricultural roads are associated with pastureland, the Dense Grass – Not Harvested BMP was entered into the program. RUSLE2 estimated soil loss to be lowered to 0.006 tons per acre, significantly reducing soil loss from agricultural roads.

9.0 ELEMENT D – TECHNICAL AND FINANCIAL ASSISTANCE NEEDED TO MEET GOALS AND CONDUCT IMPLEMENTATION PROJECTS

9.1 Technical Assistance and Permits

In addition to the key stakeholders listed in Section 2.1.3, implementation projects proposed in this Plan will often require technical assistance from engineers, architects, land surveyors, environmental consultants, and other professionals. The following chart lists the major permits, some of which may be required for the implementation of the various recommended management measures. Whenever a project will fall within the Special Management Area (SMA), impacts a stream, wetland, or other surface water feature, is within 150 feet of the shoreline, is in a flood zone, involves clearing of vegetation or earth moving activities, or will have a significant environmental impact, various permits will likely be required. Consultation with regulatory agencies is recommended to confirm permit requirements and approvals applicable to each project.

Table 28. Potential Permits needed for Implementation Projects

Permit Name	Issuer	Trigger	Application Requirements	Project Improvements
Grading and Grubbing Permit	Maui County Department of Public Works	Required for removal of vegetation and earthmoving activities associated with construction	Application will require construction plans to be submitted	Any activity that bares or grades the ground surface, such as structural installation, access roads, and equipment and material staging areas
Special Management Area (SMA) Permit	Maui County Planning Department	Required for any work being conducted in the Special Management Area	Application will require plots/drawings of work being conducted	All "development" projects require a permit. Applications for a major permit (over $500k or significant adverse environmental or ecological effect) require environmental review and more stringent review.

Permit Name	Issuer	Trigger	Application Requirements	Project Improvements
Perform Work on County Highway Permit	Maui County Department of Public Works	Required when a County roadway is disturbed by installation of pipelines	Application will require construction plans for the affected area	Any activities affecting County-owned roadways or structures, such as pipeline installation, use of bridges, and traffic control
Stream Channel Alteration Permit	State of Hawaiʻi Commission on Water Resources Management	Any activity which will affect the stream course within the channel of a perennial or intermittent stream. The regulated channel extends to the top of the streambank.	Application will include design drawings, effects on and mitigation for aquatic organisms and communities, water pollution prevention plan	Intakes, stream crossings of pipelines, construction and maintenance roads
Stream Water Diversion Permit	Commission on Water Resources Management	Any new or modified diversion of water from streams for beneficial use	Application will include amount of water to be taken, assessment of other instream and non-instream water uses, design of intake	New stream intakes and change in diversion amount at existing intakes
Department of Army Permit	U.S. Army Corps of Engineers	Any activity resulting in filling of water bodies in the U.S., including flowing streams and wetlands. Fill includes sediment and structures.	Application will require site plan, design, construction methodology, CWA Section 401 Water Quality Certification by Hawaiʻi Department of Health, as well as compliance with	New stream intakes, road and pipeline crossings of streams and wetlands

Permit Name	Issuer	Trigger	Application Requirements	Project Improvements
			environmental Federal cross-cutting authorities (e.g., Section 7 of the Endangered Species Act and Section 106 of the National Historic Preservation Act)	
Clean Water Act Section 401 Water Quality Certification	Clean Water Branch, Hawaiʻi Department of Health	Required for any Federal permit that will involve discharge into bodies of water including streams and wetlands	Application will require items submitted for Department of Army Permit, environmental and chemical evaluation of receiving water, and Hawaiʻi Water Quality Standards compliance plan	Applies to locations requiring Department of Army Permit
Conservation District Use Application (CDUA)	State of Hawaiʻi, Department of Land and Natural Resources	Any development actions in Conservation Districts as designated by the State Land Use Commission	Application will require a Hawaiʻi Chapter 343 EA/EIS	Pipeline or reservoir installation in the Conservation District

Permit Name	Issuer	Trigger	Application Requirements	Project Improvements
National Pollution Discharge Elimination System (NPDES) Permit	Clean Water Branch, Hawaiʻi Department of Health	Required for construction site runoff management when construction area exceeds one acre and if the operation of the improvement results in discharge into water bodies	Application will require sediment and runoff management designs and a water quality monitoring plan	Applies to all construction sites with potential of erosion and runoff
Use and Occupancy Permit/Construction within a State Highway Permit	Division of Highways, State of Hawaiʻi, Department of Transportation	Required for surveying, materials testing, and construction affecting State-owned roadways	Permit will depend on phase of work with full plans required for construction activities	Any activities that affect State-owned roadways or structures, such as pipeline installation, use of bridges, and traffic control
6E Submittal Letter	State of Hawaiʻi Historic Preservation Office	Identification and inventory of historical artifacts	HRS 6E: 6E-10, 6E-08, and 6E-42	Any activities that may affect historical artifacts
Section 7 of the Endangered Species Act	United States Fish and Wildlife Service	The presence of listed species or critical habitat	Informal consultation followed by formal consultation if needed	Requires entities to ensure their activities are not likely to jeopardize the continued existence of federally listed species or destroy or adversely modify designated critical habitat

9.2 Implementation Project Cost Estimates

In addition to modeling pollutant load reductions from the various implementation projects outlined in this watershed plan, project costs were estimated to facilitate stakeholders in obtaining financial assistance and in the decision-making process. Cost estimates were generated using the best information available at the time this report was written. Stakeholders are encouraged to use these cost estimates when designing projects and applying for grants. It should be noted that certain costs are specific to the type of work being conducted, location in the watershed, community support, etc. While these costs were formulated using the best information available, it is recommended that stakeholders coduct their own research to develop accurate costs at the time of project implementation.

9.2.1 Axis Deer Fencing:

9.2.1.1 Cost for Waikapū:

At a minimum, axis deer fencing should be placed along the conservation land boundary to protect native forests from this invasive species. Working with the Hawaiʻi Department of Land and Natural Resources, Division of Forestry and Wildlife and the Mauna Kahālāwai Watershed Partnership, this project would require a minimum of 15,832 linear feet of fencing. At approximately $26 a linear foot, fencing off this portion of the Waikapū Watershed would cost roughly $411,632.00.

Table 29. Estimated Costs for Axis Deer Fencing in Waikapū

Fencing Description	Length in feet	Cost at $26 a linear foot
Fence along conservation boundary	15,832	$411,632.00
Fence between Honoapiʻilani Hwy and Kuihelani Hwy	30,573	$794,898.00
Fence between Kuihelani Highway and Mokulele Hwy	49,867	$1,296,542.00
Total Fencing Costs		$2,503,072.00

9.2.1.2 Cost for Waiakoa:

Deer fencing should be placed at strategic locations throughout the watershed and connect to existing fencing in order to establish management areas. It is recommended for fencing along Mokulele Highway, in Midlevel Ag lands, makai of the Kula Community, and mauka of the Kula Community. In total, this equals approximately 23 miles of fencing and would cost roughly $3,126,838.00.

Table 30. Estimated Costs for Axis Deer Fencing in Waiakoa

Fence Description	Fence Length in Feet	Fencing Cost at $26 a Foot
Fencing Along Mokulele Highway	24,358	$633,306
Fencing in Midlevel Ag Lands	32,690	$849,934
Fencing Makai of Kula Community	19,975	$519,344
Fencing Mauka of Kula Community	43,240	$1,124,233

Total Fencing Costs	$3,126,838.00

9.2.2 Wildfire Recovery

Costs associated with Pūlehu Wildfire Recovery effort in Waiakoa Watershed include both feral ungulate and livestock fencing to protect riparian corridors, irrigation infrastructure, and the installation of cisterns/water tanks to provide dip tank access by aerial firefighters and a cache of emergency water for first responders and fire fighters. Other costs associated with the project are still being compiled.

Table 31. Pūlehu Fire Mitigation Estimated Costs

Item	Units	Unit Cost	Total Cost
Game Fencing (6ft)	9661	$25	$241,525
Cattle Fencing (4ft)	23300	$10	$233,000
Waterline (HDPE)	41131	$3	$123,393
Water Tanks (100,000 gal)	2	$125,000	$250,000
Drip Lines	TBD		
Seed	TBD		
Misc	TBD		
Total			$847,918

9.2.3 Culvert Protection from Debris:

Small culvert grates range in price from $150.00 to $350.00, and can vary depending on size, materials, and structure. Other costs may include an environmental assessment, engineering, and installation.

9.2.4 Detention Basins:

According to the 2016 Kīhei Drainage Master Plan, detentions basins proposed for Kīhei range in cost from approximately $700,000 to $3,500,000. The difference in price is largely based on the size of the basin, its location, and the permitting constraints associated with construction. See the table below for cost estimates for a single detention basin.

Table 32. Approximate Costs for a Large Detention Basin (Kīhei Drainage Master Plan, 2016)

Task	Quantity	Unit	Unit Price	Total
Environmental Assessment	1	1	$350,000	$350,000
Excavation of Detention Basin	25820	CY	$30	$774,600
Hydromulch for Detention Basin	95800	SF	$2	$191,600
GRP Slope Protection at Spillway	60	CY	$540	$32,400
Inlet/Outlet Concrete Headwall	2	EACH	$16,050	$32,100
Perimeter Chain Link Fence (6ft)	1240	LF	$60	$74,400
1-18' RCP	50	LF	$260	$13,000
Subtotal				$1,468,100
Contingency (20%)				$293,620.0
Total				$1,761,720

9.2.5 Gabions:

Gabion wire mesh walls are fairly inexpensive at $60-$100 a cubic yard. Other costs include an environmental assessment, rock fill, engineering, and placement.

9.2.6 Golf Course Nutrient Curtain:

Costs are highly variable per nutrient curtain installation. Estimated costs are approximately $15,000. A sample budget for a nutrient curtain 40’ long x 4’ wide x 4’ deep is included for illustrative purposes (depth is dependent upon depth to groundwater and may be more or less).

Table 33. Sample Budget for Nutrient Curtain Installation

Item	**Cost**
Site planning and design	$4,000
Excavation	$3,000
Materials (biochar, woodchips, sand, and sawdust)	$5,000
Construction management and oversight	$3,000
TOTAL	**$15,000**

9.2.7 Land Slide Mitigation:

Costs will vary based on location, accessibility, planting density, plant availability, and project goals. To install fiber rolls in strategic locations (assuming a 3:1 slope ratio), and to revegetate the landscape at a moderate density (200 plants per acre) would cost approximately $24,810 per square acre. Helpful information about fiber roll installation can be found on the EPA’s national menu of BMPs for stormwater (U.S. EPA, 2021). Click the link that follows to access the webpage. Stormwater BMP: Fiber Rolls

Assessments to identify locations where landslides have occurred as well as the causes behind landslide-prone areas are needed, and those costs are not included in this report.

Table 34. Cost Estimates for 1 Square Acre of Fiber Roll Installation and Revegetation

Item	**Cost**
Fiber Roll	$14,610 ($10.00 per linear foot x 1,461 feet needed)
Wooden Stakes	$1,400
Plants	$800 ($4.00 x 200 plants)
Installation and Maintenance	$8,000
TOTAL	**$24,810**

9.2.8 Reef Friendly Landscaping:

Costs are highly variable depending on project objectives and property types. Large, commercial test plots can cost upwards of $12,000 per acre for labor and production application. Individuals can purchase a compost tea kit for (organic soil amendments) for as little as $120.00.

9.2.9 Regional Stormwater Management Park:

Costs for a Regional Stormwater Management Park are difficult to estimate. Because these areas are typically public spaces, the cost to purchase the land by the County should be included in the total price. To create the basin, costs would be similar to a detention basin as outlined in 9.2.3. Additional costs would be to landscape the area or place infrastructure such as parking, fences, and other facilities.

9.2.10 Unimproved Road Stabilization:

Costs can vary depending on the level of disrepair of each road. Slope steepness, soil composition, location, and other factors may influence road stabilization costs.

The table below provides a sample budget to repair approximately 3 miles of road based on a similar project that took place in 2019 in the neighboring Pōhākea Watershed. Note that this sample budget is for the repair of approximately 12,000 linear feet of dirt road. Repair included regrading to address channelizations and rills, the cleaning out and repair of kickouts, and the establishment of water bars where needed. In addition, herbicide treatment was included on either side of the road for fire suppression.

Table 35. Cost Estimates for Road Stabilization Based on a Project in the Pōhākea Watershed

Task Description	Unit	Unit Price	Total Price
Mobilization	NA	$5,000	$5,000
Water Truck	10 Days	$1,530	$15,300
Spencer Road Grading	7920	$23	$182,160
MECO Road Grading	7920	$28	$221,760
Herbicide Treatments	15,840	$1	$16,000
Total Price			$440,220

9.2.11 Wetland and Stream Buffers and Protection:

Costs can vary depending on buffer size and project objectives. An estimated cost to restore 10.8 acres of a riparian corridor along Waiakoa Gulch is $173,280.

Table 36. Cost Estimates for 10.8 Acres of Riparian Rehabilitation Along Waiakoa Gulch

Task	Cost per Unit	Number of Units	Total Cost
Weekly fencing and irrigation infrastructure inspections	$550.00	52	$28,600.00
Fencing Materials	$30.00	3,896	$116,880.00
Irrigation Infrastructure	$4,000.00	1	$4,000.00
Irrigation installation and planting	$2,200.00	5	$11,000.00
Plants	$4.00	1,000	$4,000.00

Quarterly vegetative monitoring, photo documents, drone flights	$1,100.00	4	$4,400.00
Quarterly and annual reports	$1,100.00	4	$4,400.00
Total Cost		$173,280.00	

10.0 ELEMENT E – INFORMATION AND EDUCATION OUTREACH PROGRAM

10.1 Education and Outreach Program Goals

The main goal of the Information and Education Outreach Program is to build public understanding of the Māʻalaea Bay Watersheds Management Plan, Hawaiʻi water quality standards, and the projects proposed by the Plan to remove and reduce pollutants entering our coastal waters through stormwater runoff. Efforts will be focused on discussing nonpoint sources of pollution and how these pollutants enter streams and coastal waters and harm coral reefs. In addition, land-based issues relating to flooding and erosion from stormwater, nutrient runoff, oil and hazardous materials, and wastewater reclamation will all be addressed.

10.2 Education and Outreach Objectives

The Central Maui Soil and Water Conservation District, the Hawaiʻi Department of Health Clean Water Branch, and Maui County should consider establishing and maintaining a Watershed Coordinator position to direct, organize, and coordinate efforts related to the Māʻalaea Bay Watersheds Management Plan. This individual would be the primary contact between the conservation district, the community, government entities, and other organizations involved in improving water quality within the watershed. The Watershed Coordinator would be responsible for spearheading the education and outreach objectives listed below.

10.2.1 Build Public Awareness and Support

Lack of understanding of nonpoint sources of pollution is a major factor affecting water quality. The implementation projects outlined in the MBWMP will require some level of stakeholder awareness and involvement. The community will be educated about current DOH, CWB, and Hui O Ka Wai Ola water quality monitoring locations and data trends arising from these water quality monitoring efforts. Links to both organizations' data portals are available on the www.mauiwatershed.org website.

Stakeholders who implement projects proposed in this Plan should incorporate community education and engagement. Information on project location, objectives, and the improvements to water quality should be made available to the public. Providing opportunities for volunteers to participate in project implementation is also an effective mechanism to gain community involvement and support. The community can also provide technical assistance. Sharing knowledge of project implementation strategies to improve water quality will empower members of the community to refrain from engaging in and to report activities that cause pollution. Public awareness can be expected to improve water quality and coral reef health.

10.2.2 Focused Outreach to Engage Businesses and Decision Makers

In conjunction with the project implementation schedule offered in Section 11 of this watershed plan, the SWCD, as well as MNMRC will continue to conduct focused outreach to natural resource managers, large landowners, and businesses. Examples of focused outreach include:

- Updates to Mauiwatershed.org
- Maui Nui Marine Resource Council's Reef in Brief Newsletter
- Maui Nui Marine Resource Council's Know Your Ocean Speaker Series

10.2.3 Advertise Implementation Projects

Implementation projects can be featured on the www.mauiwatershed.org website, on social media, as well as various news outlets. Individual stakeholders are encouraged to promote their contributions to watershed management measures on platforms that best serve them. The main purpose of advertisement is to inform the community about projects occurring within the watershed to improve water quality, and to highlight successes, failures, and data gaps. Marketing events can serve as public relations opportunities for businesses and large landowners alike. Informing the public will provide opportunities for community members to participate in improving and maintaining healthy water quality standards. Utilizing volunteers can also make projects more feasible by lowering costs.

Maui County and/or the Central Maui Soil and Water Conservation District can create mailings, pamphlets, brochures, and other project-specific materials as well as design informative materials and presentations to engage potential project partners.

10.2.4 Participation with Government Agencies and Community Groups

Implementation projects listed in this Plan are all meant to improve water quality by reducing pollutant loads entering coastal waters. Depending on the proposed project, meetings will have to be conducted between the SWCD, the watershed coordinator, and government agencies, community groups, and businesses. Government agencies at the Federal, State, and local levels will have to be engaged on several fronts. These agencies can act in their regulatory capacity to force action be taken for certain pollutants or to provide a permit. They can provide technical support, expertise, training, and background knowledge and can serve as a source of funding for implementation projects.

10.3 Education and Outreach Structure and Support

Table 37 provides the basic components making up the structure of the Education and Outreach Program. This table includes tasks associated with the objectives listed above, cost per unit, and a five-year budget for enacting the programs.

Table 37. Māʻalaea Bay Watersheds Management Plan Education and Outreach with Costs

Māʻalaea Bay Watersheds Management Plan Education and Outreach Program							
Objectives	Cost per Unit	Year 1	Year 2	Year 3	Year 4	Year 5	Total 5 Year Cost
Build Public Awareness and Support							
Maintain Central Maui Soil and Water Conservation District website dedicated to watershed information - www.mauiwatershed.org	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$10,000
Watershed Coordinator Position (Costs dedicated to Education and Outreach Program)	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$50,000
Maintain Central Maui Soil and Water Conservation District administrative staff support of outreach and education efforts	$8,000	$8,000	$8,000	$8,000	$8,000	$8,000	$40,000
Focused Outreach to Engage Businesses and Decision Makers							
Establish mailings, pamphlets, brochures and other materials specific to projects being implemented and design persuasive materials and presentations to provide to potential project partners such as resorts and golf courses.	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$10,000
Participation with Government Agencies, Community Groups, Small Group Meetings, and Trainings							
Meetings between Maui County, the SWCD, the watershed coordinator, and government agencies, community groups, and businesses	Included in Watershed Coordinator position costs	$2,000	$2,000	$2,000	$2,000	$2,000	$10,000
Total for Outreach and Education							$120,000

11.0 ELEMENT F – CRITICAL SOURCE AREAS AND IMPLEMENTATION SCHEDULE

Critical Source Areas are areas within a watershed that contribute a disproportionately large amount of pollutant load to a water body. It should be noted that all water quality data associated with Waikapū and Waiakoa Watersheds currently comes from two monitoring sites in nearshore coastal waters. Sampling at various locations within the perennial Waikapū Stream as it makes its way towards Keālia Pond, as well as stormwater sampling at various locations in the ephemeral streams that make up the bulk of both watersheds is needed to accurately identify Critical Source Areas of non-point source pollution. Water quality data from the State of Hawaiʻi Integrated Water Quality Report Assessments, 303d list of impaired waters, and Hui O Ka Wai Ola water quality data was compared with nonpoint sources of pollution on the landscape to develop the project schedule for the Māʻalaea Bay Watersheds Management Plan. This comparison assisted in identifying which projects should be given priority status. Project costs and complexity were also considered when assigning priority status.

Sediment and Nitrogen are the two pollutants of major concern within the Waiakoa and Waikapū Watersheds, respectively. The major source of sediment in these watersheds, and especially in the Waiakoa Watershed, is coming from axis deer overgrazing large tracts of land. Furthermore, the August 2023 fires that devastated Lahaina also burned thousands of acres on Haleakalā and will likely exacerbate sediment loading. This will be especially true in the Waiakoa Watershed, where over 6,000-acres burned and currently only bare ground exists. Without fencing, any vegetation that may become reestablished will immediately be grazed upon by axis deer populations that are no longer being supported by the forage that was lost to the fire. Figure 75 on page 152 depicts the mitigation strategy proposed for the Pūlehu Fire. A cross fence is needed to connect two existing fences that run parallel to Kūlanihākoʻi and Waiakoa Gulches. This cross fence will provide a 2,885-acre axis deer exclusion zone which can then be repopulated with groundcover to armor soils against erosion.

Within Waikapū, while nutrient loading is the of major concern, axis deer fencing along the conservation boundary should be given a top priority. Healthy watersheds begin with healthy, native forests, and axis deer and other feral ungulates have shown the capacity to destroy these sensitive environments. Aquifer recharge and stream flow, notably for the perennial Waikapū Stream, originate in the upper reaches of the Waikapū Watershed.

Riparian buffers provide a secondary mechanism for reducing sediment loading. Placement of these buffers should be prioritized in those streams that discharge directly into Ma'alaea Bay during flooding events, namely Waiakoa and Keahuaiwi Gulches located in the Waiakoa Watershed. As discussed earlier, these riparian corridors should be fenced off from feral ungulates and livestock to allow for vegetation to armor soils associated with these areas. Any sediment transport occurring as a result of sheet flow during storm events will be forced to flow through these densely vegetated riparian corridors prior to entering the stream channel. Groundcover vegetation can reduce sheet flow energy by slowing water and capturing sediment, acting as a linear, mauka to makai filter for these gulches.

Within the Waikapū Watershed, Critical Source Areas of nutrient pollution include organic nitrogen sources such as cesspools and axis deer feces, as well as inorganic nitrogen from fertilized areas such as farms, condominiums, and golf courses. Waikapū Watershed has two golf courses and the lower portion of the watershed is dominated by agricultural operations. Nitrogen loading is the major concern for this watershed. Organic nitrogen loading from axis deer feces can be reduced using feral ungulate fencing and riparian corridor protection in the same way that sediment loading is addressed. Axis deer seek refuge from the sun during the day by hunkering down in the canopied portions of streams and gulches. This results in a concentration of feces within streambeds, which is then swept downstream during stormwater events. By fencing off large tracts of land and continuing axis deer culling efforts, the population of deer contributing to the amount of feces generated in each watershed will be greatly reduced. Furthermore, by excluding axis deer from entering riparian corridors, organic nitrogen associated with feces will not be transported downstream.

Within the confines of the Waikapū Watershed, inorganic nitrogen is typically associated with man-made fertilizers and is primarily used in golf course greens, the landscaped grounds of condominiums and resorts, and on agricultural lands. Additional sources of inorganic nitrogen pollution from outside these watersheds may be contributing to the impairment status of the two water quality monitoring sites associated with the Māʻalaea Bay Watersheds. To best reduce inorganic nitrogen loading, the MNMRC Reef Friendly Landscaping Certification program discussed in Section 7.1.7, or a similar program, should be implemented throughout Waikapū and Waiakoa. Despite sediment being the major pollutant of concern in the Waiakoa Watershed, it has some agricultural operations, mainly associated with the Bayer property in north Kihei, and some shoreline condominiums that could benefit from a nutrient BMP program, Within the Waikapū Watershed, 46 percent of which is cropland, nitrogen loading is the major pollutant of concern. The MNMRC Reef Friendly Landscaping Certification program can be modified to address nutrient loading from fertilizer use associated with agricultural activities in the Waikapū Watershed. The following maps depict both sediment and nitrogen Critical Source Areas where BMPs such as fencing and reef friendly landscaping/fertilization programs should be implemented (Figure 78. Waiakoa Critical Source Areas for Sediment and Figure 79. Waikapū Critical Source Areas for Nitrogen).

For both the Critical Source Areas of sediment for the Waiakoa Watershed and nutrient pollution for the Waikapū Watershed discussed above, and for the remainder of the projects proposed to reduce pollutant loading more generally in this Plan, considerations regarding the severity of pollution as represented in the water quality data, expected load reductions of individual projects, and whether the nonpoint source of pollution is related to stormwater or groundwater were used to estimate when water quality standards would be achieved. Timelines for individual project completion generally range from six months to five years. Several projects may need to be implemented in succession before water quality standards are met for particular pollutants. Estimated timelines for water quality standard attainment generally range from 15 to 20 years. Timelines specific to individual water quality attainment statuses are discussed in detail in Section 13, Element H. Funding and feasibility of execution are also limiting factors on the timeliness of this plan. Projects that require large amounts of funding and development of infrastructure will likely extend the timeline.

Figure 78. Waiakoa Critical Source Areas for Sediment

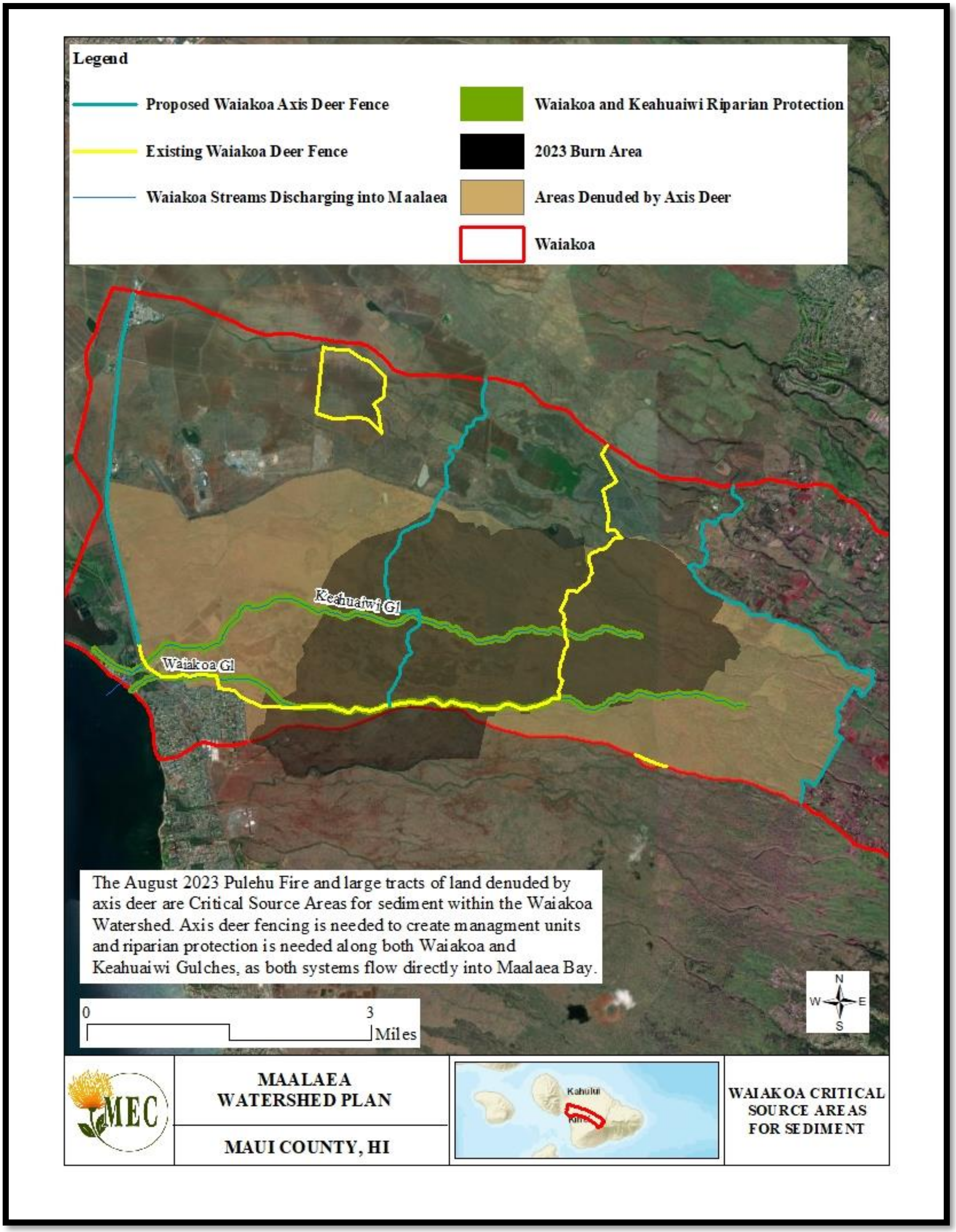


Figure 79. Waikapū Critical Source Areas for Nitrogen

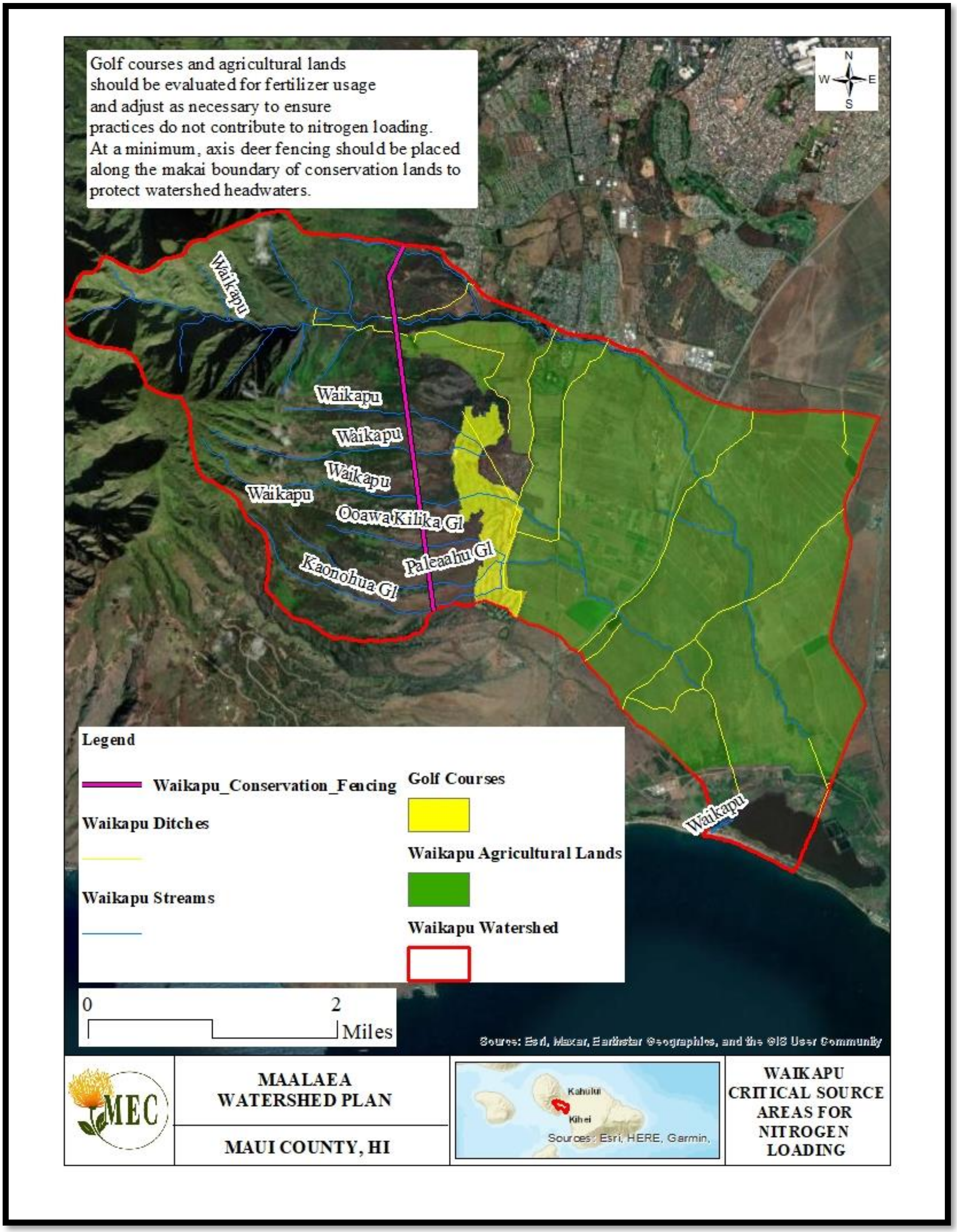


Table 38. Implementation Project Priority Status and Approximate Timeline

Implementation Project	Location (Gulch)	Description	Approximate Timeline to Completion	Organization(s) Responsible for Implementation	Priority
Axis Deer Fencing	At strategic locations throughout Waikapū and Waiakoa Watersheds	Install feral ungulate fencing to manage axis deer populations	Ongoing with 10 miles of fencing installed every five years	Hawaiʻi Department of Land and Natural Resources, Division of Forestry and Wildlife, Mauna Kahālāwai Watershed Partnership, Haleakalā Ranch, State of Hawaiʻi, Kula Ranch, Von Tempsky, Alexander and Baldwin, Mahi Pono, Department of Hawaiian Homelands, Mālama Haleakalā Foundation	High
Pūlehu Wildfire Mitigation Strategy	Waiakoa and Kūlanihākoʻi Gulches	2,800-acre Axis Deer Exclusion Zone and Riparian Protection	2-5 years	Mahi Pono, Haleakalā Ranch, Kaonoulu Ranch, NRCS, Central Maui Soil and Water Conservation District	High
Culvert Protection from Debris	Mauka side of stormwater infrastructure in Waiakoa watershed	Retrofit culverts with protective devices to prevent clogging of drainageways	5-10 years	Maui County Department of Transportation, Department of Public Works	Medium
Detention Basins	Waiakoa Gulches	Install detention basins to capture stormwater and reduce sedimentation and increase infiltration	Ongoing-20 years	County of Maui, Department of Public Works, Mālama Haleakalā Foundation	Medium

Implementation Project	Location (Gulch)	Description	Approximate Timeline to Completion	Organization(s) Responsible for Implementation	Priority
Gabions	Waiakoa Gulches	Install gabions to reduce velocity of flowing stormwater	20 years, with Gabions installed in Waiakoa Watershed Gulches every 5 years	Central Maui Soil and Water Conservation district, private landowners, Mālama Haleakalā Foundation, Maui Nui Marine Resource Council	Medium
Golf Course Nutrient Curtain	Kahili and Kamehameha Golf Courses within Waikapū Watershed	Install nutrient curtains to filter excess nutrients and pollutants from groundwater	Ongoing	Kahili and Kamehameha Golf Courses, Maui Nui Marine Resource Council	Medium
Land Slide Mitigation	Mauka regions of Waikapū Watershed	Stabilize hillslopes to prevent landslides from occurring	Ongoing	Mauna Kahālāwai Watershed Partnership, Maui Nui Marine Resource Council, private landowners	Low
Reef Friendly Landscaping	Commercial and private properties throughout Waikapū and Waiakoa Watersheds	Utilize organic products to enhance soil health and meet landscaping needs.	Ongoing	Kahili Golf Course, Kamehameha Golf Course, Sugar Beach Resort, Keālia Resort, Māʻalaea Surf Resort, Kīhei Beach Condos, Maui Nui Marine Resource Council, private landowners	High
Regional Stormwater Managment Park	Outfalls of Waiakoa and Keahuaiwi Gulches	Build stormwater management park to be utilized dually for community park and flood control	20 years, with one stormwater park constructed every 10 years	State of Hawaiʻi, Maui County Department of Public Works, Mahi Pono, Weinberg Property Owners	Medium

Implementation Project	Location (Gulch)	Description	Approximate Timeline to Completion	Organization(s) Responsible for Implementation	Priority
Unimproved Road Stabilization	Throughout Watersheds	Decommission, repair, and stabilize roads to prevent erosion	Ongoing	Mahi Pono, Goodfellow Bros, Wailuku Water Company, County of Maui, Alexander and Baldwin, Haleakalā Ranch, Kula Ranch	Medium
Wetland and Stream Buffers and Protection	Throughout Watersheds	Protect and restore buffers along gulches and wetalnds	Ongoing	Maui County, Mālama Haleakalā Foundation, Maui Nui Marine Resource Council, Haleakalā Ranch, Mahi Pono	High
Education and Outreach	Throughout Watersheds	Watershed coordinator to oversee Plan implementation and conduct outreach	Ongoing	Maui County, Central Maui Soil and Water Conservation District, Keālia Pond National Wildlife Refuge, Maui Nui Marine Resource Council	Medium

12.0 ELEMENT G – INTERIM MILESTONES

The following section provides interim milestones for the various implementation projects proposed in the watershed management plan. Individual project timelines were estimated based on five-year increments and a total timeline of twenty years. While watershed planning and project implementation is continuous, the scope of this Plan spans two decades. Milestones listed in this section are meant to be both measurable and attainable, with clearly described benchmarks for measuring progress. Table 39 summarizes the information presented in this section.

12.1 Axis Deer Fencing

The installation of axis deer fencing has been given a high priority status. As deer populations grow exponentially, denuded landscapes continue to erode and negatively impact water quality. Fencing is needed to control migrations throughout the watersheds and to enable proper management and control of this invasive species. The magnitude of the problem is widespread, and fencing to be placed at strategic locations throughout the watershed is recommended. Approximately 40 miles of feral ungulate fencing is proposed in this Plan.

12.2 Pūlehu Wildfire Mitigation Strategy

Addressing the fire damage caused during the August 2023 on over 6,000-acres in the Waiakoa Watershed has been given a high priority status. The burned area is completely devoid of vegetation and is highly susceptible to erosion during stormwater events. Both fencing for feral ungulates and livestock coupled with Waiakoa and Kūlanihākoʻi riparian protection and an active reestablishment of groundcover using water and grass seed is required to armor soils in place.

12.3 Culvert Protection from Debris

Protecting culverts from debris has been given a medium priority status. A study should be conducted to identify those portions of the watershed that have inadequate of outdated stormwater infrastructure. Once identified, culverts can be retrofitted with protective devices that allow for stormwater flow to continue. Culvert grates are relatively inexpensive and easy to install, therefore, this implementation project would be a feasible action to mitigate flooding.

12.4 Detention Basins

The basins described in this Plan have been given medium priorty status. While detention basins are regarded as highly effective in the capturing of stormwater and in the removal of sediment, they are expensive to construct and often require extensive permitting, especially if connected to an existing stream.

Estimated costs for detention basin installation ranges from $700,000 to is $3,500,00 according to the 2016 Kīhei Drainage Master Plan. A realistic goal for achievement would be to construct one basin every five years. Basins should be constructed in succession beginning with the greatest capacity to capture stormwater and sediment and ending with the least capacity.

12.5 Gabions

Gabion installation has been given a medium priority status of implementation. Highly effective at reducing the velocity of stormwater, gabions can have a direct and immediate impact of minimizing the impacts of flooding. A comprehensive assessment to include engineering, placement, fill materials, and to determine permitting requirements is needed before installation can begin.

12.6 Golf Course Nutrient Curtain

Golf course nutrient curtains have been given a medium priority status. To filter nutrients from entering groundwater, it is proposed that a nutrient curtain be installed every five years alternating between Kahili and Kamehameha Golf Courses.

12.7 Landslide Mitigation

Hillslope stabilization methods to address landslides have been given a low priority status due to their relatively small size and landscape position in the upper reaches of the watershed. Beginning with an assessment of landscapes that are vulnerable to the potential occurrence of landslides, projects to address and mitigate for loss of soil can be employed at strategic locations. Stabilizing one hillside annually would reduce sediment loads within Waikapū Watershed.

12.8 Reef Friendly Landscaping

Transitioning to chemical-free landscaping alternatives has been given a high priority status. Programs and resources to do so are available through Maui Nui Marine Resource Council. Beginning with golf courses and stakeholders that manage large landscapes will have the greatest impact to water quality. Education and outreach to smaller entities and individuals should continue to highlight the importance to chemical-free alternatives to synthetic pesticides, herbicides, and fertilizers.

12.9 Regional Stormwater Management Park

Converting the Weinburg Property at the base of Waiakoa Gulch and the State of Hawaiʻi and Mahi Pono properties at the base of Keahuaiwi Gulch into a stormwater management park has been given a medium priority status. Once engineering, permitting, and environmental assessment requirements are met, project design can be determined. A new regional stormwater management park can be installed every 10 years.

12.10 Unimproved Road Stabilization

Decommissioning, repair, and stabilization of unpaved roads are a medium priority in this Plan. A comprehensive assessment needs to be conducted for work to begin. The Plan proposes completing an inventory of roads every five years to fully understand condition and to prioritize repair needs. Based on this assessment, repairs or decommissioning would occur as needed throughout the timeline of this Plan.

12.11 Wetland and Stream Buffers and Protection

Protection of wetlands and stream riparian buffers have been given high priority status. In October of 2022 the Maui County Council passed a bill to protect and restore wetlands (Ordinance 5421). As a requirement of this law, a wetland overlay map is currently in the works.

12.12 Education and Outreach

Education and outreach events will occur quarterly every year throughout the duration of the Plan. Each event will focus on educating the community and engaging stakeholders on water quality standards and current trends, nonpoint sources of pollution, wetlands and riparian corridors, and the various implementation projects either ongoing or proposed for the watershed.

Table 39. Interim Milestones

Implementation Project	Location (Gulch)	Description	Priority	Twenty Year Timeline			
				Present - 2029	2034	2039	2044
Axis Deer Fencing	At strategic locations throughout Waikapū and Waiakoa Watersheds	Install feral ungulate fencing to manage axis deer populations	High	10 miles of fencing installed	20 miles of fencing installed	30 miles of fencing installed	40 miles of fencing installed
Pūlehu Wildfire Mitigation Strategy	Land in between Waiakoa and Kūlanihākoʻi Gulches	Ungulate fencing and riparian protection	High	Installation and reestablishment of groundcover	Rotational grazing to minimize fuel loads	Continued monitoring and maintenance	Continued monitoring and maintenance
Culvert Protection from Debris	Mauka side of stormwater infrastructure in Waiakoa watershed	Retrofit culverts with protective devices to prevent clogging of drainageways	Medium	Conduct a study to identify inadequate or outdated stormwater infrastructure Retrofit stormwater infrastructure with protective devices	Retrofit stormwater infrastructure with protective devices	Continued monitoring and maintenance	Continued monitoring and maintenance
Detention Basins	Waiakoa Gulches	Install detention basins to capture stormwater and reduce sedimentation	Medium	1st basin completed	2nd basin completed	3rd basin completed	4th basin completed

Implementation Project	Location (Gulch)	Description	Priority	Twenty Year Timeline			
				Present - 2029	2034	2039	2044
		and increase infiltration					
Gabions	Waiakoa Gulch	Install gabions to reduce velocity of flowing stormwater	Medium	Gabions installed in Waiakoa Gulch	Gabions installed in Keahuaiwi Gulch	Gabions installed in Pūlehu Gulch	Gabions installed in Kolaloa Gulch
Golf Course Nutrient Curtain	Kahili and Kamehameha Golf Courses within Waikapū Watershed	Install nutrient curtains to filter excess nutrients and pollutants from groundwater	Medium	Nutrient curtain installed at Kahili Golf Course	Nutrient curtain installed at Kamehameha Golf Course	Nutrient Curtain installed at Kahili Golf Course	Nutrient curtain installed at Kamehameha Golf Course
Land Slide Mitigation	Mauka regions of Waikapū Watershed	Stabilize hillslopes to prevent landslides from occurring	Low	Five hillslopes stabilized	Ten hillslopes stabilized	15 hillslopes stabilized	20 hillslopes stabilized
Reef Friendly Landscaping	Commercial and private properties throughout Waikapū and Waiakoa Watersheds	Utilize organic products to enhance soil health and meet landscaping needs.	High	Obtain RFL Certification for Kahili Golf Course	Obtain RFL Certification for Kamehameha Golf Course	Obtain RFL certification for Keālia Resort and Sugar Beach Resort	Obtain RFL certification for Māʻalaea Surf Resort and Kīhei Beach Condos
Regional Stormwater Management Park	Outfalls of Waiakoa and Keahuaiwi Gulches	Build stormwater management park to be	Medium	Conduct engineering, permitting, environmental	Continued maintenance	Conduct engineering, permitting, environmental	Continued maintenance

Implementation Project	Location (Gulch)	Description	Priority	Twenty Year Timeline			
				Present - 2029	2034	2039	2044
		utilized dually for community park and flood control		assessments, overall project design and construct first stormwater management park		assessments, overall project design and construct 2nd stormwater management park	
Unimproved Road Stabilization	Throughout Watersheds	Decommission, repair, and stabilize roads to prevent erosion	Medium	Conduct assessment and inventory of roads. Begin repair and stabilization of priority roads	Conduct additional assessments every five years and repair roads as necessary	Conduct additional assessments every five years and repair roads as necessary	Conduct additional assessments every five years and repair roads as necessary
Wetland and Stream Buffers and Protection	Throughout Watersheds	Protect and restore buffers along gulches and wetalnds	High	Protect riparian corridor of Waiakoa Gulch	Protect riparian corridor of Keahuaiwi Gulch	Protect riparian corridor of Waikapū Gulch (east)	Rehabilitate riparian corridor of Waikapū Gulch (west)
Education and Outreach	Throughout Watershed	Watershed coordinator to oversee Plan implementation and conduct outreach	Medium	Quarterly events per year = 20 events by 2029	40 events by 2034	60 events by 2039	80 events by 2044

12.13 Existing Management Practices

12.13.1 Water Quality Monitoring

Increased water quality monitoring is recommended as a high priority in the MBWMP. HOKWO currently samples two locations in the nearshore waters associated with Māʻalaea Bay and Keālia Pond. These include one site directly offshore from the pond and a second site in front of Kīhei Canoe Club. A Water Quality Monitoring Plan has since been proposed and is described in Section 14.0. Marine surface waters, stormwater, stream and pond surface waters, and subsurface groundwater should all be monitored to better assess pollutant sources and the success of management measures as they are employed.

12.13.2 Feral Ungulate Control

The infiltration of feral ungulates pose a great threat throughout the MBWMP watersheds. Problems associated with these animals, in particular axis deer, include depletion of native forests, land and habitat degradation, topsoil exposure and loss, and the spread of invasive species. DOFAW has aerially removed several thousand axis deer from upper elevations of the Waikapū watershed. Mahi Pono, Haleakalā Ranch, Kaonoulu Ranch, and other large landowners have axis deer population management programs in place and continue to install feral ungulate fencing. Feral ungulate management remains a priority BMP in protecting native forests and improving water quality within the watershed.

13.0 ELEMENT H - INTERIM NUMERIC CRITERIA

13.1 Interim Numeric Criteria

The lack of surface water within the Māʻalaea Bay Watersheds makes it difficult to measure load reductions. The continued monitoring of coastal waters will be used to show the success of projects following implementation. Interim numeric criteria were developed to assist in quantifying progress made towards attaining water quality standards over the course of time (Table 40. Interim Numeric Criteria for Māʻalaea Bay Watershed). To develop these criteria, Hui O Ka Wai Ola's entire period of record data from two sites within Waikapū and Waiakoa watersheds were analyzed. Keālia Pond sampling occurs within Waikapū Watershed and the Kīhei Canoe Club sample site lies within Waiakoa Watershed. The geometric mean was calculated for measurements of turbidity, total nitrogen, total phosphorus, nitrate + nitrite, and ammonia. Geometric means were compared with the listed open coastal waters criteria for Dry Season water quality standards due to the highly ephemeral nature of the streams in the watershed planning area. Dry season criteria apply when the open coastal waters receive less than three million gallons per day of freshwater discharge per shoreline mile. The difference between the geometric mean and the dry season water quality standard for the period of record for each pollutant listed was calculated.

13.2 Expected Dates of Achievement

To define realistic dates of achievement, this difference between observed values and the Dry Season standard were divided into thirds to create interim numeric criteria to be attained over the next 18 years. The Dry Season standard was used because the majority of these watersheds contain ephemeral streams that only flow in response to a stormwater event. The Dry Season standard should be used when open coastal waters receive less than three million gallons per day of fresh water discharge per shoreline mile. Every six years the Plan aims to decrease pollutants by one-third of the amount that they are currently observed above the water quality standard. This timeline affords for both larger projects like detention basins, that require several years to complete, while also being a small enough timeframe to capture water quality improvements from smaller projects.

As an example, the period of record geometric mean for total nitrogen at Kīhei Canoe Club is 230.01 µg/L. The Dry criteria for total nitrogen in open coastal waters is 110.00 µg/L. This means that currently, Kīhei Canoe Club is 120.01 µg/L above the standard. To generate interim numeric criteria, we divided 120.01 µg/L by three to generate a six-year target reduction value of 40.003 µg/L. Therefore, beginning in 2022 and running through 2028, the geometric mean for this period needs to decrease by 40.003 µg/L to a value of 80.01 µg/L.

13.3 Review Process

Data will be reviewed annually by the acting watershed coordinator and the Hui O Ka Wai Ola staff. In addition, DOH Surface Water Protection Branch (SWPB) staff will review data resulting from implementation projects funded by their 319 Nonpoint Source Program and DOH Clean Water Branch (CWB) staff will review data biennially in preparation of the Integrated Report (IR). While interim numeric criteria were developed along an 18 to 20-year timeline, many sampling locations may attain water quality standards in a much shorter timeframe.

13.4 Criteria for Plan Revision

Whenever data shows that interim numeric criteria will not be met for a given pollutant, an analysis of potential pollutant sources will be conducted. Additional implementation projects will be developed to address pollutant loading not being reduced by current activities. Likewise, any on-going projects will be reviewed to determine their effect on removing pollutants.

13.5 Revisions Strategy

When interim numeric criteria are not being met, the watershed coordinator will work with the SWCD and other stakeholders in the community to change the management practices currently being implemented. This will include updating and or reevaluating critical source areas of pollution. Additional models or sampling will be utilized to better understand the sources of pollution affecting water quality. Timelines will be reassessed based on this information.

13.6 Agency Responsible for Evaluating Progress

As implementation projects are executed on the landscape, their effectiveness at reducing pollutant loads will be analyzed by the watershed coordinator and the SWCD. DOH SWPB will also evaluate the effectiveness of implementation projects funded by their 319 Nonpoint Source Program to reduce pollutant loads. In addition, DOH CWB will play an active role in determining the overall success of the watershed plan through the preparation of the biennial IR using available water quality data from existing monitoring sites. Acceptable data provided to DOH CWB by Hui O Ka Wai Ola and input from the community may also be reviewed for preparation of the IR.

Table 40. Interim Numeric Criteria for Māʻalaea Bay Watershed

Site	Hui O Ka Wai Ola Period of Record	Number of Data Points	Interim Numeric Criteria - Difference between Geometric Mean Value and Dry Water Quality Standard	Pollutant				
				Turbidity (NTU)	Total Nitrogen (µg/L)	Total Phosphorus (µg/L)	Nitrate + Nitrite (µg/L)	Ammonia (µg/L)
				Geometric Mean Not to Exceed:				
				0.20	110.00	16.00	3.50	2.00
Keālia Pond	02/22/2018 to 08/04/2022	75	2022	1.09	Meeting Standard	Meeting Standard	0.34	0.05
			2028 IR Report	0.73	NA	NA	0.23	0.03
			2034 IR Report	0.36	NA	NA	0.11	0.02
			2042 IR Report	0.00	NA	NA	0.00	0.00
Kīhei Canoe Club	02/22/2018 to 08/04/2022	75	2022	3.53	120.01	Meeting Standard	141.74	0.17
			2028 IR Report	2.35	80.01	NA	94.47	0.11
			2034 IR Report	1.18	40.00	NA	47.23	0.06
			2042 IR Report	0.00	0.00	NA	0.00	0.00

14.0 ELEMENT I – MONITORING PROGRAM FOR EVALUATING IMPLEMENTATION PROJECT SUCCESS

The current water quality monitoring program within the MBWMP is limited to the coastal waters just outside Keālia Pond. Currently, the DOH CWB lists three water quality monitoring sites, including Keālia Pond, Mai Poina ʻOe Iʻau Beach Co. Park, and Kīhei Coast-Mokulele. Of these three sites, Keālia Pond is the only site to attain water quality standards for nitrogen and phosphorus. Unfortunately, this site is listed as having insufficient data for each of the water quality parameters tested. Continued monitoring is required to produce a sufficient dataset for this sampling location. The Hui O Ka Wai Ola tests along the beach in front of Keālia Pond and at the beach in front of the Kīhei Canoe Club.

A major flaw in the current sampling methodology is that sampling is only pulled from the surface of coastal waters, meaning that the samples are a diluted representation of pollutants without any indication to the pollutant origin. To better identify and quantify land-based sources of pollution, a more robust and inclusive water sampling methodology should be employed. Identifying pollutant sources and quantifying pollutant loads will provide insight into solutions to improving water quality and will highlight the efficacy of projects implemented within the watershed. Due to the ephemeral nature of streams and wetlands in the MBWMP, water quality sampling must take place during stormwater events when these gulches are actually discharging. In addition, ground water sampling can provide information on sources of pollution. Piezometers placed across a landscape can provide sampling locations for groundwater which has received surface water pollution via permeable soils. A Water Quality Monitoring Plan has been developed and is described below.

14.1 Waikapū Water Quality Monitoring Plan Methodology

To fully capture pollution loads and stormwater runoff within the Waikapū Watershed, surface waters associated with Waikapū Stream, which is perrenial, Keālia Pond, and the coastal waters of Māʻalaea Bay should be monitored at various locations listed in the map below (Figure 80. Waikapū Water Quality Monitoring Map). Several locations within the larger portion of the pond should be sampled as well as a sample from the smaller portion of the pond, makai of North Kīhei Road. In addition to these sites, surface water sampling should be collected from the smaller Waikapū Stream, which only discharges after rain events, using an automatic stormwater sampler.

A total of five groundwater monitoring stations have been proposed within the Waikapū Watershed to collect water quality samples of groundwater immediately mauka of Keālia Pond. Groundwater samples will be collected via installed piezometers. These devices serve two puposes. They allow for water quality sample collection and provide an opportunity for groundwater level monitoring.

A depiction of a typical piezometer installation is included as Figure 81 below. Placement of piezometers was designed to collect representative samples from locations in the Waikapū Watershed potentially affecting nearshore coastal water quality associated with Keālia Pond and Māʻalaea Bay. These include anthropogenic alterations associated with Haycraft Beach, North Kīhei Road, The Maui Electric Company Power Plant, Mahi Pono Agricultural lands, and the central portion of Keālia Pond, which has histroically been used for aquaculture.

Figure 80. Waikapū Water Quality Monitoring Map

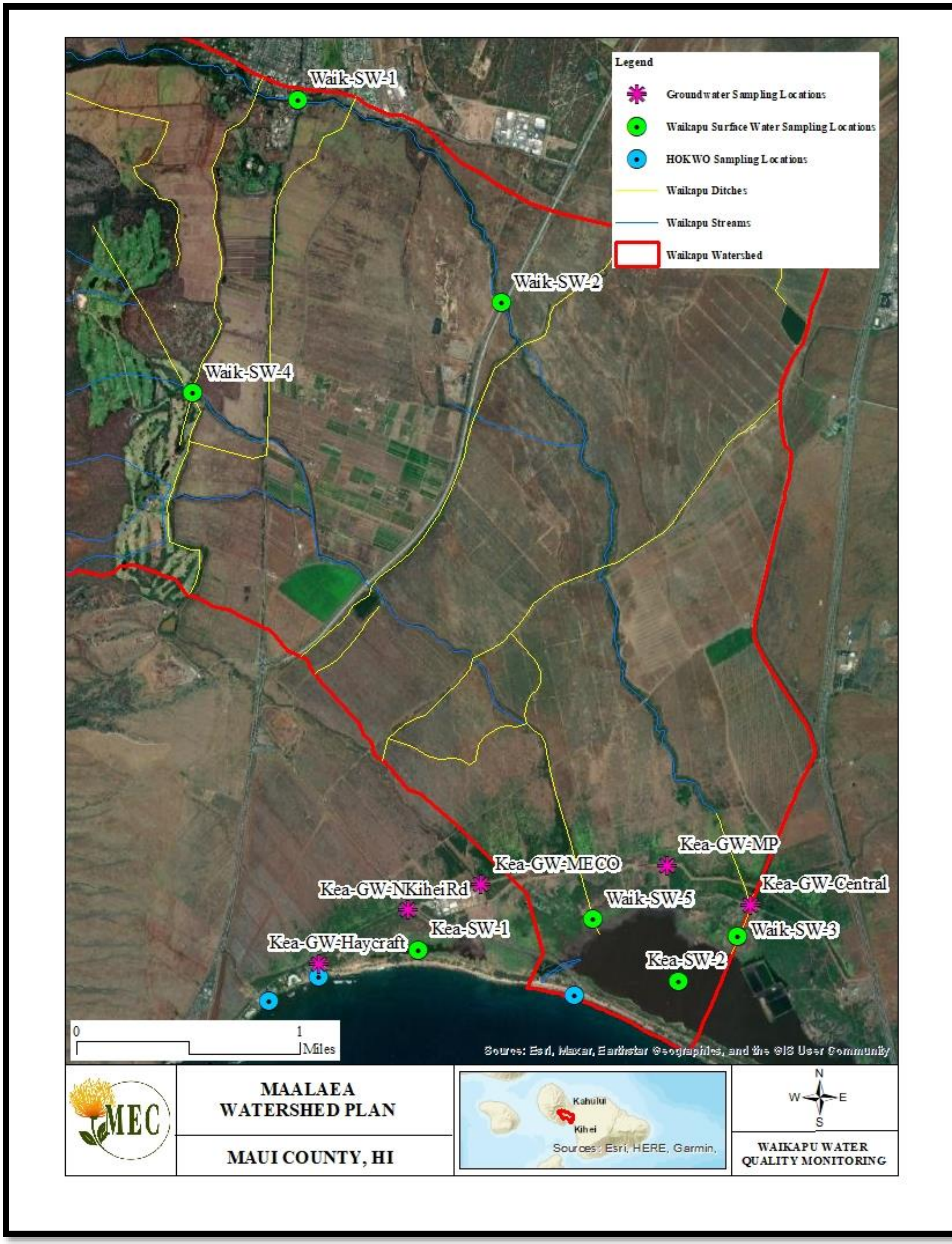
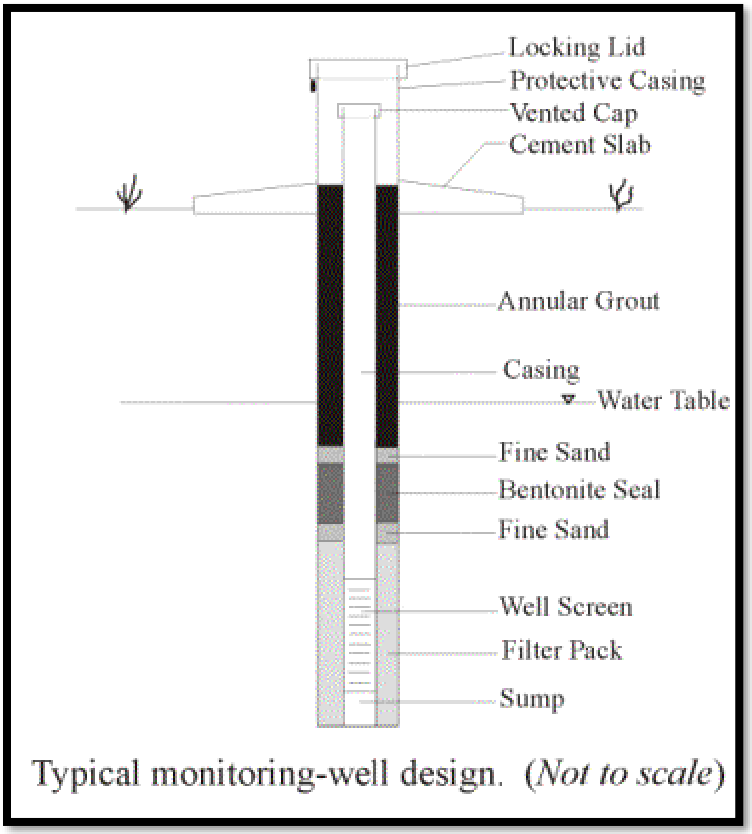


Figure 81. Depiction of a typical Piezometer Installation

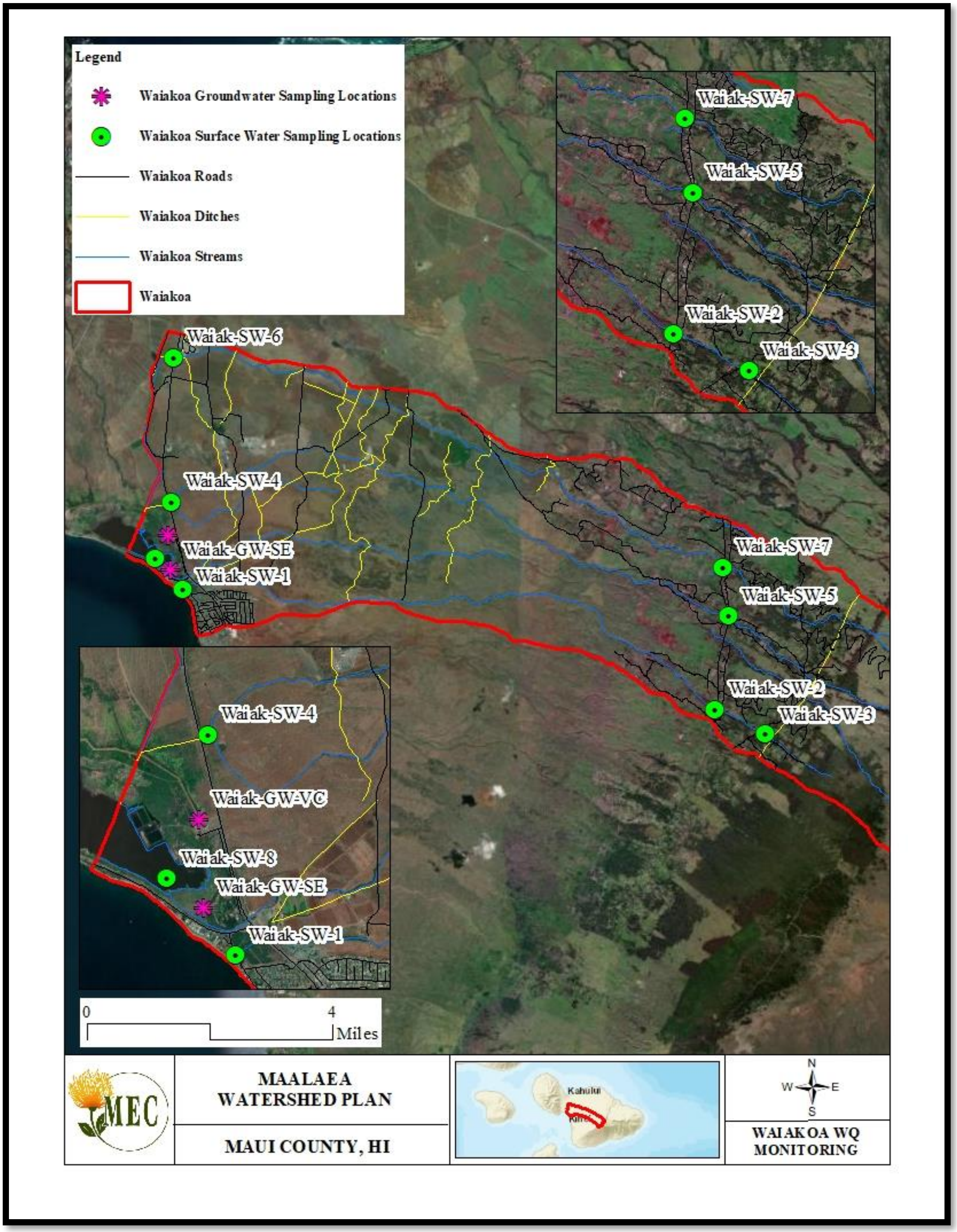


14.2 Waiakoa Water Quality Monitoring Plan Methodology

To better understand the sources of pollution within the Waiakoa Watershed, stormwater sampling should occur at eight locations throughout the watershed (Figure 82. Waiakoa Water Quality Monitoring Map). Because all of the gulches associated with the Waiakoa Watershed are ephemeral, automatic stormwater samplers should be employed. Three sampling locations are proposed for the upcountry portions of the watershed, where Waiakoa, Kolaloa, and Pūlehu Gulches cross under Kula Highway. A forth upcountry surface water sampling location is proposed for Waiakoa Gulch at the intersection of Kekaulike Avenue. Within the makai portions of the watershed, an additional four surface water sampling stations are being proposed. These include the downstream side of the intersection of Pūlehu Gulch with Mokulele Highway, the downstream side of Kolaloa Gulch where it interescts with Mokulele Highway and enters into a ditch system, the downstream side of Waiakoa Gulch where it intersects South Kīhei Road prior to discharging into the Pacific Ocean, and the southeastern portion of Keālia Pond where Keahuaiwi Gulch is believed to discharge during large storm events.

In addition to these surface water sampling locations, additional ground water sampling via piezometers is proposed for the vistor center and southeast corner of Keālia Pond.

Figure 82. Waiakoa Water Quality Monitoring Map



14.3 Water Quality Monitoring Parameters

Each site was selected specifically to represent samples from locations within the watershed that are likely to influence nearshore coastal water quality. Surface samples and groundwater samples should be collected from perrenial locations monthly, and again from both perennial and ephemeral streams and gulches when stormwater flow is occurring. Local rain gauges should be referenced after storm events to categorize each storm event and to correlate rainfall amounts to observed flows and groundwater levels in the watershed.

In Situ Sampling Parameters:

Temperature
Salinity / Conductivity
Dissolved Oxygen
pH
Turbidity

Laboratory Sampling Parameters:

Total Nitrogen
Total Phosphorus
Orthophosphates
Nitrate+Nitrite
Ammonia nitrogen
Total Suspended Solids

Table 41. Proposed Water Quality Monitoring Sites and Sampling Frequency

Waikapū Watershed			
Station	Description	Sampling Type	Frequency
Waik-SW-1	Waikapū at Honoapiilani Highway	Surface Water	Monthly
Waik-SW-2	Waikapū at Kuihelani Highway	Surface Water	Monthly
Waik-SW-3	Waikapū at Keālia Pond Outfall	Surface Water	Monthly
Waik-SW-4	Ditch System Makai of Gold Courses	Surface Water	Storm
Waik-SW-5	Second Outfall into Keālia Pond	Surface Water	Storm
Kea-SW-1	Secondary Pond at Keālia	Surface Water	Monthly
Kea-SW-2	Center of Keālia Pond	Surface Water	Monthly
Kea-GW-Central	Central Pond	Groundwater	Monthly
Kea-GW-MP	Mahi Pono at Keālia Pond	Groundwater	Monthly
Kea-GW-MECO	MECO Powerplant at Keālia Pond	Groundwater	Monthly
Kea-GW-NKīheiRd	North Kīhei Road at Keālia Pond	Groundwater	Monthly
Kea-GW-Haycraft	Haycraft Park at Keālia Pond	Groundwater	Monthly
Waiakoa Watershed			
Station	Description	Sampling Type	Frequency
Waiak-GW-SE	Southeast Corner of Keālia Pond	Groundwater	Monthly
Waiak-GW-VC	Keālia Pond Visitor Center	Groundwater	Monthly
Waiak-SW-1	Waiakoa Outfall to Pacific Ocean	Surface Water	Storm
Waiak-SW-2	Waiakoa Gulch and Kula Highway	Surface Water	Storm
Waiak-SW-3	Waiakoa Gulch and Kekaulike Highway	Surface Water	Storm
Waiak-SW-4	Kolaloa Gulch and Mokulele Highway	Surface Water	Storm
Waiak-SW-5	Kolaloa Gulch and Kula Highway	Surface Water	Storm
Waiak-SW-6	Pūlehu Gulch and Mokulele Highway	Surface Water	Storm
Waiak-SW-7	Pūlehu Gulch and Kula Highway	Surface Water	Storm
Waiak-SW-8	Southeast Corner of Keālia Pond	Surface Water	Monthly

In an effort to generate quality-assured coastal water-quality data to be used by the DOH CWB and other interested entities, a Quality Assurance Project Plan (QAPP) will be prepared for this water quality monitoring methodology. This will ensure that information used to address water quality issues within the watershed is accurate. Fortunately, a QAPP already exist for the Hui O Ka Wai Ola monitoring program to ensure Standard Operating Procedures (SOPs) such as sample depths, proper equipment usage, labeling, sample chain of custody etc., are being met and data is being collected, compiled, and reported accurately. As an active member of the Hui O Ka Wai Ola, the Maui Nui Marine Resource Council understands the importance of SOPs when sampling water and should continue to implement water sample collection procedures as spelled out in the existing QAPP.

14.4 Consistency in Monitoring

Discrepancies currently exist regarding site names and locations sampled by the Hawaiʻi Department of Health and the Hui O Ka Wai Ola. Site locations and names should match across the board to avoid confusion when interpreting data. A strict sampling schedule should also be adhered to, and stormwater sampling events should not be skipped. Consistent naming, mapping, and sampling throughout the watershed is needed to ensure accuracy in identifying and addressing sources of pollution and monitoring project effectiveness.

15.0 REFERENCES

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APPENDIX A.

NONPOINT SOURCE POLLUTION IMPLEMENTATION PROJECTS

Axis Deer Fencing

	High	Med.	Low
Priority	X		

	High	Med.	Low
Feasibility		X	

Sediment Trapping	
Nutrient Reduction	X
Flood Mitigation	
Stormwater Infrastructure	
Erosion Prevention	X
Feral Ungulate Control	X

Description: Fencing is needed to manage the increasing population of axis deer. Creating management areas allows the community to control the migration of axis deer throughout the watershed. While it is believed that axis deer do not typically roam very far, during drought, wildfire, or other pressures such as removal, fencing enables proper management of this invasive species.

Cost For Waikapū: At a minimum, axis deer fencing should be placed along the conservation land boundary to protect native forests from this invasive species. Working with the Hawaiʻi Department of Land and Natural Resources, Division of Forestry and Wildlife and the Mauna Kahālāwai Watershed Partnership, this project would require a minimum of 15,832 linear feet of fencing. At approximately $26 a linear foot, fencing off this portion of the Waikapū Watershed would cost roughly $411,632.00.

Fencing Description	Length in feet	Cost at $26 a linear foot
Fence along conservation boundary	15,832	$411,632.00
Fence between Honoapiʻilani Hwy and Kuihelani Hwy	30,573	$794,898.00
Fence between Kuihelani Highway and Mokulele Hwy	49,867	$1,296,542.00
Total Fencing Costs		$2,503,072.00

Cost For Waiakoa: Deer fencing should be placed at strategic locations throughout the watershed and connect to existing fencing in order to establish management areas. It is recommended for fencing along Mokulele Highway, in Midlevel Ag lands, makai of the Kula Community, and mauka of the Kula Community. In total, this equals approximately 23 miles of fencing and would cost roughly $3,126,838.00.

Fence Description	Fence Length in Feet	Fencing Cost at $26 a Foot
Fencing Along Mokulele Highway	24,358	$633,306
Fencing in Midlevel Ag Lands	32,690	$849,934
Fencing Makai of Kula Community	19,975	$519,344
Fencing Mauka of Kula Community	43,240	$1,124,233
Total Fencing Costs		$3,126,838.00

Estimated Load Reductions: The table below depicts the pollutant load reductions for Waiakoa and Waikapu Watersheds per 100-acre Heavy Use Protection BMP. These exclusion management units should be placed in high priority areas where groundcover vegetation has been nearly or completely denuded.

Watershed	N Reduction	P Reduction	BOD Reduction	Sediment Reduction
	pounds/year	pounds/year	pounds/year	tons/year
Waiakoa	198.97	37.52	142.43	22.25
Waikapu	137.05	40.76	195.64	30.57

Timeline and Milestones:

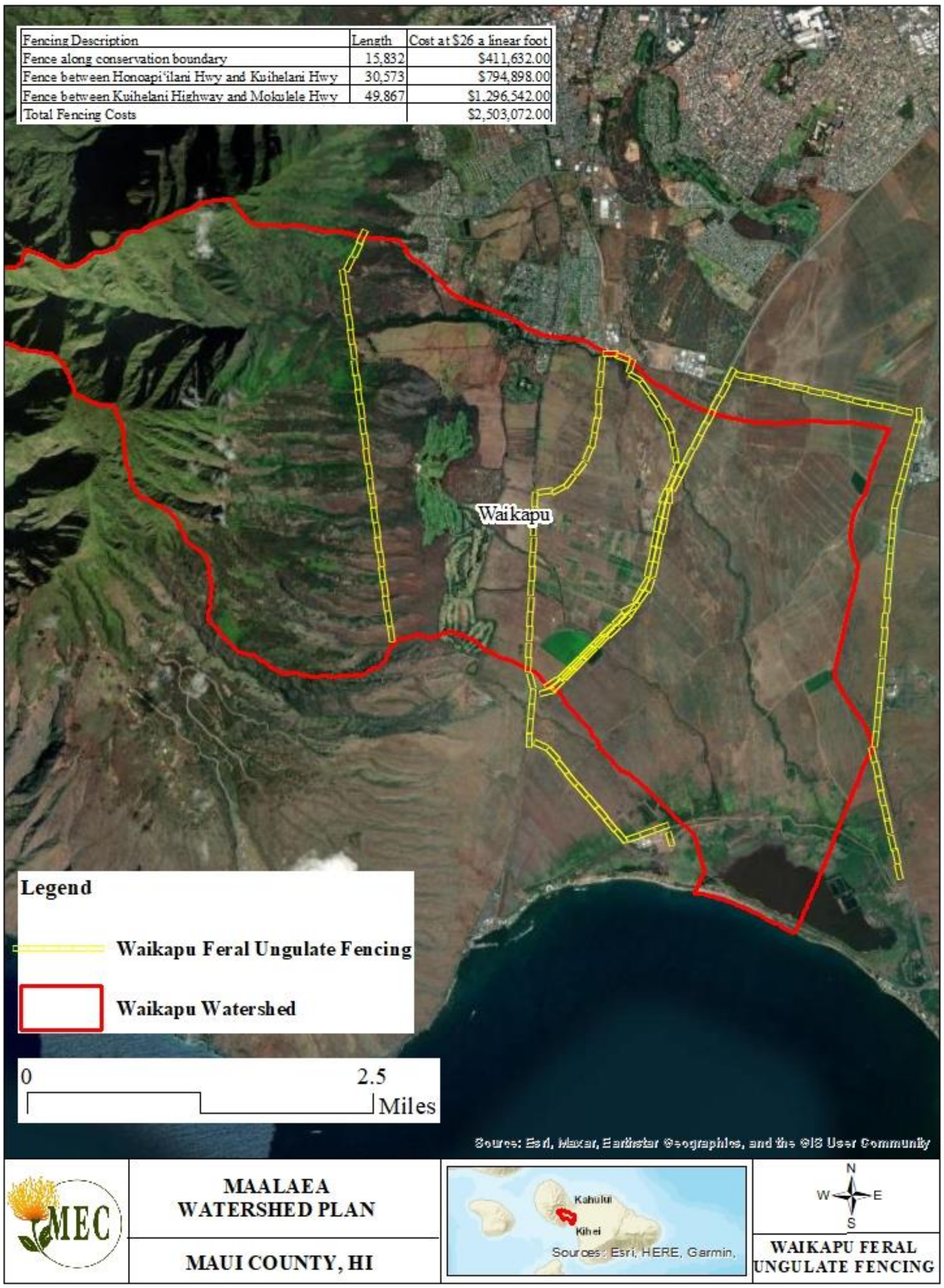
Location (Gulch)	Description	Priority	Twenty Year Timeline			
			Present - 2029	2034	2039	2044
At strategic locations throughout Waikapū and Waiakoa Watersheds	Install feral ungulate fencing to manage axis deer populations	High	10 miles of fencing installed	20 miles of fencing installed	30 miles of fencing installed	40 miles of fencing installed

Based on length of fencing recommended in this plan for both Waikapū and Waiakoa Watersheds, approximately 40 miles of feral ungulate fencing is needed.

Potential Permitting Requirements:

If placed on private land, axis deer fencing should not require permitting.

Regional Axis Deer Fencing Proposed for Waikapū Watershed



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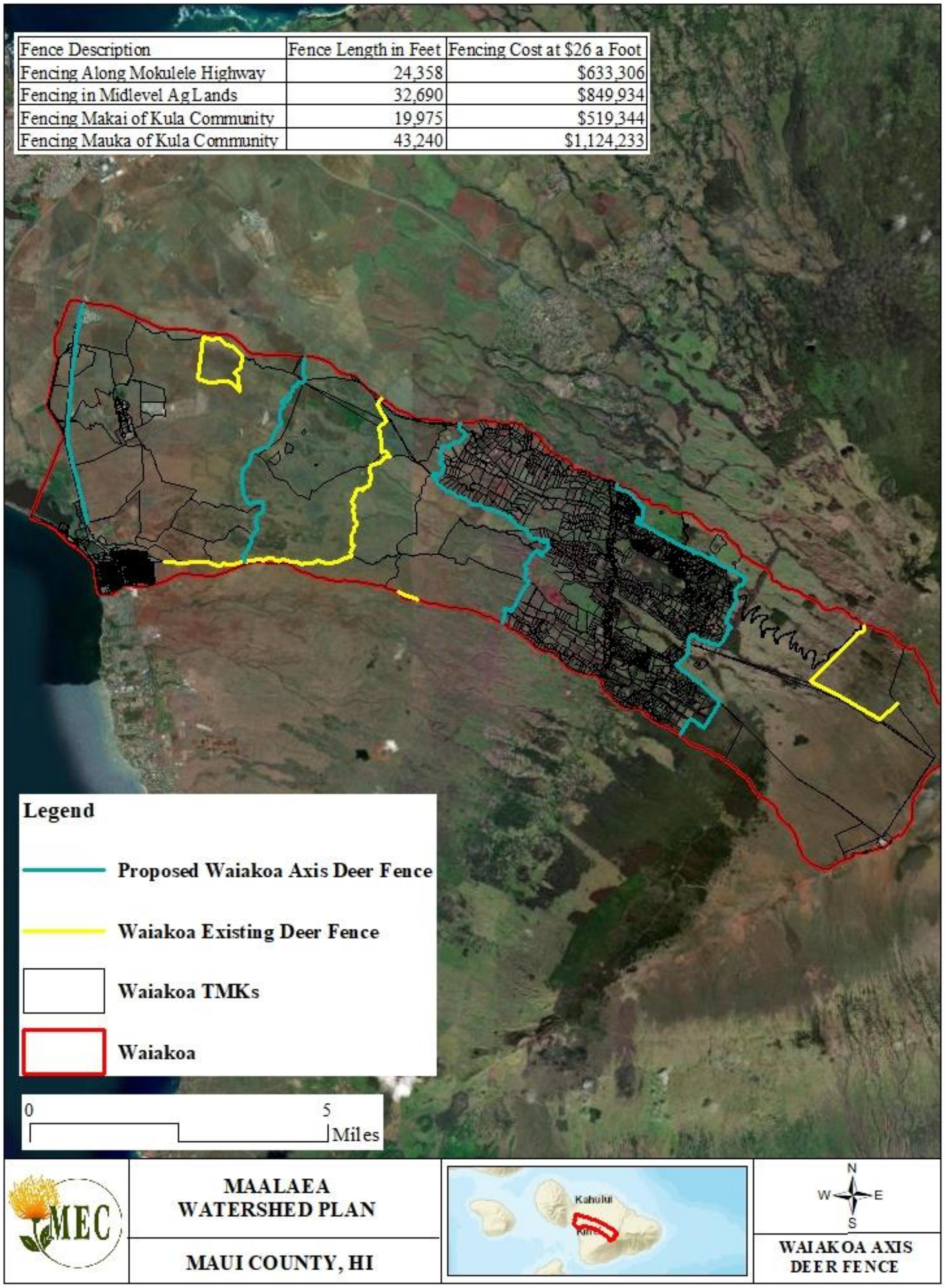

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Pūlehu Wildfire Mitigation Strategy

	High	Med.	Low
Priority	X		

	High	Med.	Low
Feasibility	X		

Sediment Trapping	X
Nutrient Reduction	X
Flood Mitigation	X
Stormwater Infrastructure	
Erosion Prevention	X
Feral Ungulate Control	X

Description: In August 2023, wildfires burned over 6,000-acres in Pūlehu associated with the Waiakoa Watershed. Waiakoa and Kūlanihākoʻi Gulches flow through the 6,000-acre burn area. These two gulches are both known to flow after Kona storm events, discharging sediment onto infrastructure associated with North Kīhei and into nearshore coastal waters and their associated coral reefs. To mitigate this fire and restore these slopes, Mahi Pono, Haleakalā Ranch, and Kaonoulu Ranch have proposed the following tasks to reestablish vegetation and prevent soil loss.

- Installation of 10,000 feet of game fence across Haleakalā Ranch and Kaonoulu Ranch to tie into existing game fences installed by the ranches to create a 2,800-acre Axis Deer Exclusion Zone that includes the Waiakoa Stream and lower Kūlanihākoʻi Gulch systems
- Installation of a water system originating from the Kula Agricultural Park system meters to establish and maintain revegetated corridors of Waiakoa and Kūlanihākoʻi within the exclusion zone
- Installation of open water tanks necessary to support irrigation, helicopters requiring water collection locations, and other regional wildfire suppression needs
- Installation of livestock fence to complement existing game fencing and to manage livestock access to the revegetated corridors for hazard fuel load control
- Installation of drip irrigation and associated practices of establishing appropriate vegetation
- Ongoing management of the area via aggressive deer control and rotational grazing

Cost: Costs associated with Pūlehu Wildfire Recovery effort in Waiakoa Watershed include both feral ungulate and livestock fencing to protect riparian corridors, irrigation infrastructure, and the installation of cisterns/water tanks to provide dip tank access by aerial firefighters and a cache of emergency water for first responders and fire fighters. Other costs associated with the project are still being compiled.

Pūlehu Wildfire Mitigation Estimated Costs

Item	Units	Unit Cost	Total Cost
Game Fencing (6ft)	9661	$25	$241,525
Cattle Fencing (4ft)	23300	$10	$233,000
Waterline (HDPE)	41131	$3	$123,393
Water Tanks (100,000 gal)	2	$125,000	$250,000
Drip Lines	TBD		
Seed	TBD		
Misc	TBD		
Total			$847,918

Estimated Load Reductions: The table below depicts STEPL pollutant load reduction estimates for the Pūlehu Wildfire Mitigation Project. It should be noted that STEPL estimates are based on the Pastureland land use classification and the software does not take into account for complete loss of vegetative cover within this land use associated with the August 2023 fires.

Pūlehu Wildfire Mitigation Strategy

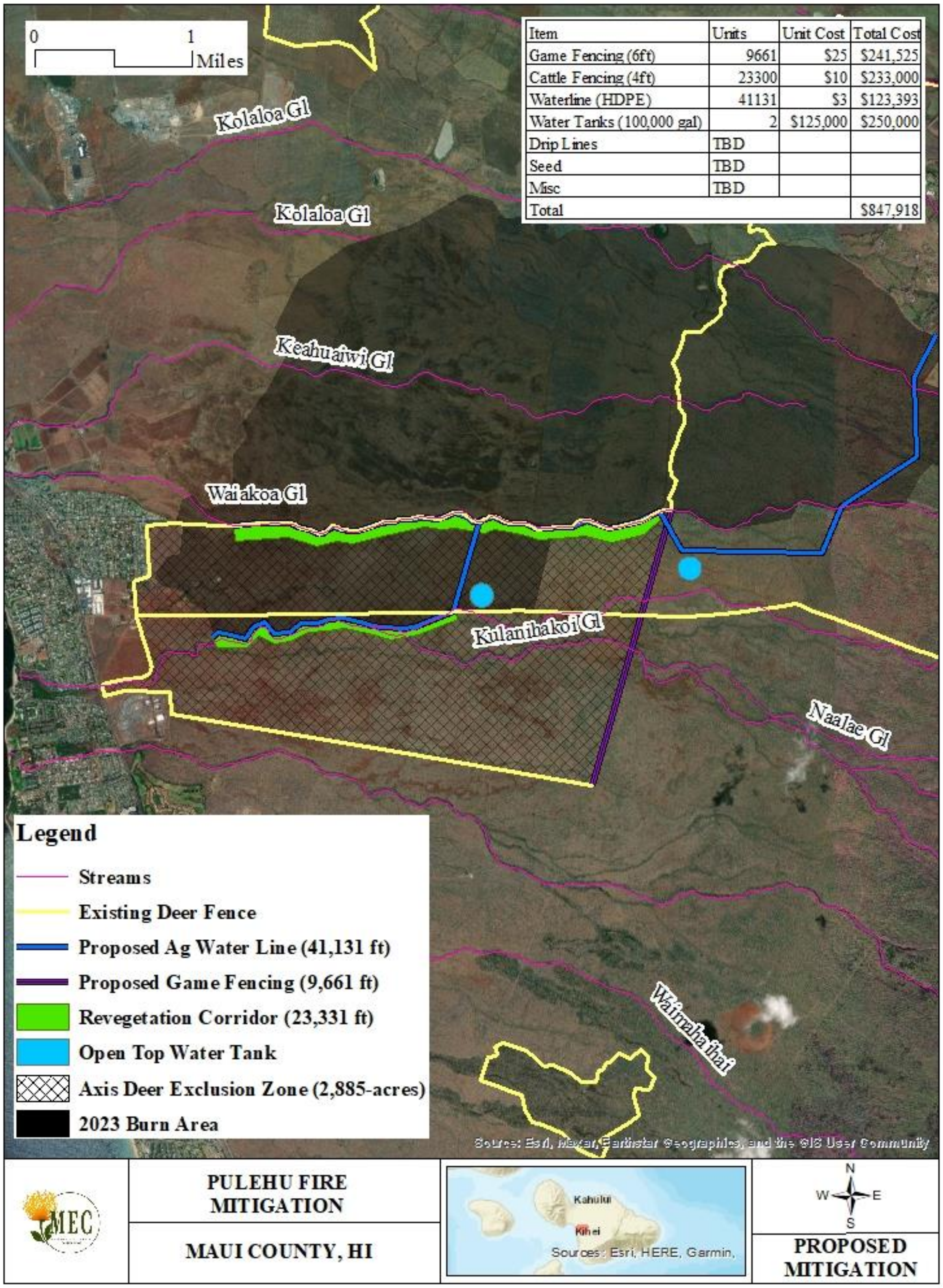
Best Management Practice	Nitrogen Reduction in Pounds per Year	Phosphorus Reduction in Pounds per Year	Sediment Reduction in Tons per Year
Axis Deer Exclusion Zone	10,440.72	1,152.52	652.59
Waiakoa Riparian Protection	487.05	53.76	30.44
Waiakoa Cattle Exclusion	27.6	6.74	4.17
Kūlanihākoʻi Cattle Exclusion	17.25	4.21	2.61
Kūlanihākoʻi Riparian Protection	464.59	68.62	34.05
Totals	11,437.21	1,285.85	723.85

Timeline and Milestones:

Location (Gulch)	Description	Priority	Twenty Year Timeline			
			Present - 2029	2034	2039	2044
Land in between Waiakoa and Kūlanihākoʻi Gulches	Ungulate fencing and riparian protection	High	Installation and reestablishment of groundcover	Rotational grazing to minimize fuel loads	Continued monitoring and maintenance	Continued monitoring and maintenance

Potential Permitting Requirements:
No permits should be needed for fencing and irrigation installation and restoring vegetative cover.

Proposed Pūlehu Wildfire Mitigation Strategy



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Game Fencing (6ft)	9661	$25	$241,525
Cattle Fencing (4ft)	23300	$10	$233,000
Waterline (HDPE)	41131	$3	$123,393
Water Tanks (100,000 gal)	2	$125,000	$250,000
Drip Lines	TBD		
Seed	TBD		
Misc	TBD		
Total			$847,918

Culvert Protection from Debris

	High	Med.	Low
Priority		X	

	High	Med.	Low
Feasibility	X		

Sediment Trapping	
Nutrient Reduction	
Flood Mitigation	X
Stormwater Infrastructure	X
Erosion Prevention	
Feral Ungulate Control	

Description: Much of the flooding that occurs in the Waiakoa Watershed is due to debris piling up on the mauka side of stormwater infrastructure such as culverts and bridges. The debris clogs drainageways, which then causes stormwater to flood surrounding upland areas as it finds alternative routes downstream within the watershed. A study should be conducted to identify those portions of the watershed that have inadequate or outdated stormwater infrastructure. Engineers working with the Department of Public Works and affected stakeholders from the community should come together to retrofit this infrastructure with protective devices that allow for stormwater flow to continue even when debris has stacked up in a stream.

Cost: Culvert grates range in price from $150.00 to $350.00, and can vary depending on size, materials, and structure. Other costs include an environmental assessment, engineering, and installation.

Estimated Load Reductions: Load reductions are highly variable depending on rainfall, land uses, and location.

Timeline and Milestones:

Location (Gulch)	Description	Priority	Twenty Year Timeline			
			Present - 2029	2034	2039	2044
Mauka side of stormwater infrastructure in Waiakoa watershed	Retrofit culverts with protective devices to prevent clogging of drainageways	High	Conduct a study to identify inadequate or outdated stormwater infrastructure, Retrofit stormwater infrastructure with protective devices	Retrofit stormwater infrastructure with protective devices	Continued monitoring and maintenance	Continued monitoring and maintenance

Potential Permitting Requirements:

Permit Name	Issuer	Trigger	Application Requirements	Project Improvements
Clean Water Act Section 401 Water Quality Certification	Clean Water Branch, Hawaiʻi Department of Health	Required for any Federal permit that will involve discharge into bodies of water including streams and wetlands	Application will require items submitted for Department of Army Permit, environmental and chemical evaluation of receiving water, and Hawaiʻi Water Quality Standards compliance plan	Applies to locations requiring Department of Army Permit
Department of Army Permit	U.S. Army Corps of Engineers	Any activity resulting in filling of water bodies in the U.S., including flowing streams and wetlands. Fill includes sediment and structures.	Application will require site plan, design, construction methodology, CWA Section 401 Water Quality Certification by Hawaiʻi Department of Health, as well as compliance with environmental Federal cross-cutting authorities (e.g., Section 7 of the Endangered Species Act and Section 106 of the National Historic Preservation Act)	New stream intakes, road and pipeline crossings of streams and wetlands
Perform Work on County Highway Permit	Maui County Department of Public Works	Required when a County roadway is disturbed by installation of pipelines	Application will require construction plans for the affected area	Any activities affecting County-owned roadways or structures, such as pipeline installation, use of bridges, and traffic control

Detention Basins

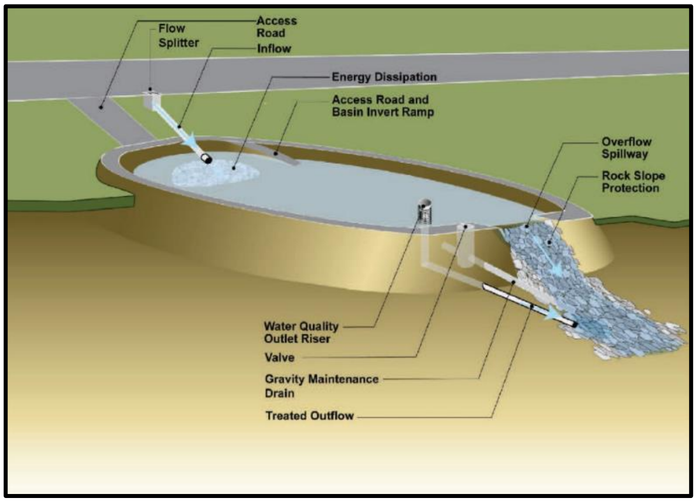


Photo courtesy of Caltrans.gov

	High	Med.	Low
Priority		X	

	High	Med.	Low
Feasibility		X	

Sediment Trapping	X
Nutrient Reduction	X
Flood Mitigation	X
Stormwater Infrastructure	X
Erosion Prevention	
Feral Ungulate Control	

Description: Excavated basins in series, connected by berms or channels for sedimentation and infiltration purposes, have been identified as having a high priority as a management measure to improve water quality in the watersheds. "Excavated basins are often constructed in sequences adjacent to streams, so that excess stormwater flows, from the stream or stormwater channel, can be diverted under gravity to the first basin, then overflows from each basin to the next under gravity, and back to the stream or stormwater channel at the end" (A Handbook for Stormwater Reclamation and Reuse Best Management Practices in Hawaii, December 2008, Commission on Water Reclamation Management).

The Final Report for the Kīhei Drainage Master Plan (KDMP) was released in November of 2016. While several detention basins are proposed in the County plan associated with the Waiakoa drainage area, none are proposed to occur in immediate proximity to Waiakoa Gulch. While the locations of the basins proposed in the KDMP are subject to change, and the depiction of the basins are meant as an example, appropriate sites can be found in the watershed gulch systems, in locations based on the following:

- Where sufficient undeveloped land exists on the sides of the gulches for the infiltration drain field
- After the convergence of tributaries to maximize efficiency
- Preferably in shallow segments where earth-moving to extract the water can be minimized
- In locations where stormwater intakes can be feasibly installed
- On soils which have adequate permeability

Cost: According to the 2016 Kihei Drainage Master Plan, detentions basins proposed for Kihei range in cost from approximately $700,000 to $3,500,000. The difference in price is largely based on the size of the basin, its location, and the permitting constrains associated with construction. See the table below for cost estimates for a single detention basin.

Approximate Costs for a Large Detention Basin (Kihei Drainage Master Plan, 2016)

Task	Quantity	Unit	Unit Price	Total
Environmental Assessment	1	1	$350,000	$350,000
Excavation of Detention Basin	25820	CY	$30	$774,600
Hydromulch for Detention Basin	95800	SF	$2	$191,600
GRP Slope Protection at Spillway	60	CY	$540	$32,400
Inlet/Outlet Concrete Headwall	2	EACH	$16,050	$32,100
Perimeter Chain Link Fence (6ft)	1240	LF	$60	$74,400
1-18' RCP	50	LF	$260	$13,000
Subtotal				$1,468,100
Contingency (20%)				$293,620.0
Total				$1,761,720

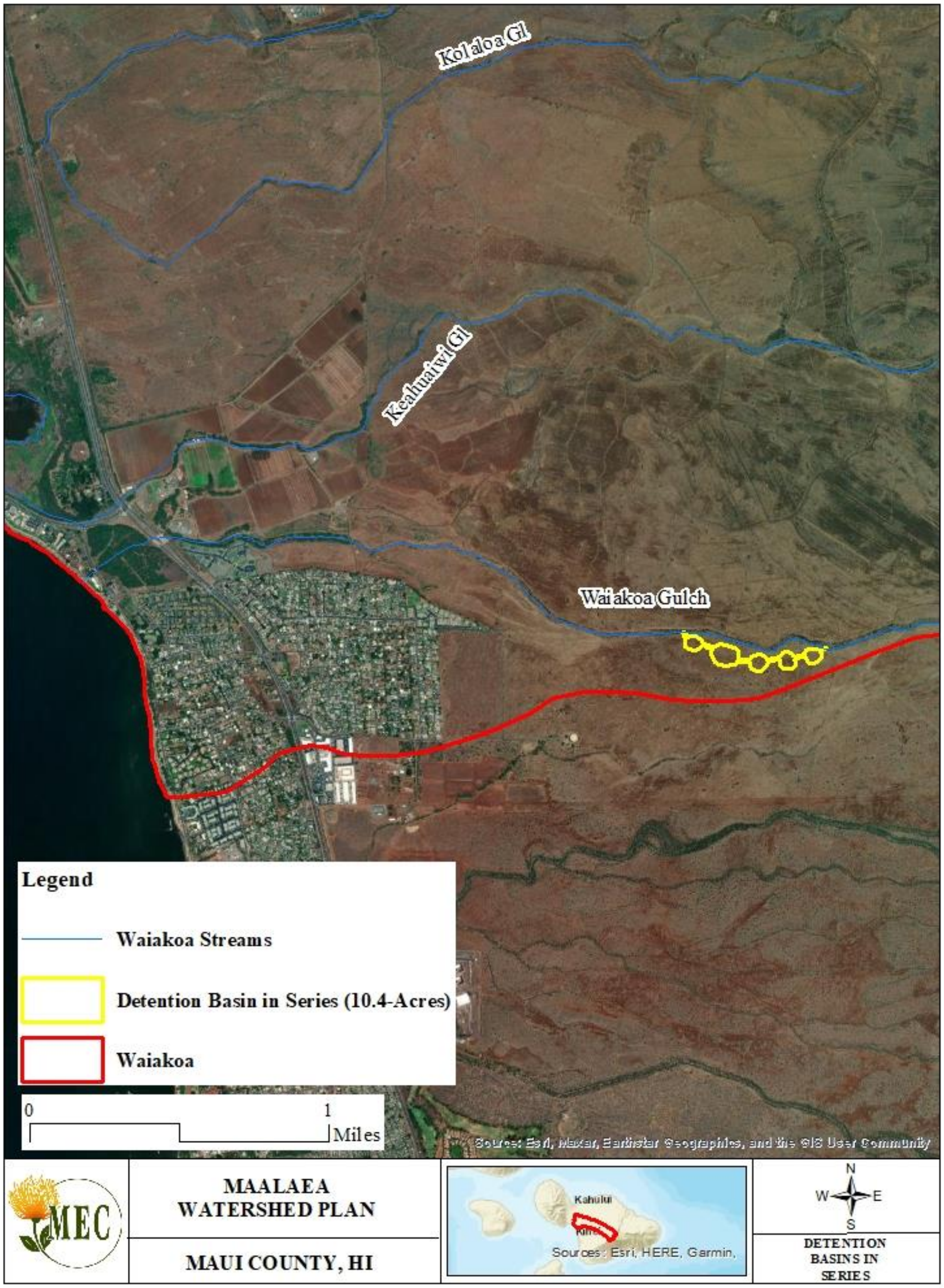
Estimated Load Reductions:

Basin	Acreage Based on Map Renderings	Pollutant Load Reduction		
		N Reduction	P Reduction	Sediment Reduction
		lb/year	lb/year	t/year
Waiakoa Basins in Series	10.42	13.54	2.13	0.59
Large Waiakoa Basin	56.40	73.27	11.55	3.19

Timeline and Milestones:

Location (Gulch)	Description	Priority	Twenty Year Timeline			
			Present - 2029	2034	2039	2044
Waiakoa Gulches	Install detention basins to capture stormwater and reduce sedimentation and increase infiltration	High	1st basin completed	2nd basin completed	3rd basin completed	4th basin completed

Example of Waiakoa Gulch Basins in Series



Potential Permitting Requirements:

Permit Name	Issuer	Trigger	Application Requirements	Project Improvements
Grading and Grubbing Permit	Maui County Department of Public Works	Required for removal of vegetation and earthmoving activities associated with construction	Application will require construction plans to be submitted	Any activity that bares or grades the ground surface, such as structural installation, access roads, and equipment and material staging areas
Special Management Area (SMA) Permit	Maui County Planning Department	Required for any work being conducted in the Special Management Area	Application will require plots/drawings of work being conducted	All "development" projects require a permit. Applications for a major permit (over $500k or significant adverse environmental or ecological effect) require environmental review and more stringent review.
Stream Channel Alteration Permit	State of Hawaiʻi Commission on Water Resources Management	Any activity which will affect the stream course within the channel of a perennial or intermittent stream. The regulated channel extends to the top of the streambank.	Application will include design drawings, effects on and mitigation for aquatic organisms and communities, water pollution prevention plan	Intakes, stream crossings of pipelines, construction and maintenance roads
Stream Water Diversion Permit	Commission on Water Resources Management	Any new or modified diversion of water from streams for beneficial use	Application will include amount of water to be taken, assessment of other instream and non-instream water uses, design of intake	New stream intakes and change in diversion amount at existing intakes
Department of Army Permit	U.S. Army Corps of Engineers	Any activity resulting in filling of water bodies in the U.S., including flowing streams and wetlands. Fill includes sediment and structures.	Application will require site plan, design, construction methodology, CWA Section 401 Water Quality Certification by Hawaiʻi Department of Health, as well as compliance with environmental Federal cross-cutting authorities	New stream intakes, road and pipeline crossings of streams and wetlands

Permit Name	Issuer	Trigger	Application Requirements	Project Improvements
			(e.g., Section 7 of the Endangered Species Act and Section 106 of the National Historic Preservation Act)	
Clean Water Act Section 401 Water Quality Certification	Clean Water Branch, Hawaiʻi Department of Health	Required for any Federal permit that will involve discharge into bodies of water including streams and wetlands	Application will require items submitted for Department of Army Permit, environmental and chemical evaluation of receiving water, and Hawaiʻi Water Quality Standards compliance plan	Applies to locations requiring Department of Army Permit

Gabions

	High	Med.	Low
Priority		X	

	High	Med.	Low
Feasibility	X		

Sediment Trapping	X
Nutrient Reduction	X
Flood Mitigation	X
Stormwater Infrastructure	X
Erosion Prevention	
Feral Ungulate Control	

Description: Gabions are wire containers filled with rock, gravel, broken concrete, riprap, or other material to create large blocks. These blocks can be placed within stream beds to create small weirs or dams. As stormwater flows down a gulch, it pools behind the gabions, slowing in velocity and losing erosional force. Pools created by these gabions allow sediment in the water to fall out of suspension. When placed in stepped series, these structures can provide flood protection by dissipating energy in flowing systems. Over time the voids fill with sediment and promote vegetative growth, which will further enhance stormwater slowing and sediment trapping capabilities.

Cost: Gabion wire mesh walls are fairly inexpensive at $60-$100 a cubic yard. Other costs include an environmental assessment, rock fill, engineering, and placement.

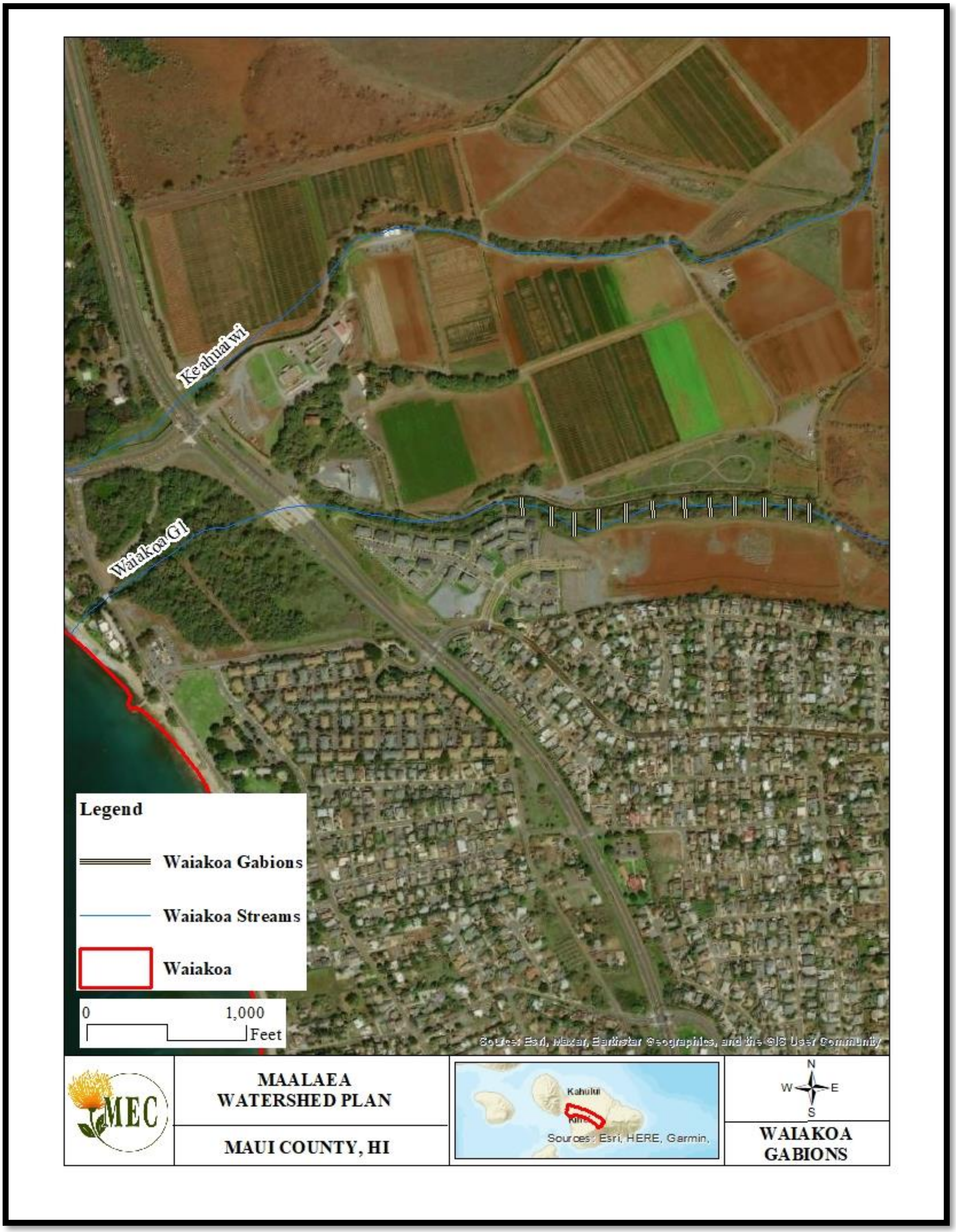
Estimated Load Reductions: Load reductions are highly variable depending on rainfall, land uses, and location, fill materials, and scale of project.

Timeline and Milestones:

Location (Gulch)	Description	Priority	Twenty Year Timeline			
			Present - 2029	2034	2039	2044
Waiakoa Gulches	Install gabions to reduce velocity of flowing stormwater	High	Gabions installed in Waiakoa Gulch	Gabions installed in Keahuaiwi Gulch	Gabions installed in Pūlehu Gulch	Gabions installed in Kolaloa Gulch

The following map provides potential locations for gabion placement in Waiakoa Gulch. Actual placement should be determined by topography, access for installation and maintenance, land ownership, and other factors. The life expectancy of gabion is based on the type of wire used to create the cage and not on the material used as filling. Typically, these cages are constructed of galvanized steel wire with a life expectancy of 50 years.

Proposed Waiakoa Gabions



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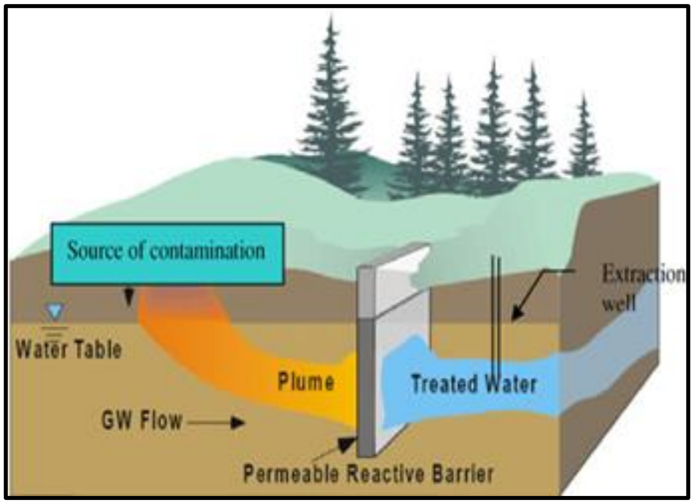
Stream Channel Alteration Permit	State of Hawaiʻi Commission on Water Resources Management	Any activity which will affect the stream course within the channel of a perennial or intermittent stream. The regulated channel extends to the top of the streambank.	Application will include design drawings, effects on and mitigation for aquatic organisms and communities, water pollution prevention plan	Intakes, stream crossings of pipelines, construction and maintenance roads
Stream Water Diversion Permit	Commission on Water Resources Management	Any new or modified diversion of water from streams for beneficial use	Application will include amount of water to be taken, assessment of other instream and non-instream water uses, design of intake	New stream intakes and change in diversion amount at existing intakes
Department of Army Permit	U.S. Army Corps of Engineers	Any activity resulting in filling of water bodies in the U.S., including flowing streams and wetlands. Fill includes sediment and structures.	Application will require site plan, design, construction methodology, CWA Section 401 Water Quality Certification by Hawaiʻi Department of Health, as well as compliance with environmental Federal cross-cutting authorities (e.g., Section 7 of the Endangered Species Act and Section 106 of the National Historic Preservation Act)	New stream intakes, road and pipeline crossings of streams and wetlands

Permit Name	Issuer	Trigger	Application Requirements	Project Improvements
Clean Water Act Section 401 Water Quality Certification	Clean Water Branch, Hawaiʻi Department of Health	Required for any Federal permit that will involve discharge into bodies of water including streams and wetlands	Application will require items submitted for Department of Army Permit, environmental and chemical evaluation of receiving water, and Hawaiʻi Water Quality Standards compliance plan	Applies to locations requiring Department of Army Permit

Golf Course Nutrient Curtain



	High	Med.	Low
Priority		X	

	High	Med.	Low
Feasibility		X	

Sediment Trapping	
Nutrient Reduction	X
Flood Mitigation	
Stormwater Infrastructure	
Erosion Prevention	
Feral Ungulate Control	

Description: A Permeable Reactive Barrier (a.k.a. 'nutrient curtain') is constructed by excavating a trench approximately three feet wide, and four feet deep and long enough to bisect the groundwater moving through the area. It consists of a mix of hardwood chips, sand, sawdust, and activated charcoal (a.k.a. 'biochar'). This precise mixture converts nitrogen pollution contained in the groundwater into atmospheric nitrogen effectively filtering pollutants from groundwater passing through. This process requires no maintenance once installed and has a long effective lifespan because charcoal lasts for hundreds of years when buried in the soil (charcoal makes up a substantial portion of ancient archaeological sites in the Amazon Basin as well as Pacific Islands). There may be a slight loss in nutrient removal efficiency when the woodchips eventually break down (10-15 years), but the system will still function well beyond this time horizon.

Cost: Costs are highly variable nutrient curtain installation. An estimated cost is $15,000. A sample budget for a nutrient curtain 40' long x 4' wide x 4' deep is included for illustrative purposes (depth is dependent upon depth to groundwater and may be more or less).

Sample Budget for Nutrient Curtain Installation

Item	**Cost**
Site planning and design	$4,000
Excavation	$3,000
Materials (biochar, woodchips, sand, and sawdust)	$5,000
Construction management and oversight	$3,000
TOTAL	**$15,000**

Estimated Load Reductions: Load reductions would be determined based on current landscaping practices and overall project design.

Timeline and Milestones:

Location (Gulch)	Description	Priority	Twenty Year Timeline			
			Present - 2029	2034	2039	2044
Kahili and Kamehameha Golf Courses within Waikapū Watershed	Install nutrient curtains to filter excess nutrients and pollutants from groundwater	Medium	Nutrient curtain installed at Kahili Golf Course	Nutrient curtain installed at Kamehameha Golf Course	Nutrient Curtain installed at Kahili Golf Course	Nutrient curtain installed at Kamehameha Golf Course

Potential Permitting Requirements:

Permit Name	Issuer	Trigger	Application Requirements	Project Improvements
Grading and Grubbing Permit	Maui County Department of Public Works	Required for removal of vegetation and earthmoving activities associated with construction	Application will require construction plans to be submitted	Any activity that bares or grades the ground surface, such as structural installation, access roads, and equipment and material staging areas
Department of Army Permit	U.S. Army Corps of Engineers	Any activity resulting in filling of water bodies in the U.S., including flowing streams and wetlands. Fill includes sediment and structures.	Application will require site plan, design, construction methodology, CWA Section 401 Water Quality Certification by Hawaiʻi Department of Health, as well as compliance with environmental Federal cross-cutting authorities (e.g., Section 7 of the Endangered Species Act and Section 106 of the National Historic Preservation Act)	New stream intakes, road and pipeline crossings of streams and wetlands
Clean Water Act Section 401 Water Quality Certification	Clean Water Branch, Hawaiʻi Department of Health	Required for any Federal permit that will involve discharge into bodies of water including streams and wetlands	Application will require items submitted for Department of Army Permit, environmental and chemical evaluation of receiving water, and Hawaiʻi Water Quality Standards compliance plan	Applies to locations requiring Department of Army Permit

Land Slide Mitigation

	High	Med.	Low
Priority			X

	High	Med.	Low
Feasibility		X	

Sediment Trapping	X
Nutrient Reduction	X
Flood Mitigation	X
Stormwater Infrastructure	
Erosion Prevention	X
Feral Ungulate Control	

Description: While the scale of this problem is extensive, attempts to mitigate the loss of topsoil and native vegetation caused by sloughing and mini landslides should be piloted in mauka areas adjacent to major gulches. Landslides are discussed in Chapter 5 Section 2 of the Hawaiʻi Watershed Guidance report, and areas with high erosion potential need to be identified and addressed. Preserving high quality functional, native habitat should be a priority. Drawing upon lessons learned from projects conducted in Hawaiʻi and other high islands in the Pacific, a better understanding of the geologic processes causing this problem is needed. Hillslope stabilization methods could be employed at strategic locations in mauka lands that are vulnerable to landslides.

Revegetation

Revegetation after a land slide can help prevent further soil loss and mitigate slope instability. Plants should be selected based on their ability to become quickly established, root structures, and the hydrological conditions of the area. Native plants should be given preference over non-native species whenever possible.

Fiber Rolls

In areas with high erosion potential, fiber rolls may be placed in intervals along the slope face and/or within stream banks. Fiber rolls are made of straw, coir (coconut fibers), or other biodegradable materials to redirect runoff, decrease stormwater flow velocity, and trap sediment. To maximize effectiveness, fiber rolls should be placed on a level contour in a shallow trench, staked at regular intervals, and tightly abutted to one another. Fiber rolls can also be seeded with native vegetation or coupled with plantings behind them for continued slope stabilization once the roll decomposes. Helpful information about fiber roll installation can be found on the EPA's national menu of BMPs for stormwater (U.S. EPA, 2021). Follow the link below to access the webpage.

Stormwater BMP: Fiber Rolls

Cost: Costs will vary based on location, accessibility, planting density, plant availability, and project goals. To install fiber rolls in strategic locations (assuming a 3:1 slope ratio), and to revegetate the landscape at a moderate density (200 plants per acre) would cost approximately $24,810 per square acre. Helpful information about fiber roll installation can be found on the EPA's national menu of BMPs for stormwater (U.S. EPA, 2021). Click the link that follows to access the webpage. Stormwater BMP: Fiber Rolls

Assessments to identify locations where landslides have occurred as well as landslide-prone areas are needed, and those costs are not included in this report.

Cost Estimates for 1 Square Acre of Fiber Roll Installation and Revegetation

Item	**Cost**
Fiber Roll	$14,610 ($10.00 per linear foot x 1,461 feet needed)
Wooden Stakes	$1,400
Plants	$800 ($4.00 x 200 plants)
Installation and Maintenance	$8,000
TOTAL	**$24,810**

Estimated Load Reductions: Load reductions are dependent on topography, project design, and stabilization methodology.

Timeline and Milestones:

Location (Gulch)	Description	Priority	Twenty Year Timeline			
			Present - 2029	2034	2039	2044
Mauka regions of Waikapū Watershed	Stabilize hillslopes to prevent landslides from occurring	High	Five hillslopes stabilized	Ten hillslopes stabilized	15 hillslopes stabilized	20 hillslopes stabilized

*Assesments should be made annually to determine and prioritize locations for hillslope stabilization projects

Permitting Requirements:

Permit Name	Issuer	Trigger	Application Requirements	Project Improvements
Grading and Grubbing Permit	Maui County Department of Public Works	Required for removal of vegetation and earthmoving activities associated with construction	Application will require construction plans to be submitted	Any activity that bares or grades the ground surface, such as structural installation, access roads, and equipment and material staging areas

*A grading and grubbing permit may not be required, depending on project needs and designs

Reef Friendly Landscaping

Photo courtesy of Maui Nui Marine Resource Council

	High	Med.	Low
Priority	X		

	High	Med.	Low
Feasibility	X		

Sediment Trapping	
Nutrient Reduction	X
Flood Mitigation	
Stormwater Infrastructure	
Erosion Prevention	
Feral Ungulate Control	

Description: Chemical-free alternatives to synthetic pesticides, herbicides, and fertilizers should be considered to meet landscaping needs. Organic products enhance soil health by restoring the soil microbiome to create ideal conditions that support healthy vegetative growth while fighting against pests and disease. Healthy, biodiverse soils become low-maintenance and cost-saving once established. Maui Nui Marine Resource Council has conducted several pilot projects that demonstrate the success of biological soil amendments. MNMRC has also developed a Reef Friendly Landscaping (RFL) Certification program, where interested parties can obtain a free consultation with an organic land care consultant and receive recommendations on products, equipment, and resources to aid in the transition to reef friendly landscaping. More information can be found on Maui Nui Marine Resource Council's Page. https://www.mauireefs.org/residential-reef-friendly-landscaping/

Cost: Costs are highly variable depending on project objectives and property types. Large, commercial test plots can cost upwards of $12,000 per acre for labor and product application. Individuals can purchase a compost tea kit (organic soil amendments) for as little as $120.00.

Estimated Load Reductions: Load reductions would be determined based on current landscaping practices and the scale of project implementation.

Timeline and Milestones:

Location (Gulch)	Description	Priority	Twenty Year Timeline			
			Present - 2029	2034	2039	2044
Commercial and private properties throughout Waikapū and Waiakoa Watersheds	Utilize organic products to enhance soil health and meet landscaping needs.	High	Obtain RFL Certification for Kahili Golf Course	Obtain RFL Certification for Kamehameha Golf Course	Obtain RFL certification for Keālia Resort and Sugar Beach Resort	Obtain RFL certification for Māʻalaea Surf Resort and Kīhei Beach Condos

Potential Permitting Requirements:
Transitioning to organic, reef-friendly landscaping practices should not require any permits.

Regional Stormwater Management Park

	High	Med.	Low
Priority		X	

	High	Med.	Low
Feasibility		X	

Sediment Trapping	X
Nutrient Reduction	X
Flood Mitigation	X
Stormwater Infrastructure	X
Erosion Prevention	
Feral Ungulate Control	

Description: Stormwater management parks are essentially large, shallow detention basins engineered to be multifunctional and utilized as recreational facilities or open spaces such as community parks, sports fields, community gardens, dog parks, etc. During times of heavy rainfall, they collect stormwater and provide flood control, stormwater treatment, wetland protection, and contribute to aquifer recharge. The Weinburg Property, located just mauka of South Kīhei Road and immediately above the outfall of Waiakoa Gulch into the Pacific Ocean, could be repurposed as a community park.

Across North Kīhei Road, Keahuaiwi Gulch discharges into a narrow strip of land immediately north of North Kīhei Road, before flowing into Keālia Pond. Adjacent landowners include the State of Hawaiʻi and Mahi Pono. While Keahuaiwi Gulch does not discharge frequently, when it does, it typically floods into the intersection of North and South Kīhei Roads. Like the Weinburg property on the south side of this intersection, the State of Hawaiʻi and Mahi Pono properties should be repurposed to capture flood waters from Keahuaiwi Gulch and properly direct stormwater towards Keālia Pond.

Costs: Costs for a Regional Stormwater Management Park are difficult to estimate. Because these areas are typically public spaces, the cost to purchase the land by the County should be included in the total price. To create the basin, costs would be similar to a detention basin as outlined in 9.2.3. Additional costs would be to landscape the area or place infrastructure such as parking, fences, and other facilities.

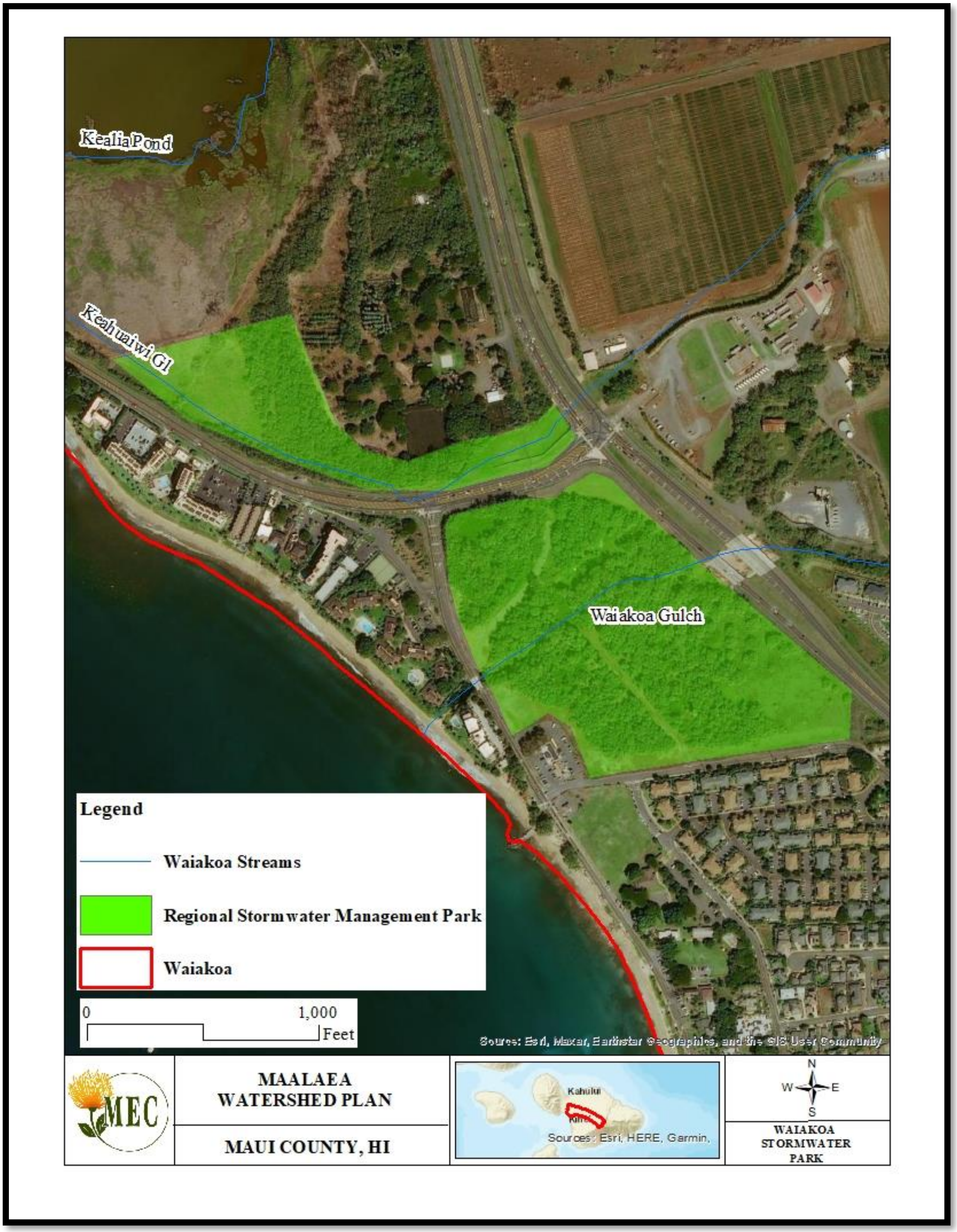
Estimated Load Reductions:

Basin	Acreage Based on Map Renderings	Pollutant Load Reduction		
		N Reduction	P Reduction	Sediment Reduction
		lb/year	lb/year	t/year
Regional Stormwater Management Park	45.43	35.69	3.09	1.60

Timeline and Milestones:

Proposed Location (Gulch)	Description	Priority	Twenty Year Timeline			
			Present - 2029	2034	2039	2044
Outfalls of Waiakoa and Keahuaiwi Gulches	Build stormwater management park to be utilized dually for community park and flood control	High	Conduct engineering, permitting, environmental assessments, overall project design and construct first stormwater management park	Continued maintenance	Conduct engineering, permitting, environmental assessments, overall project design and construct 2nd stormwater management park	Continued maintenance

Waiakoa Potential Stormwater Management Park Location



***Locations depicted are for illustrative purposes and may not represent property owner intentions for these areas.**

Potential Permitting Requirements:

Permit Name	Issuer	Trigger	Application Requirements	Project Improvements
Grading and Grubbing Permit	Maui County Department of Public Works	Required for removal of vegetation and earthmoving activities associated with construction	Application will require construction plans to be submitted	Any activity that bares or grades the ground surface, such as structural installation, access roads, and equipment and material staging areas
Special Management Area (SMA) Permit	Maui County Planning Department	Required for any work being conducted in the Special Management Area	Application will require plots/drawings of work being conducted	All "development" projects require a permit. Applications for a major permit (over $500k or significant adverse environmental or ecological effect) require environmental review and more stringent review.
Perform Work on County Highway Permit	Maui County Department of Public Works	Required when a County roadway is disturbed by installation of pipelines	Application will require construction plans for the affected area	Any activities affecting County-owned roadways or structures, such as pipeline installation, use of bridges, and traffic control
Stream Channel Alteration Permit	State of Hawaiʻi Commission on Water Resources Management	Any activity which will affect the stream course within the channel of a perennial or intermittent stream. The regulated channel extends to the top of the streambank.	Application will include design drawings, effects on and mitigation for aquatic organisms and communities, water pollution prevention plan	Intakes, stream crossings of pipelines, construction and maintenance roads
Stream Water Diversion Permit	Commission on Water Resources Management	Any new or modified diversion of water from streams for beneficial use	Application will include amount of water to be taken, assessment of other instream and non-instream water uses, design of intake	New stream intakes and change in diversion amount at existing intakes

Permit Name	Issuer	Trigger	Application Requirements	Project Improvements
Department of Army Permit	U.S. Army Corps of Engineers	Any activity resulting in filling of water bodies in the U.S., including flowing streams and wetlands. Fill includes sediment and structures.	Application will require site plan, design, construction methodology, CWA Section 401 Water Quality Certification by Hawaiʻi Department of Health, as well as compliance with environmental Federal cross-cutting authorities (e.g., Section 7 of the Endangered Species Act and Section 106 of the National Historic Preservation Act)	New stream intakes, road and pipeline crossings of streams and wetlands
Clean Water Act Section 401 Water Quality Certification	Clean Water Branch, Hawaiʻi Department of Health	Required for any Federal permit that will involve discharge into bodies of water including streams and wetlands	Application will require items submitted for Department of Army Permit, environmental and chemical evaluation of receiving water, and Hawaiʻi Water Quality Standards compliance plan	Applies to locations requiring Department of Army Permit
National Pollution Discharge Elimination System (NPDES) Permit	Clean Water Branch, Hawaiʻi Department of Health	Required for construction site runoff management when construction area exceeds one acre and if the operation of the improvement results in discharge into water bodies	Application will require sediment and runoff management designs and a water quality monitoring plan	Applies to all construction sites with potential of erosion and runoff
Use and Occupancy Permit/Construction within a State Highway Permit	Division of Highways, State of Hawaiʻi, Department of Transportation	Required for surveying, materials testing, and construction affecting State-owned roadways	Permit will depend on phase of work with full plans required for construction activities	Any activities that affect State-owned roadways or structures, such as pipeline installation, use of bridges, and traffic control

Unimproved Road Stabilization

	High	Med.	Low
Priority		X	

	High	Med.	Low
Feasibility	X		

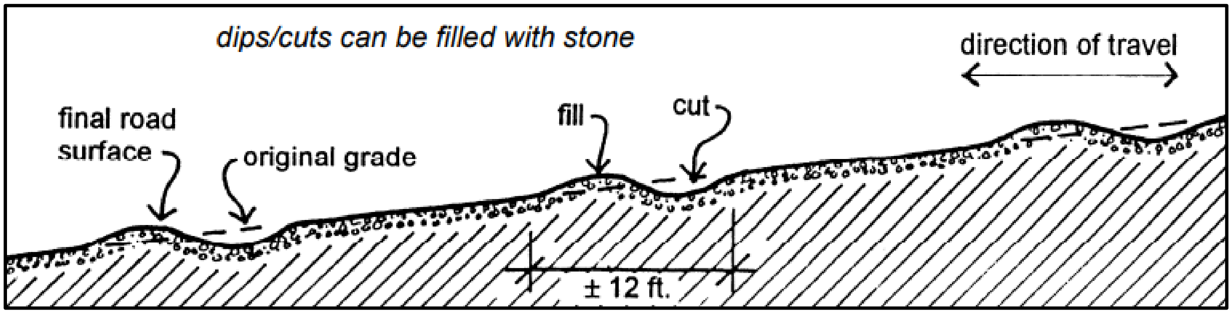
Sediment Trapping	X
Nutrient Reduction	
Flood Mitigation	X
Stormwater Infrastructure	
Erosion Prevention	X
Feral Ungulate Control	

Description: Miles of poorly maintained and disused former agricultural roads are major sources of sediment transfer and pathways for channeling stormwater runoff into stream gulches. As mentioned in Chapter 5 Sections 2 and 3 of the Hawaiʻi Watershed Guidance report, proper road management and runoff mitigation efforts are important to consider in managing pollution within a watershed. A comprehensive inventory of the Waiakoa and Waikapū roads should be conducted to determine stakeholder access needs and to identify those roads that are candidates for decommissioning or repair. Closing roads using structural methods (barriers) such rocks, logs, or vetiver plantings can capture sediment and attenuate runoff. In coordination with landowners and potential road users, disused, and unnecessary or redundant roadways should be identified for decommissioning. Any roads likely to stay in use should be improved using water bars, sediment traps and other BMPs to minimize downslope transport of eroded sediments. Several appropriate BMPs can be found in the document entitled: Unpaved Road Standards for Caribbean and Pacific Islands. Common drainage control techniques highlighted in the document include grade breaks, dips and low water crossings, water bars, cross-drains and culverts, ditches, turnouts, sediment traps, geosynthetics, soil and/or aggregate stabilization, and slope stabilization. Examples from the *Gravel Road Maintenance Manual: A Guide for Landowners on Camp and Other Gravel Roads* are displayed below.

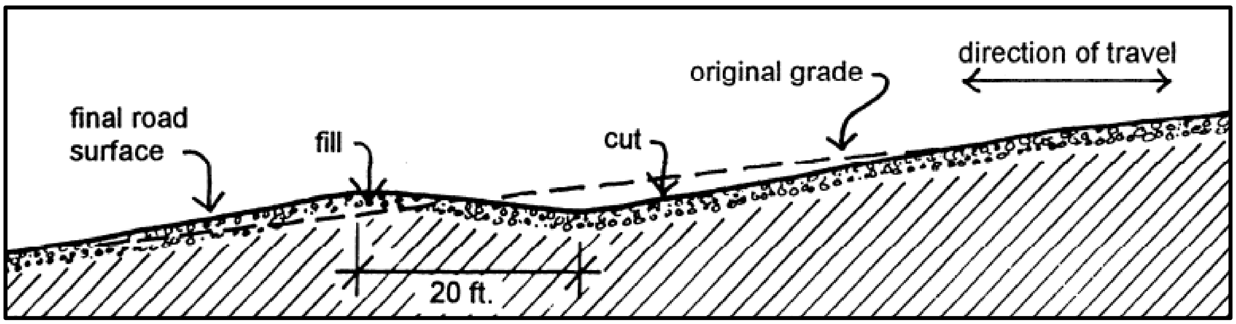
https://www.maine.gov/dep/land/watershed/camp/road/gravel_road_manual.pdf

Mahi Pono and other agricultural entities should conduct an assessment of the current necessity and future needs of dirt agriculture roads within the Waikapū and Waiakoa Watersheds. Locations where agriculture roads parallel or cross the stream gulches provide areas where erosion can occur and can often act as a sediment source for stormwater moving through the watershed. Several years may pass between major storm events, and these gulches and stream corridors remain dry for long periods of time. Personnel should be educated on best management practices when working in riparian corridors or near wetlands so that when major events do occur, soil loss is not exacerbated by these daily operations or periodic construction activities.

Water Bar Example Diagram



Water Dip Example Diagram



Diagrams are courtesy of Brian Kent from the *Gravel Road Maintenance Manual: A Guide for Landowners on Camp and Other Gravel Roads*.

Roads identified for stabilization and/or closure should be prioritized based on 1) utility 2) slope, 3) percentage of sand, silt, clay, and stone, 4) erosion and infiltration rates, and 5) likelihood of transport to streams/gulches based on models developed by Ramos-Scharron in 2009. Other agricultural roads on Maui have been decommissioned based on the following criteria:

1. Roads with high levels of erosion and deep ruts that render them dysfunctional as a road.
2. Those roads which have clearly not been used for at least two years.

Lines of vetiver can be planted on contours across disused roads. These lines serve to interrupt and spread stormwater flows, capture sediment, and infiltrate water safely into the ground. As plants mature, and especially if coupled with stones or other physical barriers, they effectively delineate a road as decommissioned. It is important to conduct stakeholder engagement with any potential road users such as ranchers, fire crews, rangers, illicit dirt bikers, hunters, hikers, etc. to help select appropriate sites, and to ensure the purpose of the road closure is understood and not damaged or tampered with. Signage can be useful to convey this information.

The table below provides a sample budget to repair approximately 3 miles of road based on a similar project that took place in 2019 in the neighboring Pōhākea Watershed. Note that this sample budget is for the repair of approximately 12,000 linear feet of dirt road. Repair included regrading to address channelizations and rills, the cleaning out and repair of kickouts, and the establishment of water bars where needed. In addition, herbicide treatment was included on either side of the road for fire suppression.

Cost Estimates for Road Stabilization Based on a Project in the Pōhākea Watershed

Task Description	Unit	Unit Price	Total Price
Mobilization	NA	$5,000	$5,000
Water Truck	10 Days	$1,530	$15,300
Spencer Road Grading	7920	$23	$182,160
MECO Road Grading	7920	$28	$221,760
Herbicide Treatments	15,840	$1	$16,000
Total Price			$440,220

Estimated Load Reductions:

Watershed	Unpaved Roads	Bare Ground Soil Loss	Potential Soil Loss in Tons from Unimproved Roads	Dense Groundcover Soil Loss	Potential Soil Loss in Tons if all Unimproved Roads were Grassed Over
	Acres	Tons per Acre per Year		Tons per Acre per Year	
Waikapu	123	4.7	578.1	0.006	0.738
Waiakoa	367	4.7	1724.9	0.006	2.202

To approximate the sediment reduction accomplished by the decommissioning of roads in the Waikapū and Waiakoa Watersheds, MEC used the RUSLE2 program. Several data points were entered into the program, including rainfall of 15-16 inches, major soil types, and a slope length of 1400 feet. Slope steepness was assumed to be approximately 6% based on contours and map measurements. Without any BMPs, soil loss was estimated to be 4.7 tons per acre of road. To calculate areage of dirt roads, the lengths in miles were converted to feet and multiplied by a assumed constant width of 20 feet. Once an area of dirt road was calculated in square feet, it was converted to acres of bare ground dirt road. Because much of the lower agricultural roads are associated with pastureland, the Dense Grass – Not Harvested BMP was entered into the program. RUSLE2 estimated soil loss to be lowered to 0.006 tons per acre, significantly reducing soil loss from agricultural roads.

Timeline and Milestones:

Location (Gulch)	Description	Priority	Twenty Year Timeline			
			Present - 2029	2034	2039	2044
Throughout Watersheds	Decommission, repair, and stabilize roads to prevent erosion	Medium	Conduct assessment and inventory of roads. Begin repair and stabilization of priority roads	Conduct additional assessments every five years and repair roads as necessary	Conduct additional assessments every five years and repair roads as necessary	Conduct additional assessments every five years and repair roads as necessary

Potential Permitting Requirements:

Permit Name	Issuer	Trigger	Application Requirements	Project Improvements
Grading and Grubbing Permit	Maui County Department of Public Works	Required for removal of vegetation and earthmoving activities associated with construction	Application will require construction plans to be submitted	Any activity that bares or grades the ground surface, such as structural installation, access roads, and equipment and material staging areas
Special Management Area (SMA) Permit	Maui County Planning Department	Required for any work being conducted in the Special Management Area	Application will require plots/drawings of work being conducted	All "development" projects require a permit. Applications for a major permit (over $500k or significant adverse environmental or ecological effect) require environmental review and more stringent review.

Wetland and Stream Riparian Buffers and Protection

	High	Med.	Low
Priority	X		

	High	Med.	Low
Feasibility		X	

Sediment Trapping	X
Nutrient Reduction	X
Flood Mitigation	X
Stormwater Infrastructure	
Erosion Prevention	X
Feral Ungulate Control	X

Description: Riparian buffers along gulches and gullies prevent sediment laden sheet flow from entering flow ways and ultimately discharging into coastal waters. They also offer important habitat for native flora and fauna to inhabit from mauka to makai throughout the watershed. Existing wetlands should be delineated, protected and restored wherever possible. Wetlands have the ability to filter stormwater from sediment, nutrients and pathogens, they serve as flood prevention and aquifer recharge locations, and provide habitat for native flora and fauna. Lastly, wetlands represent greenspace within urban communities, offering a place for recreation that can improve the community's relationship with the natural environment.

The U.S. Army Corps of Engineers (USACE) has regulatory authority over wetlands and other water bodies of the U.S. (WBUS) based on two federal laws. These include Section 404 of the Clean Water Act (CWA) of 1972, and Section 10 of the Rivers and Harbors Act of 1899.

Section 404 of the CWA states that dredged and fill material may not be discharged into jurisdictional WBUS (including wetlands) without a permit. According to 40 CFR 230.3, WBUS subject to agency jurisdiction under Section 404 include navigable waters and their tributaries, interstate waters and their tributaries, wetlands adjacent to these waters, and impoundments of these waters.

A Section 404 permit is required for all fill or discharge activities below the high tide line in tidal waters or below the ordinary high-water mark (OHWM) for non-tidal, non-wetland waters. Corps regulations define the term "ordinary high-water mark" for purposes of the CWA lateral jurisdiction at 33 CFR 328.3(e), which states:

"The term ordinary high-water mark means that line on the shore established by the fluctuations of water and indicated by physical characteristics such as a clear, natural line impressed on the bank, shelving, changes in the character of soil, destruction of terrestrial vegetation, the presence of litter and debris, or other appropriate means that consider the characteristics of the surrounding areas."

The Rivers and Harbors Act of 1899 prevents unauthorized obstruction or alteration of navigable WBUS. Navigable waters are defined as waters that are "subject to the ebb and flow of the tide and/or presently used, or have been used in the past, or may be susceptible for use to transport interstate or foreign commerce" (33 Code of Federal Regulations [CFR] 325.5(c)(2)). A Section 10 permit is required for non-fill discharging activities proposed in, over, or under WBUS.

In May of 2023, the United States Supreme Court released an opinion in Sackett v. EPA, in which the Court unanimously held that the Environmental Protection Agency (EPA) overstepped its jurisdiction in classifying wetlands on the Sackett property as "waters of the United States" (WOTUS). The court stated: "…the CWA extends to only those wetlands that are "as a practical matter indistinguishable from waters of the United States." This requires the party asserting jurisdiction over adjacent wetlands to establish "first, that the adjacent [body of water constitutes]… 'water[s] of the United States,' (i.e., a relatively permanent body of water connected to traditional interstate navigable waters); and second, that the wetland has a continuous surface connection with that water, making it difficult to determine where the 'water' ends and the 'wetland' begins."

In October of 2022 the Maui County Council passed a bill to protect and restore wetlands (Ordinance 5421). As a requirement of this law, a wetland overlay map is being created. Any wetlands that contain at least two of the three wetland indicators listed by the USACE in their wetland delineation manual and any flow through systems depicting a high-water mark as defined in the 2005 USACE Regulatory Guidance Letter on Ordinary High Water Mark Determination are now considered protected by the bill. County protections may include 50-to-200-foot buffers placed around the wetland edges and stream banks as determined by the Maui County Planning Department.

The Keokea Riparian Rehabilitation project is a pilot project funded by the HDOH and Maui County to show the proof of concept of large-scale riparian protection. The project consisted of first protecting the Keokea riparian zone with the installation of feral ungulate fencing. Next, R-1 dripline irrigation infrastructure was installed. This infrastructure included over 9,000 feet of dripline and approximately 3,000 emitters. Next, native dryland forest plant species were planted at each emitter. Each plant is watered with one gallon per day. Additional riparian rehabilitation projects are being proposed for streams within the Hapapa Watershed (covered by the Southwest Maui Watershed Plan).

Cost: Costs can vary depending on buffer size and project objectives. An estimated cost to restore 10.8 acres of a riparian corridor along Waiakoa Gulch is $173,280.

Cost Estimates for 10.8 Acres of Riparian Rehabilitation Along Waiakoa Gulch

Task	Cost per Unit	Number of Units	Total Cost
Weekly fencing and irrigation infrastructure inspections	$550.00	52	$28,600.00
Fencing Materials	$30.00	3,896	$116,880.00
Irrigation Infrastructure	$4,000.00	1	$4,000.00
Irrigation installation and planting	$2,200.00	5	$11,000.00
Plants	$4.00	1,000	$4,000.00
Quarterly vegetative monitoring, photo documents, drone flights	$1,100.00	4	$4,400.00
Quarterly and annual reports	$1,100.00	4	$4,400.00
Total Cost		$173,280.00	

Estimated Load Reductions: The table below depicts the STEPL pollution load reduction estimates for the proposed Waiakoa Riparian Rehabilitation Project.

N Reduction	**P Reduction**	**BOD Reduction**	**Sediment Reduction**
Pounds/Year	Pounds/Year	Pounds/Year	Tons/Year
10.9	3.4	14.8	2.3

Timeline and Milestones:

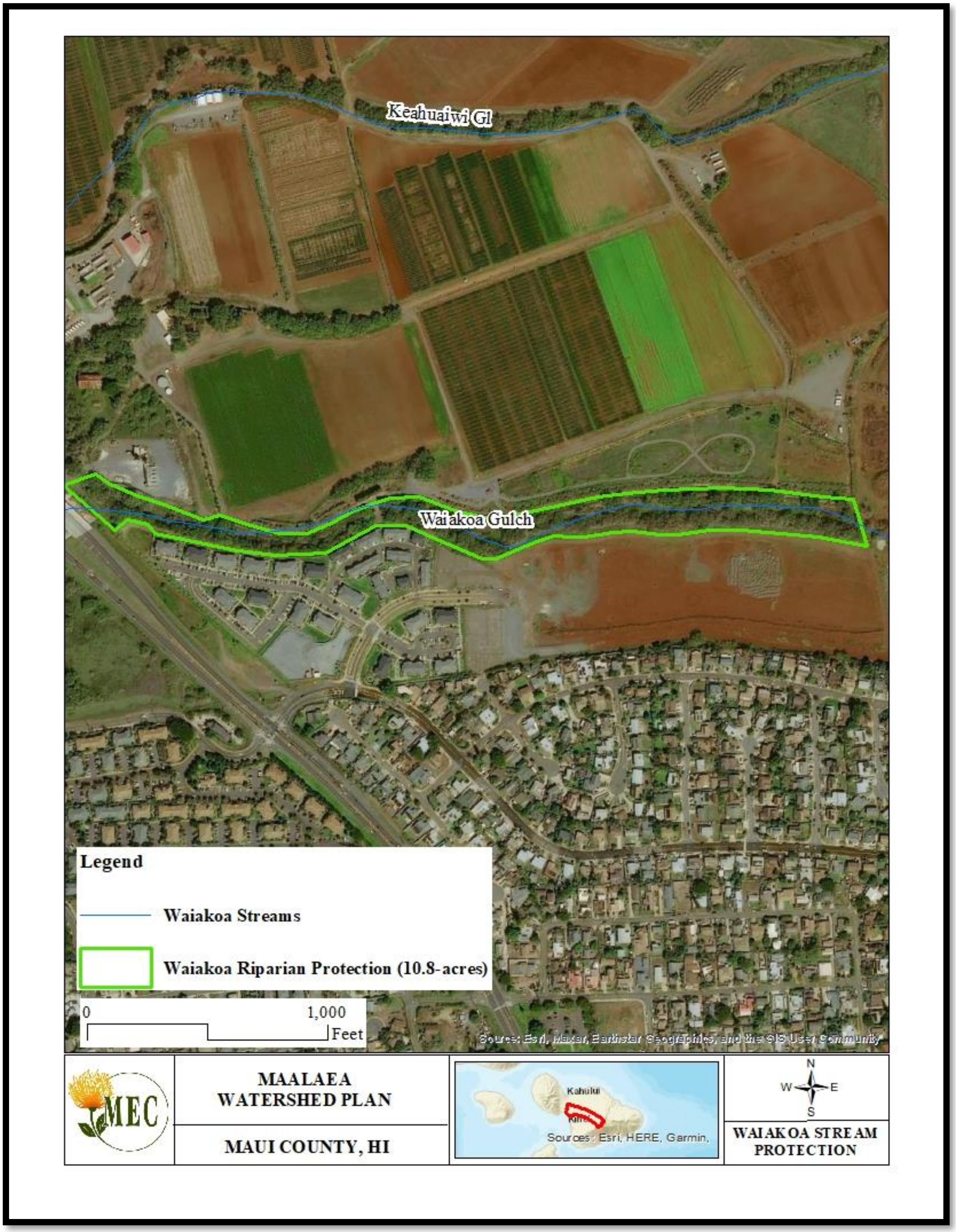
Location (Gulch)	Description	Priority	Twenty Year Timeline			
			Present - 2029	2034	2039	2044
Throughout Watersheds	Protect and restore buffers along gulches and wetalnds	High	Protect riparian corridor of Waiakoa Gulch	Protect riparian corridor of Keahuaiwi Gulch	Protect riparian corridor of Waikapū Gulch (east)	Rehabilitate riparian corridor of Waikapū Gulch (west)

Riparian protection should be performed in conjuction with restoration efforts conducted at Keālia Pond.

Potential Permitting Requirements:

No permits should be needed for fencing and irrigation installation and restoring vegetative cover.

Riparian Rehabilitation Proposed along Waiakoa Gulch.



APPENDIX B.

HUI O KA WAI OLA QUALITY ASSURANCE PROJECT PLAN (QAPP)

Hui O Ka Wai Ola
Quality Assurance Project Plan

Prepared for:

Hui O Ka Wai Ola

Prepared by:

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Date: April, 2017

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Acronyms and abbreviations

COC	Chain of custody
CWB	Clean Water Branch
HAR	Hawaiʻi Administrative Rules
HI-DOH	State of Hawaiʻi Department of Health
MNMRC	Maui Nui Marine Resource Council
MPN	Most Probable Number of Colony Forming Units
PM	Project Manager
QAPP	Quality Assurance Project Plan
QA Officer	Quality Assurance Officer
QC	Quality Control
S-LAB	SOEST Laboratory for Analytical Biogeochemistry
SOEST	School of Ocean and Earth Science and Technology
SOP	Standard Operating Procedures
TAG	Technical Advisory Group
TMDL	Total maximum daily load
TNC	The Nature Conservancy
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WRRC	Water Resources Research Center

1. Introduction

This Quality Assurance Project Plan (QAPP) has been prepared for water-quality monitoring along the Maui Island coastline to assist the State of Hawaiʻi Department of Health Clean Water Branch (HI-DOH-CWB) beach monitoring Program. This document was prepared by members of Hui O Ka Wai Ola, a community-based, quality-assured coastal-monitoring program based on Maui Island. The project was initiated in 2014 by the following partner organizations: The Nature Conservancy (TNC), Maui Nui Marine Resource Council (MNMRC), West Maui Ridge-to-Reef Initiative, and University of Hawaiʻi-Maui College (UHMC), with assistance from NOAA's Hawaiian Islands Humpback Whale Sanctuary.

The monitoring activities of the Hui O Ka Wai Ola program began in 2016. The overarching goal of the program is to increase the capacity for monitoring water quality in Maui coastal waters by generating reliable data to assess long-term water-quality conditions and detect temporal trends. These data augment the data produced by the HI-DOH-CWB beach monitoring program on Maui. To reach this goal, Hui O Ka Wai Ola is organizing a network of monitoring teams drawn from watershed stewardship groups that operate under the same quality assurance guidelines outlined in this document. The teams are trained in monitoring procedures, and conduct regular monthly monitoring and opportunistic, event-based monitoring at sites in Maui's coastal waters at predetermined sites. Producing reliable water-quality data requires that the teams work with water-quality professionals to operate in accordance with an approved QAPP.

This document defines the scope of the program, sets out the organization and goals of the project, and describes the quality control and quality assurance (QC/QA) procedures that are used to ensure that data generated in the program are accurate, complete, and representative of actual field conditions. The content and format of this QAPP follows the requirements and guidance of the United States Environmental Protection Agency (USEPA) QA/R-5, EPA Requirements for Quality Assurance Project Plans (U.S. Environmental Protection Agency 2001). Detailed procedures for water-quality monitoring are provided in Standard Operating Procedures (SOPs), which are also included in this document.

2. Project Management

2.1. Project Organization

The Hui O Ka Wai Ola program consists of monitoring teams, each with a team leader, who are supported by a centralized group that provides project management, data management, and technical advice. Each team monitors or will monitor one of the following sections of Maui coastline: west Maui (Lahaina to Honolua), Southwest Maui (Polanui and Olowalu), South Shore Maui (including Maʻalaea, Kīhei, and Makena), North Shore Maui (Iao, Kahului and Paia) and Hana. All teams use identical calibration, operating and handling procedures (Appendix A, Standard Operating Procedures) to measure the same suite of water-quality parameters or some subset of the parameter suite based on resources available to each regional team.

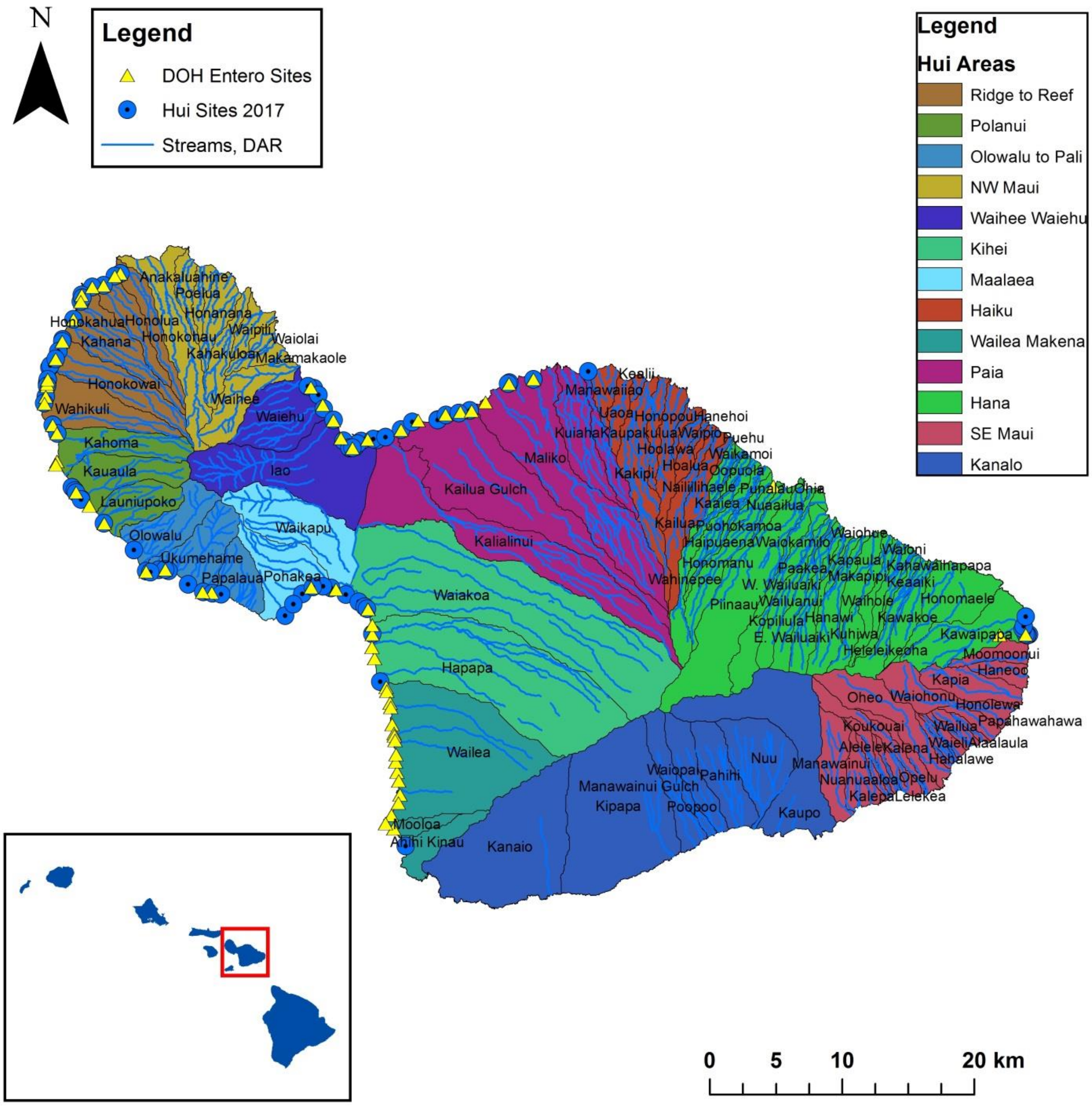

Figure 1-1: Map showing sampling sites, and the sampling zones for each of the participating organizations in Hui o ka Wai Ola. More detailed information about sampling sites can be found in Appendix B.

The primary roles for participants in the Hui O Ka Wai Ola program are Project Manager (PM), Quality Assurance Officer (QA officer), Regional Coordinator, Monitoring Team Leader, Training Leader, Monitoring Team Member, and Science Lead. In general, the PM is responsible for administering and coordinating the program and maintaining records; the QA officer is responsible for data management and program quality assurance and quality control (QA/QC), and management of QAPP review and update; the Regional Coordinator organizes the lab facilities, shipping and processing of samples; the Monitoring Team Leaders and monitoring teams are responsible for field monitoring, some laboratory analyses. The Training Leader is responsible for preparing and conducting training sessions for new members and doing refresher courses for existing members. In addition, the Hui O Ka Wai Ola project has a steering committee composed of representatives of the organizations that established the project. The steering committee is responsible for strategic decisions such as the geographic scope of the project, outreach, and coordinating with community organizations and agencies. Specific responsibilities are set out below. Figure 2 and Table 1 show the personnel designated for the roles in Hui O Ka Wai Ola.

Note that the PM can seek advice from the supervisor of the HI-DOH-CWB Monitoring and Analysis Section, from the TAG and from the director of the SOEST Laboratory for Analytical Biogeochemistry (S-LAB). The QA Officer can seek advice from the QA Officer at HI-DOH-CWB. The QA Officer operates independently from the PM and the monitoring teams.

Table 2-1: Key personnel for the Hui O Ka Wai Ola program. TBD: to be designated.

Name	Project Role	Affiliation
Emily Fielding	Project Manager	The Nature Conservancy, Hawai‘i Marine Program
Kim Falinski	QA Officer, Training Leader	The Nature Conservancy, Hawai‘iHawaii Marine Program
Watson Okubo	Supervisor, Monitoring and Analysis Section, Clean Water Branch	Clean Water Branch, Department of Health
Terence Turuya (retired 2017)	Quality Assurance Manager, Environmental Management Division	Environmental Management Division, Department of Health
Roland Asakura (retired 2017)	Maui Environmental Health Specialist, Clean Water Branch, Maui District Health Office	Clean Water Branch, Department of Health
Danielle Hull	Analytical Laboratory Manager	SOEST S-LAB, University of Hawai‘i at Mānoa
Dana Reed	Regional Coordinator – West Maui	Maui Nui Marine Resource Council, The Nature Conservancy
Roxie Sylva	Monitoring Team Leader – Hāna to Kahului	The Nature Conservancy of Hawai‘i
TBD	Monitoring Team Leader – Mā‘alaea to ‘Āhihi-Kīna‘u	University of Hawai‘i, Maui College
Cathy Maxwell	Monitoring Team Leader – Honolua to Wahikuli	Maui Nui Marine Resource Council, West Maui Ridge-to-Reef Initiative
George Burnette	Monitoring Team Leader – Papalaua to Lāhaina	Maui Nui Marine Resource Council, West Maui
TBD	Data Manager	

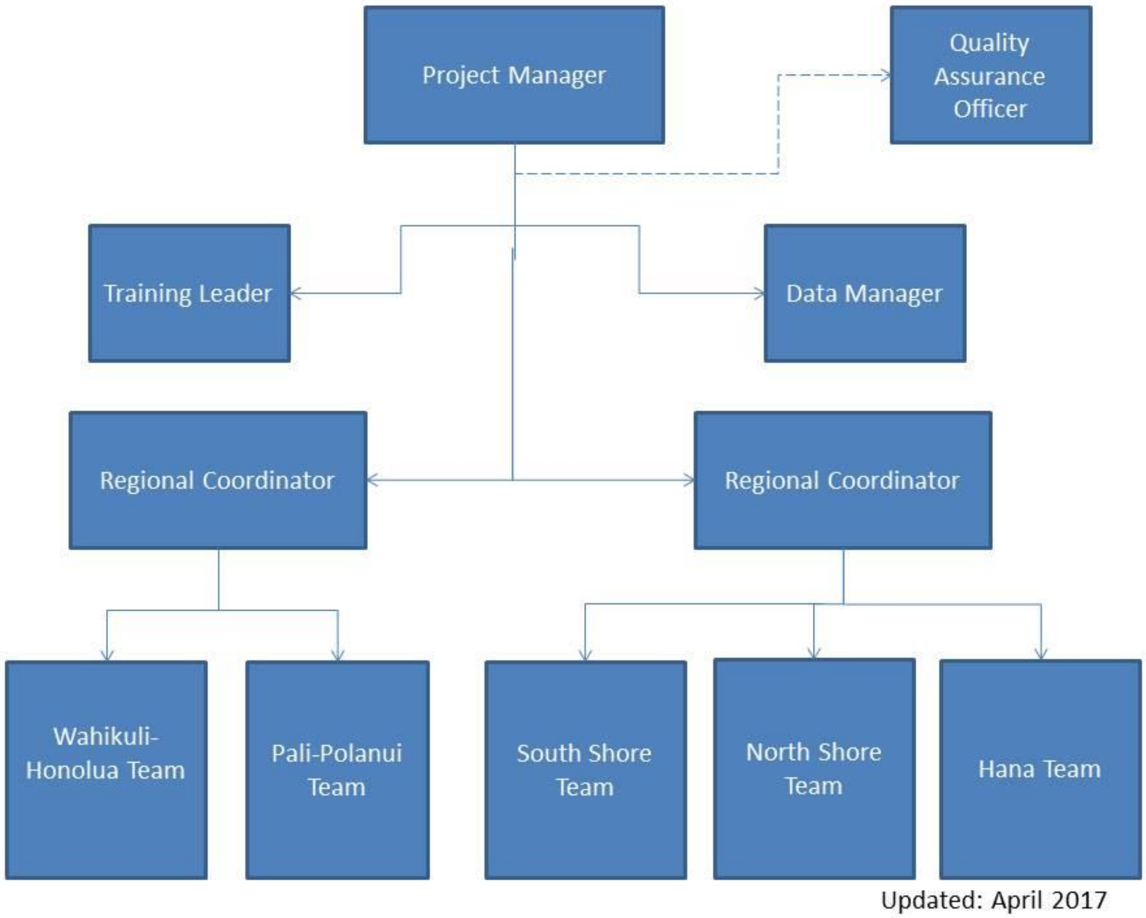

Figure 2-2: Hui O Ka Wai Ola organizational chart

2.1.1. Ongoing project roles

Project Manager

The PM is responsible for administering the project and coordination and communication with partner organizations. Specific responsibilities for the PM are:

- Assist with program start-up, and ongoing communications with community groups, TNC, MNMRC, West Maui R2R, the HI-DOH, Lahainaluna High School, and the S-LAB.
- Coordinate monitoring team training with the training leader, QA Officer, team leaders and community organizations (through the working group).
- Manage permitting and paperwork (e.g., health and safety, boating, volunteer waivers).
- Liaise with other monitoring groups and agencies. Represent program at workshops and conferences.
- Lead changes in monitoring design as necessary (e.g., parameters, procedures, locations).

- Coordinate additions of new groups and new sites to the program, and maintain records of document training class completion.
- Initiate regular outreach efforts to inform the community about the program and findings.
- Call regular meetings of the steering committee.
- Assist the steering committee with grant proposal preparation and other fundraising efforts.
- Resolve challenges encountered by monitoring teams (e.g., beach access).
- Support the Regional Manager and QA officer, as described below

Quality Assurance Officer

The QA Officer is responsible for ensuring that the project is carried out according to the QAPP. Specific QA Officer responsibilities are:

- Conduct data review, validation and verification, including reviewing data prior to submission to HI-DOH to ensure that all information is accurate and conforms to the QAPP.
- Ensure that all field information is correctly documented.
- Maintain and oversee records (raw data sheets, laboratory reports, chain-of-custody forms, QC checks and calibrations, SOPs, QAPP, laboratory QA/QC plans, training records for monitoring team members).
- Assist in monitoring team training in field and laboratory procedures and data entry.
- Review the QAPP and SOPs twice per year. Identify required procedural changes. Update QAPP as necessary in coordination with DOH.
- Collaborate with both the DOH and the analytical laboratories on changes in protocol or QA/QC steps.
- Prepare SOPs (with training leaders and monitoring team leaders).
- Ensure that everyone on the distribution list has updated copies of the controlled documents (QAPP, SOPs, laboratory QA/QC plans, etc.).
- Review the field and lab data that has been entered into the database by the Data Manager to help minimize transcription/translation errors.
- Review and verify data entries provided by the Regional Manager and / or Monitoring Team Leaders, and release the data to the website and Hawaii State Department of Health (DOH).
- Bi-annually meet with all staff members associated with data generation (sample collection, field measurements, lab analysis, data analysis, data reporting, etc.) to review the QAPP.

The QA officer must remain independent of all generation activities, including sample collection, field measurements and laboratory analyses.

Regional Coordinator

- Coordinate local laboratory facilities, equipment and supply purchases, payments for analytical services and sample shipping, maintain supply inventory, and reorder supplies as necessary.
- Ship or deliver nutrient samples to the SOEST laboratory for analysis
- Oversee calibration of all equipment and keep records of calibration/verification.
- Provide ongoing program oversight to ensure accurate data collection an dentry
- Maintain program membership and contact lists
- Communicate changes in monitoring design to quality assurance officer, as necessary (parameters, procedures, locations).
- Provide and monitor team training in field and laboratory procedures and data entry – with updates as needed.
- Ensure that all waivers are signed and safety measures are in place, understood and practiced.
- Enter field and laboratory data into program database.
- Maintain data records for near real time analysis to determine when there are problems with equipment, or a water quality problem that needs immediate attention.
- Fill in for team leaders as required.
- Ensure that original datasheets are filled out accurately and delivered to the QA Officer on schedule.
- Ensure that samples for laboratory analysis are collected, processed, stored and shipped in accordance with the QAPP and associated SOPs.
- Support the Project Manager and QA officer in trainings by participating in the production of training modules; designing field and laboratory demonstrations; scheduling training days coordinating facilities; present classroom, field and laboratory material to trainees; training Monitoring Team Leaders; and preparing SOPs with the QA officer and MTLs.

Science Lead

- Analyze the data and post updates on the website.
- Write annual report within the first quarter of each year with support from the Project and Regional Coordinators

Data Manager

The Data Manager is responsible for the data generated by the program, and is a single point of contact for data entry and storage. Initially, the duties assigned to the Data Manager are performed by the Monitoring Team Leaders. Each site has a database managed by a single person to enter data. Specific responsibilities for the Data Manager are:

- Enter field and laboratory data into program database.

- Return field and laboratory data sheets to the Program Manager for permanent archive.
- Backup the electronic database weekly.
- Modify the database as required if additional data fields become necessary.

Monitoring Team Leaders

The Monitoring Team Leaders (MTLs) are responsible for the volunteer monitoring teams and ensuring data is collected in a timely manner and recorded accurately. Specific responsibilities for the Monitoring Team Leaders are:

- Schedule monitoring dates and times with team members.
- Maintain records of volunteer availability to ensure teams have enough volunteers for each sampling session.
- Ensure that field conditions are safe for team members, and that all volunteers are familiar with first aid kits and procedures.
- Calibrate all equipment according to the schedule laid out in the QAPP. Provide calibration data to the Regional Coordinator.
- Maintain, calibrate and properly store field and laboratory equipment. Conduct pre- and post- checks on field instruments prior to and after the day's sampling.
- Ensure that all field measurements are made in accordance with the QAPP and associated SOPs.
- Ensure that original datasheets are filled out accurately and delivered to the Regional Coordinator on schedule. Maintain copies of all datasheets.
- Store and ship applicable seawater samples for laboratory analysis after collection by Team Members.
- Process sediment samples collected by the volunteer teams in the regional laboratory and provide results to the Regional Coordinator.
- Train new members of the monitoring team using Training Leader training documents and maintain training records.
- Maintain training documentation of team members.
- Ensure that original datasheets are filled out accurately and delivered to the Regional Coordinator on schedule

All staff members associated with data generation (sample collection, field measurements, lab analysis, data analysis, data reporting, etc.) also review the QAPP. The QAPP reflects the procedures that are actually in use or should be in use by all staff members. Review of the QAPP by staff members helps to ensure that the procedures used are consistent with what is specified in the QAPP. Review of the QAPP must be performed at least once per year. Any inconsistencies identified by any staff member are promptly resolved by the QA officer and PM.

Training Leader

The Training Leader is responsible for producing training materials and scheduling and leading training sessions. Specific responsibilities for the Training Leader are:

- Produce training modules consisting of class material and instructor's guide.
- Design field and laboratory demonstrations.
- Schedule training days and coordinate facilities and attendees with the PM.
- Present classroom, field and laboratory material to trainees, including demonstrations.
- Train the Monitoring Team Leaders to train other volunteers locally.
- Prepare SOPs with the QA Officer and the Monitoring Team Leaders.

Monitoring Team Members

The Monitoring Team Members carry out water-quality monitoring tasks and some laboratory tasks, all under the supervision of the Monitoring Team Leaders. Specific responsibilities of the Team Members are:

- Make field measurements in accordance with the QAPP and associated SOPs.
- Collect, store, and process samples in accordance with the QAPP and associated SOPs.
- Carry out analyses of suspended sediment, *Enterococcus*, and other parameters in accordance with the corresponding SOPs.
- Record monitoring information and sample custody information on data sheets and chain-of-custody (COC) forms accurately and completely.
- Complete annual training under the supervision of the Training Leader, and biannual check ups with the Monitoring Team Leader.

2.1.2. Laboratory facilities

Laboratory analysis for nutrients are provided by a facility that uses the same methods as the Hui O Ka Wai Ola will use lab services from the School of Ocean and Earth Science and Technology (SOEST), Laboratory for Analytical Biogeochemistry (hereafter, S-LAB). The laboratory director of S-LABs has consulted with Hui O Ka Wai Ola to coordinate protocols on nutrient analyses, processing and shipping, laboratory quality control. The QA plan for S-LABs is attached as Appendix F.

The regional Maui laboratories are used by volunteers to prepare and store samples for shipping to the S-LAB laboratory. These regional laboratories will also be used for testing water samples for *Enterococcus*, filtering samples in a clean environment, and determining suspended sediment concentrations (SSC) of the sites under test. Different regional laboratories have been identified to minimize the transport time from sample sites to the regional laboratories. Volunteers sampling at west Maui sites will utilize the microbiology lab at Lāhainaluna High School, while volunteers sampling north Maui sites will utilize laboratory facilities at the University of Hawaiʻi Maui College.

2.1.3. Data users

The primary users of data generated by Hui O Ka Wai Ola will be HI-DOH CWB, watershed managers and academic partners. In addition, the data are available for public use and data analysis at multiple online locations. Details of data provision and public access are given in Section 5.4.1. Additional data users may include environmental scientists, fishpond operators, community organizations, high-school and college instructors, local and state and federal regulatory agencies, and participants in watershed restoration projects.

2.2. Documentation and records

Controlled documents for the Hui O Ka Wai Ola program include this document and laboratory QA/QC plans. Version control is maintained using a version number and effective date on the cover sheet of each document. This QAPP, any subsequent revisions or addenda, are reviewed and approved by the Project Manager and the QA Officer. When a new version is approved, it is distributed and the old versions are destroyed or marked "Obsolete." It is the responsibility of the QA Officer to ensure that all relevant project personnel (including everyone on the distribution list) have the most current version. To ensure that they are up-to-date, the QAPP and associated SOPs must be reviewed twice a year by the QA Officer with guidance from HI-DOH-CWB, and updated as needed. The most current version will be available online on the project website.

This QAPP is valid for a period of no longer than five years from the date of approval. If major changes are made, the QAPP must be re-submitted for approval.

3. Problem Definition

3.1. Problem statement

Long term measurements to collect physical and chemical water-quality data are needed to assess current conditions in the coastal waters of Maui Island, to detect and quantify temporal trends in water quality, and to support water-quality management decisions. The suite of water-quality parameters for which data are needed include (but are not limited to) water temperature, salinity, pH, turbidity, dissolved oxygen and dissolved and particulate forms of nitrogen and phosphorus. In addition, data from measurements of fecal indicator bacteria such as *Enterococcus* are needed to assess the suitability of coastal waters for contact recreation. Coastal water quality is affected by the presence and concentration of many other chemical and microbial constituents (e.g., pesticides, dissolved metals, *Staphylococcus, Clostridium*). However, those parameters are out of scope for the Hui O Ka Wai Ola program.

HI-DOH CWB is currently responsible for nearshore water-quality monitoring in Maui coastal waters (hereafter, 'beach monitoring') and identifying water-quality impaired and unimpaired waters. Ongoing beach monitoring is required under the Beaches Environmental Assessment and Coastal Health (BEACH) Act of 2000. HI-DOH CWB uses beach-monitoring data for the state's biennial Integrated Water Quality Monitoring and Assessment Report to the USEPA (hereafter, ‘integrated report’). The data may also be used for developing TMDLs for impaired water bodies, for assessing restoration and mitigation projects, and for basic environmental research. The most recent Water Quality Monitoring and Assessment Report includes assessments of 160 of 575 marine water-bodies in the state; the small proportion of water-bodies assessed was due to the limited availability of data (HI-DOH CWB 2014). Recent state budget cuts led to a reduction-in-force and position vacancies meaning that fewer coastal sites are monitored and there are less samples collected by CWB staff. The Hui O Ka Wai Ola program is intended to reduce this shortfall. Of the 160 assessed water bodies described in the 2014 integrated report, 85% were designated as impaired as they did not attain state numeric water-quality criteria for at least one or more pollutant. The large proportion of impaired sites provides an indication of the wide-spread water-quality problems in the Hawaiʻi coastal zone.

3.2. Mission and goals

The mission of Hui O Ka Wai Ola is to generate quality-assured coastal water-quality data, and to provide this data to HI-DOH, other resource agencies, non-governmental organizations, researchers and the public.

Specific goals of Hui O Ka Wai Ola are to 1) increase community capacity for long-term monitoring water quality in Maui coastal waters; 2) generate quality-assured reliable data that can be used to assess coastal water quality conditions and detect temporal trends that can augment HI-DOH CWB beach monitoring program sampling and be compared to state standards; 3) thereby empowering community and government mangers to take action to improve coastal water quality, benefiting the coral reef ecosystem and people alike.

We anticipate that HI-DOH CWB will use data from the Hui O Ka Wai Ola program for preparing integrated reports to US EPA, and potentially for TMDL development.

The Hui O Ka Wai Ola data will be distributed for use by the HI-DOH, non-profit partners, and academic researchers for future analyses.

3.3. Sampling and analysis summary

Data collection includes measurements of physical parameters of coastal waters including temperature, salinity, dissolved oxygen, turbidity and pH. Chemical parameters collected include dissolved nutrient analysis of water samples, analyzed at S-LABs at the University of Hawaiʻi at Mānoa. Lastly, biological parameters include bacteria analysis for *Enterococcus*, analysis are conducted at the regional Maui laboratories as described in this document. External continuous data inputs including rainfall, ocean conditions and stream flow conditions provided by outside agencies. Additional observations include weather conditions, beach use and qualitative water quality notes.

Analytical work follows the guidance of the HI-DOH and the EPA as found in the Water Quality Standards Handbook (EPA Section 304(a)). SOPs are included that describe methods for operating and maintaining the equipment required to collect and process the collected water samples. Water quality standards are adopted from Hawaii Administrative Rule 11-54 for coastal waters. Quality control of the data is established through the identification of consistent sampling sites, documentation of uniform procedures, and analysis of duplicate samples and laboratory control samples as described in Section 5 of this QAPP. Individual samples exceeding the standards specified in HAR 11-54 will be reported to the CWB for possible follow-up action.

This sampling plan covers multiple sites along the Maui Island coast.. Samples are collected from the nearshore environment at locations noted in Appendix B and seen in Figure 1-1. There is no specified end date to sampling, as the project strives to achieve a long term continuous data collection effort, however this QAPP covers a five year period from its approval. After the initial five year period, the QAPP will undergo review before it is re-submitted for approval again. Sites that do not meet HI-DOH water quality standards will be reported to the CWB for evaluation as soon as practicablepractical.

3.4. Quality assurance and data quality objectives

The objective of the Hui o Ka Wai Ola QA/QC program is to ensure that all data collected by the Hui volunteers are scientifically sound and of known and documented quality. Integrating quality control procedures into water-related monitoring activities, including collection, analysis, validation, reporting, sample storage, and dissemination of data requires implementation of standardized procedures, adequate documentation, and training of volunteers[1].

The QA/QC Program provides guidance documents and technical training to help ensure that sufficient QA measures are established before sampling. The QA objectives of this effort are:

- Study design is statistically sound
- Proper sampling, equipment and analytical procedures are used
- Field and lab volunteers are properly trained
- QC samples such as blanks, spikes and replicates are incorporated in sampling plans
- Sample chain of custody procedures are in place
- Labs analyzing the data follow appropriate QA/QC procedures
- The QA officer performs lab results validation in a timely manner
- Corrective actions are documented and applied when QC measures identify errors, or defects at any point in the data acquisition process.
  - If the sample can be re-analyzed that it

[1] State of California, Department of Water Resources

- The data management system is adequate to ensure archival and retrieval of analytical results with all their metadata

This QAPP describes efforts to reduce sampling and analytical bias through careful selection during the planning process of the sampling locations, sampling times, sampling amount (volume), sampling frequency (or estimates) and the total number of samples (or estimates) for a given location and careful adherence to the established plan (Section 4.1). In addition to standard practices described in Section 4, quality control measures are presented in Section 5 and Appendix D.

Table 3-1. Data Quality Objectives

STEP 1: State the problem Coastal water quality may change with changes in land use and climate, impacting human and ecosystem health. Long term monitoring data sets are needed to evaluate whether there are impacts to nearshore waters.
STEP 2: Identify the goals of the study The long-term study will examine the quality of coastal waters in Maui. Sites will be selected to reflect both minimally impacted and highly impacted sites, and sites where future changes to land use or climate are anticipated.
STEP 3: Identify information inputs • Analyses of regular water samples for nutrients, bacteria and total suspended sediment • In situ testing of water samples for instantaneous measurement of salinity, turbidity, dissolved oxygen, temperature and pH
STEP 4: Define the boundaries of the study • Individual sites (±3m) where water is sampled at the shoreline. Sites are organized into four large units on the island of Maui. Site names and locations are described in Appendix B. • Samples will be taken consistently within 10m of the shoreline at a specific, non-moving location.
STEP 5: Develop the analytical approach The analytical approach will conform to the guidance of the HI-DOH and the EPA as found in the Water Quality Standards Handbook (EPA Section 304(a)). SOPs are included that describe methods for operating and maintaining the equipment required to collect and process the

collected water samples. Each laboratory that handles samples will be covered under its quality assurance plan. Each sample will be verified for calibration and secondary checks within range, hold times, and transport documentation. Quality control of the data will be monitored through the collection of duplicate samples, matrix spike samples, and laboratory control samples as described in Section 6 of this QAPP.
STEP 6: Specify performance or acceptance criteria Samples are accepted if all quality assurance and quality control checks are within range of time and value, and protocols have been followed correctly.
STEP 7: Develop the plan for obtaining data and optimizing sample design Samples will be collected as outlined in this QAPP. Proposed sample locations have been developed based on the sampling objectives. Sample locations are fixed in order to best capture changes over long periods of time (on the order of years), and sampling will be done to capture tidal and moon variability. Additionally, storm sampling will help to capture variability during short term events. The frequency of sampling may be adjusted based on the variability in the data.

PARCC parameters. The PARCCs parameters are used to describe the quality of analytical data in quantitative and qualitative terms using the information provided by the laboratory quality control information. The PARCCs parameters monitored for quality assurance – precision, accuracy, representativeness, comparability, completeness, and sensitivity – are described below.

Precision is quantified in the field through replicate measurements of physical and chemical parameters, including pH, turbidity, salinity, temperature and dissolved oxygen. The laboratory analyses include replicate measurements, splits and repeated measurements of the same sample to assess the precision of the data.

Accuracy is controlled by adequate calibration and secondary verification. We adhere to calibration schedules recommended by manufacturer and intend to verify accuracy before every trip out into the field by using verification standards (pH, salinity) or secondary standards (turbidity meter). Temperature is verified by comparison with a NIST thermometer.

Measurement error is generated through variation in the operation, calibration and output of sensors and other measurement instruments. For this reason, instruments will be maintained, checked for drift, with a documented precision and accuracy (Table 5-4). Calibration and field instrument check schedules are presented in Tables 5-1 and 5-2 to ensure that the equipment is functioning according to specifications.

Representativeness of the data collected in monitoring projects is considered in the sampling design and field plan, especially in site selection and by sampling at the same time of day. Each sampling team adheres to the exact sampling sites (± 3m), a regular sampling schedule and the use of sampling/measurement procedures specified in this document.

Comparability is assured by using standardized sampling and analytical methods, units of reporting, site selection procedures, adherence to the specified sampling design, and proper training of lab and field personnel. Analytical comparability is determined by the use of split samples between the different labs and a reference lab. Changing calibration of instruments has the potential to affect comparability – and so will be noted.

The protocols used for nutrient, sediment and bacterial concentrations are described in Section 4. The protocols are specific so as to document the procedures to be reproduced by another laboratory, if necessary.

We calculate completeness as the percentage of total samples collected that were analyzed as a whole and for individual parameters and sites. Sampling efforts are either weekly, bi-monthly or monthly, depending on community resources. Completeness will be calculated once per year for each site.

Bias is addressed through careful calibration and field pre and post-verification protocols that test to make sure that probes are not drifting or reading consistently incorrect. Bias is additionally assessed through careful analysis of the data to assess if there are either increasing or decreasing trends that would indicate a sample probe is drifting.

A carefully documented sampling plan, consistent calibration and verification, and quality control measures including duplicates and blanks will ensure that the sampling and analytical bias are minimized and that sample results outside of acceptable ranges are discarded.

4. Measurement and Data Acquisition

4.1. Sampling Design

The following sampling design describes sampling and measurement of four suites of water-quality parameters:

1) **Field parameters** (water temperature, salinity, dissolved oxygen (DO), pH, turbidity),
2) **Nutrient parameters** (ammonia nitrogen (NH4), nitrate + nitrite nitrogen (NNN), dissolved reactive phosphorus (DRP), total dissolved nitrogen and phosphorus (TDN and TDP), dissolved silica).
3) **Sediment parameters** (total suspended sediment concentration (TSS)), and
4) **Bacterial parameters** (*Enterococcus*).

4.1.1. Monitoring sites

Sampling takes place selected in advance and consistent within 10 m. The sites identified are listed in Appendix B, with the first sites to be sampled focusing on west Maui and Olowalu. Additional sites will be selected through consultation with HI-DOH and community groups. The CWB will be informed yearly of all new and eliminated sites. Monitoring sites include sites that were formerly part of the HI-DOH beach monitoring program, but discontinued or monitored at a significantly reduced periodicity due to funding cuts. Resumed monitoring at these sites serves to extend existing data time-series, and provide data for sites that lack sufficient data for assessment. Priority is given to sites that have active management partners interested in the resulting data who share the same data objectives and can commit to this QAPP. Other criteria for site selection include priority watersheds and sites in watersheds with CWA Section 319-funded projects already underway.

The following criteria are used to evaluate monitoring sites with community partners:

- Access is safe,
- Location is adjacent to a public access point, or permission to cross private property is granted,
- Samples can be taken in areas of well-mixed water,
- Location corresponds to a CWB monitoring site, particularly a site where monitoring has been discontinued, or monitored at a significantly reduced periodicity
- Location represents an area with high recreational use, high importance for food gathering, or high community concern about perceived water-quality problems, and/or
- Location coincides with environmental research areas with potential for data-sharing.

Sites are classified as either Active or Inactive, with Active sites being monitored for at least one of the four suites of parameters on a regular basis.

4.1.2. Sampling schedule

Two general monitoring modes are used: regularly scheduled monitoring at fixed sites, and unscheduled (opportunistic) monitoring in response to rain and runoff events at fixed sites.

The **pre-scheduled monitoring** takes place regardless of current and antecedent weather conditions, unless safety is a concern. This sampling mode produces an unbiased estimate of average water-quality conditions at each site. For each active monitoring team, the constituents to be analyzed and the frequency of the sampling will be pre-determined in six-month year intervals. At minimum, active sites are sampled once every three months, separate from any opportunistic sampling (see below). Some sites might be sampled at a greater frequency during certain seasons or if resources allow for more frequent sampling for that site in the wet or dry seasons. To minimize bias, samples are taken at the same time of day (for instance at 08:00am) on a predetermined day and time of the month, depending on the weather.

Safety concerns will limit sampling if the conditions are unsafe. Sampling will be delayed by a day or more if there is high surf making sampling unsafe.

Opportunistic monitoring will be used to measure water-quality conditions during and after large, infrequent rainstorms, to generate information about water quality during brown-water periods and about relationships between runoff and water quality. Samples will be collected at the first safe opportunity after the storm has passed, and will be collected in three successive days after the storm at the same time of day. Hold times will be strictly met for all opportunistic samples.

4.1.3. Field measurements

Instantaneous temperature, salinity, dissolved oxygen (DO), pH, and turbidity measurements will be made at the monitoring sites by the monitoring teams using hand-held instruments. Dissolved and particulate nutrients will be measured at the SOEST Analytical Laboratory in samples collected, filtered and shipped by the monitoring teams. TSS and *Enterococcus* will be measured by the monitoring teams at laboratory facilities on Maui.

Procedures for in situ measurements, and sample collection and processing are described in the SOPs attached to this QAPP. The SOPs related to sample collection, processing and parameter measurements are listed in at the beginning of the Appendix.

Water-quality parameters measured in the field and the instruments used for those measurements are listed in Table 4.1. The instruments and sensors in Table 4.1, with the exception of dissolved oxygen, are the same make and model as the instruments used by HI-DOH-CWB. They are currently in production, so replacement parts and repair services are available. For dissolved oxygen, the HIDOH-CWB uses a Clark-type polargraphic sensor with electrolyte and membrane. These sensors require frequent maintenance and calibration, and are affected by variation in water motion, oxygen consumption at the membrane surface, and signal drift. To avoid this issue, the Hui O Ka Wai Ola program uses optical sensors (optodes) that require annual calibration and minimal maintenance, do not consume oxygen, and provide comparable accuracy and precision. The operation, maintenance and calibration of these instruments are set out in Section 4.3 and the operating manuals (Appendix A).

Table 4-1: Field instruments for measurements of in-situ parameters.

Parameter	Method/instrument	Units
Water temperature	NSIT-traceable waterproof digital Thermometer	°C
Salinity/ electrical conductivity	Hach HQ40d meter and IntelliCAL CDC401 conductivity probe	ppt µS/cm
Dissolved oxygen concentration/ % saturation	Hach HQ40d meter and IntelliCAL LDO101 dissolved oxygen probe	mg/L %
pH	Hach HQ40d meter and IntelliCAL PHC101 pH Electrode	pH
Turbidity	Hach 2100Q turbidimeter	NTU

4.1.4. Laboratory analyses

The S-LAB at the University of Hawaiʻi at Mānoa analyses samples for dissolved nutrient and silicate analyses, and particulate analyses for nitrogen and carbon. Results from an annual demostrations of proficiency in the comparison of unknown samples provided by a commercially available, nationally accredited proficiency testing provider are available in Appendix F. The analytical methods used are consistent with the methods specified in the Code of Federal Regulations, Title 40, part 136.

Enterococcus measurements and suspended sediment measurements are analyzed in satellite laboratory facilities on Maui, as described in Section 2.1.2. EPA methods numbers for the standardized analyses are listed in Table 4.2.

Table 4-2: Analytical methods used in water quality analysis.

Parameter	Method number or description	Method/instrument	Units
NH_4	EPA Method 350.1	GF/F-filtered grab samples, SEAL Analytical AA3 autoanalyzer	µg N/L
NNN	EPA Methods 353.2	GF/F-filtered grab samples, SEAL Analytical AA3 autoanalyzer	µg N/L
DRP	EPA 365.1	GF/F-filtered grab samples, SEAL Analytical AA3 autoanalyzer	µg P/L
TDN	UV-Digestion, EPA 353.2, Rev.2	GF/F-filtered grab samples, SEAL Analytical AA3 autoanalyzer	µg N/L
TDP	EPA Method 365.1	GF/F-filtered grab samples, SEAL Analytical AA3 autoanalyzer	µg P/L
Silicate	EPA Method 366.0	GF/F-filtered grab samples, SEAL Analytical AA3 autoanalyzer	µg/L
PN	EPA Method 440.0	GF/F-filters, Exeter Elemental Analyzer	% by mass
PC	EPA Method 440.0	GF/F-filters, Exeter Elemental Analyzer	% by mass
Enterococcus	IDEXX Enterolert instructions	Fluorogenic substrate test (Idexx Enterolert Quanti-tray)	MPN/100mL
Suspended sediment	EPA Method 160.2	Gravimetric, Dried at 103 - 105°C	mg/L

[1] **Mean detection limit – reported as three times the standard deviation of the blank (n=15) for autoanalyzer samples**

4.2. Sampling methods

Instantaneous temperature, salinity, dissolved oxygen (DO), pH, and turbidity measurements are made at the monitoring sites by the monitoring teams using hand-held instruments. For in situ measurements, water is collected at 0.1 m below the water surface in a bucket or similar collection device. The bucket is relocated above the high tide line to a shady place for in situ measurement for safety reasons.

For sediment samples, the team collects 500 mL sample for analysis of total suspended sediment.

For nutrient samples, we collect 125 mL bottles at the 0.1m depth for water quality analyses. Dissolved and particulate nutrients are measured, per site sampling specifications, at the SOEST Analytical Laboratory in samples collected, filtered and shipped by the monitoring teams.

For bacterial samples, sterile bags (Whirlpacks) collect water for *Enterococcus* samples. Sample water will be collected by placing the bags under water, filling and then sealed. SSC and *Enterococcus* will be measured by the monitoring teams at regional laboratory facilities on Maui.

Bottles and buckets are rinsed three times in the field before each sample is collected.

Procedures for in situ measurements, and sample collection and processing are described in the SOPs attached to this QAPP. The SOPs related to sample collection, processing and parameter measurements are listed in Table A-2.

4.3. Sample handling and custody Requirements

4.3.1. Sample transport

Samples are transported in coolers with ice from the field to the regional laboratory where they are either processed further (*Enterococcus* and SSC) or prepared for shipment to the S-Lab (nutrient analysis). Samples for nutrient analysis are frozen at the local laboratories until they are shipped. Shipments are made using FedEx or similar carrier using blue ice and coolers to keep the samples frozen during transit. Nutrient samples for analysis are delivered to the lab within two weeks of collection. Samples arriving at S-Lab are immediately frozen and processed within 28 days of the sampling date.

4.3.2. Sampling bottles and preservation

Sample containers, volumes, preservation details, and holding times for the near shore chemistry monitoring samples are listed in Table 4.4. The information in Table 4.4 was compiled from the S-Lab requirements and the HI-DOH-CWB Coastal Chemistry Monitoring QAPP.

All sample bottles that used for analyzing nutrients are cleaned at the lab using phosphate-free soap and triple-rinsed.

Table 4-3: Seawater sample handling and preservation.

Variable	Bottle	Volume	Field preservation	Lab preservation	Holding time
NH_4	Brown HDPE 125ml	80 mL	Filter, transport on ice	Freeze < -20°C	7 d
NNN	Brown HDPE 125ml	80 mL	Filter, transport on ice	Freeze < -20°C	28 d
DRP	Brown HDPE 125ml	80 mL	Filter, transport on ice	Freeze < -20°C	28 d
TDN	Brown HDPE 125ml	80 mL	Filter, transport on ice	Freeze < -20°C	28 d
TDP	Brown HDPE 125ml	80 mL	Filter, transport on ice	Freeze < -20°C	28 d
Silicate	Brown HDPE 125ml	80 mL	Filter, transport on ice	Freeze < -20°C	28 d
PN	GF/F filter	80 mL	Filter, transport on ice	Freeze < -20°C	28 d
PC	GF/F filter	NA	Filter, transport on ice	Freeze < -20°C	28 d
Suspended sediment	HDPE 1 L	500 mL	Transport on ice	Refrigerate < 6°C	60 d
Enterococcus (Collection device)	Sterile Whirl-Paks Nasco B01489WA	7oz	Transport on ice	Refrigerate < 6°C	6 hr
Enterococcus (Sample preparation)	Sterile clear bottle	100 ml	None	Pour into Quantitray for incubation	0 hr

4.3.3. Sample chain-of-custody

A chain-of-custody form is to accompany each set of water samples shipped to the nutrient lab for nutrient analyses and to the Maui facilities for *Enterococcus* and suspended sediment analyses. The chain-of-custody form must be signed and dated by the field person who maintained custody of the samples during collection, and also by the person who receives them at the local laboratory. This form then accompanies the samples that are shipped to the nutrient analytical lab and is signed and dated by the person shipping the samples and also by the person who receives the samples at the S-LAB. The COC form is attached as **Appendix C**.

When coolers with samples arrive at the Maui facilities and the S-LAB, the sample receiver is to inspect the contents of each cooler, verify that it agrees with the COC, and sign and date the COC form. If any discrepancies are noted, or if laboratory acceptance criteria are not met, the laboratory must contact the QA officer for resolution of the problem. The discrepancy, its resolution, and the identity of the person contacted must be documented by the laboratory.

In some cases, the sample collector and the sample Maui receiver/laboratory analyst are the same individual, and this will be noted.

4.3.4. Sample labeling

Each sample collected is labeled with the following information prior to or during the collection of the sample:

a. a unique sample number,
b. sample type,
c. name of collector,
d. date and time of collection, and
e. place of collection

The sample number follows this code: 3-letter site location code, two-digit year, two-digit month, two-digit day – sample type code (N for nutrients, S for suspended sediment, E for *Enterococcus*) – sample number. Letters are used for sample duplicates. For instance, a sample at Honokowai Beach Park to be analyzed for nutrients might be: HBP150601-N-1. The initials of the sampler are listed separate from the sample ID.

4.4. Analytical methods

Suspended sediment concentration

Total suspended sediment concentration (TSS) are measured gravimetrically after being dried for 24 hours at 103°C, according to the Manual of Chemical and Physical Methods for Seawater Analysis using a modified EPA method 160.2 protocol. 500-mL samples will be prefiltered to remove large debris and sand-sized particles which are typically found in the surf zone.

Nutrient and silicate analyses

Nutrient and silicate analyses are conducted on an autoanalyzer (AA3 Nutrient Autoanalyzer from Sea Analytical). The S-LAB utilizes methods and procedures outlined by Seal Analytical that are optimized for the AA3 Nutrient Autoanalyzer; references and procedures for each constituent are in accordance with the EPA methods listed in Table 4-2.

Bacteria concentration

The bacterial concentration protocol follows the Enterolert detection protocol. The Enterolert reagent, based on IDEXX's Defined Substrate Technology**,** is used for the detection of enterococci in water. Enterolert**®** uses 4-methylumbelliferyl-β-D-glucoside as the defined substrate nutrient-indicator. This compound, when hydrolyzed by enterococcus β- glucosidase, releases 4-methylumbelliferone which exhibits fluorescence under a UV365nm lamp. This reagent system is specifically formulated to achieve optimum sensitivity and specificity in the detection and identification of enterococcus. After 24 hours incubation at 41°C, if enterococcus is present, the reagent should show fluorescence when exposed to a long-wave (365-366 nm) UV lamp. The test should detect one (1) enterococcus in 100 mL of water within 24 hours.

Additional information for the above protocols is found in Appendix A.

5. QA/QC Requirements

5.1. Instrument and equipment maintenance, testing, inspection and calibration

All equipment and instrument maintenance and service, testing, inspection and calibration is documented in lab notebooks available to the QA officer for review. A summary of the procedures for documenting quality control non-conformances is in Appendix D. Appendix D also presents common data qualifiers used in the final data management system to identify types of non-conformances.

Measurement error is generated by variation in the operation, calibration and output of sensors and other measurement instruments. Instruments are maintained, checked for drift, with a documented precision and accuracy (Table 5-1).

Table 5-1: Field instrument performance specifications.

Variable	Instrument	Range	Accuracy	Precision
Water temperature	NSIT-traceable waterproof digital thermometer	50 – 300 °C	± 0.4°C between 0 and 100°C	0.1°C
Salinity & electrical conductivity	Hach HQ40d meter and IntelliCAL CDC401 conductivity probe	0.01 – 200 µS/cm 0 – 42 PSU	± 0.5 µS/cm 0.01 PSU	0.01 µS/cm
Dissolved oxygen concentration & % saturation	Hach HQ40d meter and IntelliCAL LDO101 luminescent/optical DO sensor	0.05 – 20.0 mg/L 0-200 % saturation	± 0.1 (0-8 mg/L) ± 0.2 (>8 mg/L) 1 % saturation	0.01 mg/L
pH	Hach HQ40d meter and IntelliCAL PHC101 pH Electrode	2 - 14	± 0.02	0.001 - 0.1
Turbidity	Hach 2100Q turbidimeter	0 – 1000 NTU	± 2 %	0.01 NTU

5.1.1. Field calibration and maintenance

All field calibrations/verifications, quality control measures, and sampling activities are documented on the field data sheets provided.

All field instruments used for the collection of water samples or data for the program are maintained according to the manufacturer's performance specifications and instrument SOPs and the manufacturer instructions in the operating manuals (Table 5-2, Appendix A). The Hach instruments run self-checks when they are powered on. All field equipment is to be visually inspected before use for damage. An inventory of spare parts inventory and extra equipment is to be maintained to minimize effects of equipment problems on sampling schedules. However, funding limitations prohibit the purchase of duplicate Hach instruments, and problems with those instruments may cause delays. Further details on field instrument maintenance and inspection are in the user's manuals.

To ensure that field instruments for in situ measurement have acceptably low amount of systematic error/bias, the instruments are to be calibrated following the procedures and at the frequencies specified by manufacturers. The calibration schedule and acceptance criteria for field instruments are summarized in Table 5-2. The field-check acceptance criteria refer to the similarity of measured or indicated values and the reference values (e.g., standard calibration solutions for pH, conductivity and turbidity). The instruments are calibrated according to the schedule provided in Table 5-2.

In addition, before and after each day's field sampling effort, pre- and post- check values will be ascertained and compared to the field check range indicated in Table 5-2. If more updated information about a site is available (for instance a site has been sampled continuously and has enough data to provide a smaller interval range), the 95% confidence interval will be used on a site by site basis. If the acceptance criteria are not met in the field, then the data will not be used, and the instrument will be considered for repair or replacement.

Table 5-2: Calibration schedule and field check criteria; The field check criteria is the largest range within the instrument is expected to be functioning correctly.

Instrument	Parameter	Calibration frequency	Secondary check acceptance criteria	Field check range
NSIT-traceable waterproof digital thermometer	Temperature	None (factory-calibrated)	None	20 - 35°C
Hach HQ40d meter, IntelliCAL CDC401 conductivity probe	Salinity/ conductivity	Quarterly or as needed	Pre- and post-check to ± 3% of 35ppt and 0ppt solution	20 – 38 ppt
Hach HQ40d meter, IntelliCAL LDO101 luminescent/optical DO sensor	Dissolved oxygen	Yearly or as needed	Post-check ± 5 % of pre-check	80 - 120%
Hach HQ40d meter, IntelliCAL PHC101 pH Electrode	pH	Every time equipment is used	Pre- and post-check to ± 3 % of calibration solution	7 - 9
Hach 2100Q turbidimeter	Turbidity	Yearly or as needed	± 5 % of Gelex standards (5, 50, 500 NTU). Deionized/turbidity-free blank < 0.25 NTU	0-1600 NTUs

5.1.2. Duplicates and sample blanks

Replicates and sample blanks. For every 10-20 seawater samples collected per site for nutrient, *Enterococcus* and suspended sediment analysis, one replicate sample (i.e., two samples collected from the same sample site at approximately the same time) are collected for each type of analysis. Each replicate will be analyzed as a blind-to-the-lab sample. The accumulated replicate data assesses measurement error in field collection protocol. The replicate samples are given unique sample identification numbers and treated as discrete samples. Samples that differ by more than 10% relative percent difference (RPD) will be discarded. Additionally, sample blanks (distilled water only) are analyzed once every six months per project area to ensure quality in the shipping and processing process.

For opportunistic sampling, or if the turbidity measurement in-field is above 10 NTU, duplicate samples for suspended sediment analysis is automatic. Samples that differ more than 10% RPD will not be included in the database.

The facilities carry out analyses of sample duplicates and blanks as part of a continuous check on performance. Performance records are maintained and are available to HI-DOH-CWB. Where applicable, split sample analyses is carried out with commercial or university analytical laboratories. Discrepancies are addressed as discussed in Section 6.

5.2. Shipping and handling

The Maui satellite labs prepare samples for shipment using standard protocols as described in Section 4.3.1. Each set of samples shipped is accompanied by a chain of custody form. The form is filled out on receipt of the analyzing lab for QA nonconformities (broken seals, incorrect temperature on arrival).

Shipping frozen samples only occurs between Monday and Weds, so that the lab can process the samples when they arrive. In the event a package arrives on the weekend or on a holiday, and is not opened and processed within 24 hours, the samples date will be recorded and the sample flagged for further quality assurance inspection.

5.3. Training requirements

Each monitoring team member receives consistent, documented training. Sites are sampled in pairs to reduce bias in the sampling protocol and to reinforce protocol.

Field team members receive annual training in sampling methods and procedures outlined in this plan and the SOP associated with this plan, and then observed to ensure that protocol is followed consistently. All field team members are required to read the most updated QAPP document. The training is documented by the Training Leader, including the name of the trainee, type of training they received (first time or re-training, volunteer sampler or team leader), date and name of the trainer. Training documents are available to the CWB on request. Field team members sample sites in pairs as a check to maintain sampling standards.

Prior to a staff member's independent performance of a procedure, a quantitative comparison should be conducted when possible and applicable to ensure that the trainee results are comparable to those of an experienced staff member. Documentation of this training should be provided to the Training Leader. Specifically, field team members have training in the following field activities:

- Water grab sampling and processing (manual);
- Instrument operation, calibration/verification checks, and routine maintenance (for the Hach HQ40D multi-parameter probe and Hach 2100Q turbidimeters);
- Sample filtering, including weighing and drying filters, for SSC
- Idexx Quanti-tray System operation and procedures for measuring *Enterococcus* levels
- Data recording and summarization procedures;
- Sample handling and chain of custody procedures; and,
- General and project-specific safety.

Training records for all Hui O Ka Wai Ola volunteers are maintained by the Training Leader. The addition of new personnel will require training documentation. The Monitoring Team Leader is responsible for scheduling and arranging refresher courses when applicable.

5.4. Laboratory analyses

General. The floor and work surfaces of the laboratory facility must be non-absorbent, easy to clean and disinfect. Each laboratory should have sufficient and clean storage/work space. All food and drinks are prohibited in the laboratory work area. Each laboratory should have adequate ventilation, facilities, and safety protocols.

Thermometers. Thermometers should be graduated in 0.5 ° C or less. Incubator thermometers should be graduated at 0.2 °C or less. All laboratory thermometers are calibrated semiannually against a NIST certified thermometer, and the results documented. Both the NIST thermometer and the thermometer being calibrated should be immersed in water to avoid rapid fluctuations while reading. Allow at least 5 minutes for stabilization. Each calibrated thermometer should be tagged with the following information: date of calibration, NIST reading, thermometer reading, correction factor, and technician initials.

5.4.1. Water quality laboratory facilities

Detailed quality assurance information for the nutrient analysis lab is provided in Appendix F.

Instrument maintenance. All instruments are serviced at scheduled intervals necessary to optimize factory specifications. Routine preventive maintenance and major repairs are documented in a maintenance logbook. An inventory of items to be kept ready for use in case of instrument failure will be maintained and restocked as needed. The list of spare parts includes equipment replacement parts subject to frequent failure, parts that have a limited lifetime of optimum performance, and parts that cannot be obtained in a timely manner.

Refrigerators and drying ovens. Refrigerator units must be maintained between 0 - 6 ºC. The temperature should be checked and recorded on the temperature log sheet once per day on each day of use (depending on the laboratory and frequency of analysis). The refrigerator unit should be cleaned monthly and all materials identified and dated. All outdated materials should be disposed of properly and no food or drinks should be stored in the refrigerator unit. Similarly, ovens for drying filters are inspected before each use to ensure cleanliness.

Analytical balances. Analytical balances will be calibrated once per year, and certified as necessary by national certification boards. All maintenance records will be kept on file.

Reagent water. For the reagent water system, the satellite lab checks daily the TOC (ppb) and MOhms. This is observed for passable standards prior to using water (18.2 MOhms, and <4 ppb TOC). Monthly, the system is checked for volume of water through each filter, rejection feed on the feed water, and temp of feed water. The S-LAB maintains three, six, and twelve month upkeep protocols documented for the reagent water maintenance.

Cleaning protocols. Bottles are rinsed three times and dried prior to their reuse in sampling. Between sampling in the field, equipment is rinsed with deionized water.

Inspection for supplies and consumables. Once per year, an inventory of all consumables is conducted to evaluate the physical condition of bottles, hoses and equipment. Any equipment that is substandard will be discarded. Chemical reagents will be discarded properly if past their expiration date. These inspections are documented in the laboratory notebook for QA review, if necessary.

5.4.2. Bacterial testing laboratory facilities and equipment

Incubators: Incubators should be maintained at 41 ± 0.5 ºC for Enterolert® method of analysis. The uniformity of the temperature should be established. The temperature should be checked at least once daily and recorded in the laboratory log, on each day of use. A lab technician also checks the temperature as the samples are read. If applicable, the thermometers should be placed on the highest and lowest shelves and immersed in liquid. If the incubator is out of acceptable range for more than 2 hours, the samples should be discarded and reported as "temperature out of range". Preventative maintenance is completed and recorded in equipment maintenance log book.

Autoclave: For each cycle, the technician records the date, contents, sterilization time, pressure, temperature, and technician initials in an autoclave log. The autoclave performance will be tested for each run using sterility tape. At least once during each month the autoclave is being used, appropriate biological indicators should be used to determine effective sterilization. Preventative maintenance is performed and recorded in the equipment maintenance log book.

Cleaning protocols. Bottles are rinsed three times and sterilized to their reuse in sampling. Or, if possible, sterile water collection bags will be provided.

Sealer: The Quanti-Tray 2000 sealer is checked on a monthly basis using 100 mL of water mixed with a dark colored dye or bromescol purple to ensure adequate sealing of the quanti-trays. If dye is observed outside of the wells, the sealer is serviced by a technician before use. All quality checks and maintenance are recorded on the Sealer QC Log Sheet. The long-wave ultraviolet bulb should produce a wavelength of 365 nm. Quality checks can be completed by reading the positive controls.

Consumables: Each lot of Enterolert® media will be used before the listed expiration date and stored in a cool (20-30°C) dry place out of direct sunlight. The expiration date of the media is noted on each data form. Each lot is quality checked using a positive culture to ensure growth of the target organism, and all Quanti-Tray cells must exhibit fluorescence and the expected reaction to the target organism. Each lot of media is also tested using two negative controls to demonstrate the media does not support the growth of non-target organisms. Each laboratory also processes one blank (distilled water and media) for each group of samples processed. The data quality objective for blanks is <10 MPN. For each laboratory 10% of the laboratory samples are duplicated and the RPD regularly assessed.

Reagent water : Each lot of reagent water either distilled water or water from deionization units is quality checked yearly and must meet the following criteria:

- Conductivity > 0.5 megaohms resistance or less than 2 micromhos cm^{-1} (microsiemens cm^{-1}) at 25°C.
- Total chlorine < 0.1 mg L^{-1} residual.

Conductivity is reported each time a batch of distilled water is processed. Chlorine residuals will be tested annually using test kits (for instance, the Hach chlorinity test kit).

Water to be used in bacteriological analyses will not be stored for more than 60 days before use.

5.4.1. Analytical lab quality control: replicates, standards and blanks:

A summary of quality control activities is presented in Table 5-3.

Target levels for accuracy and precision (expressed as relative percent difference) provide measurement quality objectives, and are presented in Table 5-4.

Target levels for suspended sediment concentration are from American Society for Testing and Materials (1997).

Enterolert specifications and target levels for *Enterococcus* are from the Enterolert User's guide.

Nutrient and silicate analyses

The S-LAB, responsible for analyzing for nutrient and silicate parameters, has a formal quality control program, as described in Appendix F.

Suspended sediment analyses

During the pre-weighing of the filters, each filter will be weighed twice and the average used as the initial weight. Post filtration, and after the samples have been dried for 24 hours, the filters are weighed twice and the average recorded in the lab notebook. If there is a difference of more than 10% between the two values, the data will be recorded in the lab notebook but entered with a code in the final database.

Bacterial analysis quality control

Laboratory quality control protocols for bacterial analysis include laboratory blanks and repeated positive readings that is confirmed by a second trained analyst. Lab duplicates are measured every 20 samples, in addition to field duplicates every 20 samples. If the relative percent difference is greater than 10%, the sample will be thrown out.

Additionally, the media will be tested for each batch by inoculating intentionally for *Enterococcus*.

Table 5-3: Quality control sampling activities in laboratory and field, with frequencies

QC Sample or Activity used to Assess Measurement Performance	Frequency	Measurement Performance Criteria
In situ parameters		
Bench calibration (turbidity, pH)	Before every group of samples	Table 5-1
Field blank (turbidity)	After every group of samples	<0.1 NTU
Repeated samples	▪ Temperature: If there is a difference of 1ºC or greater between any of your three measurements ▪ pH: If there is a difference of 0.2 or greater between any of your three measurements ▪ Conductivity: If there is a difference of greater than 10 uS between any of your three measurements ▪ Dissolved Oxygen: If there is a difference of 0.4 ppm or greater between any of your three measurements ▪ Turbidity: If there is a difference of 0.2 NTU or greater between any of your three measurements	
Historical trend analysis	Every 5 sampling events	Baseline average is not trending
Nutrient analysis		
Field duplicate	Every 20 samples	Within 10%
Lab blank	Once per group of samples	<5% of the total range
Lab mid-level calibration	Once per sample run	Within 5%
Standard reference material		Within 5%
Method detection limit	As needed by lab	
Suspended sediment concentration analysis		
Field duplicate	When turbidity >2 NTU	Within 10%
Repeated weighing	Every sample	Within 5%
Bacterial analysis		
Field duplicate	Every 20 samples	Within 10%
Lab reagent blank	One per group of samples	<10 MPN
Lab duplicate	Every 20 samples	Within 10%
Repeated measures	Positive samples checked by second trained analyst	Within 3%

Table 5-4: Acceptable analytical methods and quality control acceptance criteria. RPD: relative percent difference, based on duplicate samples.

Parameter	Method number or description	Method/instrument	Units	Minimum Detection Limit	Sensitivity resolution	Accuracy
S-LAB Analyses						
NH4	EPA Method 350.1	GF/F-filtered grab samples, SEAL Analytical AA3 autoanalyzer	µg N/L	1.0 µg N/L	< 20% RPD	80% - 120%
NNN	EPA Methods 353.2	GF/F-filtered grab samples, SEAL Analytical AA3 autoanalyzer	µg N/L	0.8 / 2.4 µg N/L	< 20% RPD	80% - 120%
DRP	EPA 365.1	GF/F-filtered grab samples, SEAL Analytical AA3 autoanalyzer	µg P/L	0.56 µg P/L	< 20% RPD	80% - 120%
TDN	UV-Digestion, EPA 353.2, Rev.2	GF/F-filtered grab samples, SEAL Analytical AA3 autoanalyzer	µg N/L	0.8 / 2.4 µg N/L	< 30% RPD	80% - 120%
TDP	EPA Method 365.1	GF/F-filtered grab samples, SEAL Analytical AA3 autoanalyzer	µg P/L	0.56 µg P/L	< 30% RPD	80% - 120%
Silicate	EPA Method 366.0	GF/F-filtered grab samples, SEAL Analytical AA3 autoanalyzer	µg/L	9.8 / 35.7 µg/L	< 20% RPD	80% - 120%
PN	EPA Method 440.0	GF/F-filters, Exeter Elemental Analyzer	% by mass			99%
PC	EPA Method 440.0	GF/F-filters, Exeter Elemental Analyzer	% by mass			93-99%
Enterolert lab analyses						
Enterococcus	IDEXX Enterolert instructions	Fluorogenic substrate test (Idexx Enterolert Quanti-tray)	cfu/100ml	<10 MPN	1 MPN	95%
Sediment analyses						
Suspended sediment	ASTM Method D3977-97B	Vacuum filtration	mg/L	0.001 mg	0.2 mg/L	90% - 110%

5.5. Data Management

Field and analytical data collected from this project are critical to assess water quality in the study area, assess risks to human health and the environment, and, if necessary, recommend mitigation measures in the form of waste load allocations where required. An information management system is necessary to ensure efficient access to these data, and is created specifically for this ongoing project. Hui O Ka Wai Ola will store data in a Microsoft Access database based on the HIDOH water quality database. The database will be saved in the cloud for continual back-up.

5.5.1. Documentation standards

The PM, QA Officer, monitoring teams and Hui o Ka Wai Ola lab analysts have written procedures for all activities related to the collection, processing, analysis, reporting, and tracking of water-quality data. This documentation must be in either the SOPs or QA manual, and must be readily available to field and laboratory personnel. The documentation of field and laboratory activities must meet the following requirements:

- Data must be documented directly, promptly, and legibly.
- All reported data must be uniquely traceable to the raw data through sample identification numbers that are on each sample as labels, and recorded in the field and laboratory log books.
- All data reduction formulas (such as dilutions) must be documented and include the initials of the data collector.
- Handwritten data must be recorded in ink, and changes crossed out, initialed and dated.
- All original data records include, as appropriate, a description of the data collected, units of measurement, unique sample identification (ID) and station or location ID (if applicable), name (signature or initials) of the person collecting the data, and date of data collection.
- Any changes to the original (raw data) entry must not obscure the original entry (and the change must be initialed and dated).
- The reason for the change must be documented.

5.5.2. Field data management

All field activities must be conducted using the data collection procedures described in this document and the accompanying SOPs.

Data sheets. Monitoring teams use the field data sheets developed for the program (Appendix C) to document sample collection and field measurements. The originals of the field data sheets are photocopied twice by the Monitoring Team Leaders when field work is completed. The original datasheets go to the QA Officer, and an additional copy is kept with the field team. The analytical lab returns the signed data sheets with the coolers and clean sample bottles. In addition to the field data sheets, the QA Officer requires reports from the S-LAB with nutrient data, and from the monitoring teams with suspended sediment data and bacterial data. These reports are stored electronically and in hard copy with the QA Officer.

COC forms. The monitoring teams also fill out COC forms with spaces provided to indicate who relinquished and who received the samples and when. The use of COC forms is set out below in Section 5. The COC form is attached as Appendix C. A COC form will be used for each laboratory that samples are sent to.

Data upload. Field data (pH, turbidity, salinity, DO and temperature), including the results of pre and post verification checks, is first recorded into a field log book will be entered remotely into a spreadsheet (MS Excel or Google Spreadsheets) in a way that will be compatible with the EPA and HI-DOH database guidelines, acknowledging that the spreadsheet is only accessible to the Team Leaders and QA officer. Hard data sheets will be copied and then passed to the Quality Assurance officer, once the data is entered electronically for verification.

QA review. The QA Officer will review the field sheets monthly, and review the entered data, compare a subset of the electronic data to the original data sheets, and correct entry errors. Range checks and other QA/QC methods will be performed before accepting the dataset. Upon entering the data the QA officer will sign and archive the field data sheets. A set of codes will be used to acknowledge if there are QA flags. The data will be coded as P for preliminary until the QA checks are performed and the data is accepted, upon which the A code will be used.

5.5.3. Analytical laboratory data management

Each laboratory will keep a notebook or digital system to register incoming samples.

When samples are received at the laboratory, the laboratory technician will inspect the sample containers and custody records, and verify sample integrity and preservation (temperature). The technician will reconcile the information on the chain-of-custody forms with the sample bottles received. The sample custodian will document any anomalies and report them to the laboratory project manager, who will contact the QA officer. Anomalies will be resolved with the Hui o Ka Wai Ola QA officer. The information on the COC forms will then be entered into the laboratory's information management system.

The S-LAB will report results directly to the QA Officer. The QA Officer will verify sample identification information, review the chain-of-custody forms, document the measurement performance objective for quality control samples and identify/code the data appropriately in the database.

Samples will be tracked from the time of receipt through each stage of sample preparation, analysis, and final reporting using the laboratory's information management system correlated to the unique label identifier associated with each sample. The laboratory will be responsible for tracking all QC parameters and sample results by sample delivery group. Any data that exceed the specified QC limits specified for this project will be documented. QC anomalies that directly affect data quality will immediately be communicated to the QA Officer.

Bacterial testing. Both the SSC and the *Enterococcus* results are read and recorded on the laboratory data sheet that is initiated on sample day and completed when read the following day by that day's sampling team.

5.5.4. Access

All data will be open-access once it has been approved by the QA Officer. Preliminary data will be available with codes indicating its status before it has been through the QA process to project partners.

5.5.5. Reporting

Hui o Ka Wai Ola Interim reports will be produced and distributed in January (data collected from July-December) and July (data collected from January-June). A year-end report will be produced and distributed in January of the following year. The PM is responsible for all report production and distribution. Reports will be forwarded to the distribution list noted at the beginning of this document. Summaries of all reports, highlighting the assessment results, project status, and volunteer achievements, will be distributed to all volunteers and watershed partners.

Raw data will be provided to HI-DOH-CWB in electronic form at least once per year so that it can be included in the 305(b) report. Appropriate quality assurance information may be provided on request.

5.6. Assessment and Oversight

All Hui o Ka Wai Ola field and laboratory data are reviewed by the PM and QA Officer to determine if the data meet QAPP objectives. Review protocols for the QA officer are described in Section 6. In addition, personnel at HI-DOH who are not directly connected to this project will also be contacted to review data once a year, if necessary. Decisions to reject or qualify data are made by the QA Officer.

Review of Hui o Ka Wai Ola field activities is the responsibility of the Monitoring Team Leaders in conjunction with the PM and the QA Officer.

Performance evaluations. Each monitoring team will be accompanied and their performance evaluated and documented by the PM or QA Officer once a year. If possible, volunteers in need of performance improvement will be retrained on-site by the Training Leader during the evaluation. In addition, monitoring team members will attend yearly training renewal workshops.

All training and re-training will be documented, including the name of the trainee, name of the trainer, type of training, and date.

Technical systems review. If errors in sampling techniques are consistently identified, a thorough and systematic onsite qualitative audit will be conducted of facilities, equipment, volunteers, training and record keeping. In some cases, retraining may be scheduled more frequently. Field and laboratory activities may be reviewed by state quality assurance officers as requested. Systems and data quality audits are performed by the QA Officer twice yearly. Any identified procedural problems will be corrected based on recommendations from the QA Officer.

All data review and validation results for both field and laboratory activities must be documented and maintained on file. All activities (including procedures and anticipated results) not conforming to the specifications of this QAPP must be identified and corrective actions implemented. A responsible member of the team, with approval by the QA Officer, will document and keep hard copies of all assessments and response actions (i.e., corrective actions). Documentation includes, at minimum, identification of the sampling/field measurement site, sampling/measurement date and time, sampler's name, description of the non-conforming issue, corrective action taken to remedy the situation, follow-up actions (if applicable), final decision, and approval by the QA Officer. Data verification and validation reports (if issues are identified) or acknowledgment of data verification and validation (if no issues are identified), signed by the QA Officer and PM must be incorporated into all reports submitted to HI-DOH.

6. Data Quality Assessment

The data quality assessment process will use standardized forms to summarize each sample.

6.1. Data validation and verification methods

Once the data have been entered into the Hui o Ka Wai Ola database, the QA Officer will print out the data and proofread it against the original data sheets. Errors in data entry will be corrected. Outliers and inconsistencies will be flagged for further review, or discarded. Problems with data quality will be discussed in the interim and final reports to data users. The data management system will be designed to ensure archival and retrieval of analytical results with all their metadata.

6.1.1. Field Parameters Verification

If a result does not pass QA/QC, the Monitoring Team Leaders will make the initial identification of procedure that did not conform to the SOPs or QAPP protocol, and take corrective action to ensure that protocols are followed.

As part of standard field protocols, any sample readings out of the expected range (Table 5-1) will be reported to the Monitoring Team Leaders and to the QA Officer. A second sample or reading will be taken as soon as possible to verify the initial reading. If the data is outside the normal range, then the data will be noted (flagged) on the data sheet. We will take further actions to trace any sources of error, and to correct those problems. Outliers that result from errors found during data verification will be identified and corrected; outliers that cannot be attributed to errors in sampling, measurement, transcription, or calculation will be clearly identified in project reports.

Samples or field measurements that do not pass QA/QC will be documented with the following information: sample/measurement identification, sample location, sampling date, name of sampler, reason for QA/QC failure, and corrective action taken.

6.1.2. Laboratory Data Verification

For water samples, if an error is detected in the collection, storage or shipping of the samples, the QA Officer and Monitoring Team Leader will be notified. Upon receiving the data sheets and results from the laboratory, the QA Officer will identify any results where holding times have been exceeded, sample identification information is incorrect, samples were inappropriately handled, or calibration information is missing or inadequate. Such data will be marked as unacceptable by the QA Officer and will be coded to include this information in the electronic database. The data will remain in the database but will not be reported to the HI-DOH.

6.2. Reconciliation with data quality assurance objectives

As soon as possible after each sampling event, calculations and determinations for precision, completeness, and accuracy will be made and corrective action implemented if needed. If data quality indicators do not meet the project's specifications, data may be discarded and resampling may occur. The cause of failure will be evaluated. If the cause is found to be equipment failure, calibration/ maintenance techniques will be reassessed and improved. If the problem is found to be monitoring team error, team members will be consulted, and if the problem persists more than once, members will be re-trained.

For analytical samples, the QA officer will document each of the QC samples and the QC purpose (controlling bias, accuracy, etc). If the data quality objectives are not met, additional QC samples will be used to identify where in the process there is room for improvement or changes.

Any limitations on data use will be detailed in both interim and final reports, and other documentation as needed. If failure to meet project specifications is found to be unrelated to equipment, methods, or sample error, specifications may be revised for the next sampling season. Revisions will be submitted to the state quality assurance officers for approval

7. References

ASTM (American Society for Testing and Materials). 1997. Standard test methods for determining sediment concentration in water samples (ASTM Designation: D-3977-97). ASTM, West Conshohocken, Pennsylvania.

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South Yuba River Citizens League. Water Quality Monitoring Field Procedures Manual. Feb 2012. 7th Edition.

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Appendix List

Appendix A- Standard Operating Procedures

- Appendix A-1 Preparation
- Appendix A-2 Calibration of field instruments
- Appendix A-3 Field measurements with hand-held instruments
- Appendix A-4 Nutrient sample processing
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Appendix B – Site List

Appendix C – Forms for sampling and analysis

Appendix D – Quality control guide

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Appendix F – S-LABs QAPP; Proficiency tests of S-LABS

Version Notes

v21

February 2017

- Clarified that monitoring methods are following the methods specified in HAR 11-54. This included changing the name of the sediment analyses to Total Suspended Solids (instead of SSC), although functionally the procedure is the same.
- Changed tense from future to present
- Replaced Myron Honda with Terence Teruya as the DOH Quality Assurance officer
- Updated site map with divisions and new sites
- Added pre and post field equipment checks to the data forms, as a responsibility of the team leaders.
- Fully added S-LABs QAPP to this version
- Deleted language about external data sources

v22

April 2017

- Added signature page!
- Added Data Quality Objectives per Terry Teruya's request
- Updated organizational chart.
- Slightly reworded the opportunistic sampling section
- Added Surfrider North Shore sites
- "Working group" changed "steering committee" in Roles and Responsibilities
- Removed reference to a technical advisory group (TAG) and the members therein. The group had not functioned in this capacity over the last 3 years. Consultation of process will be left to consultation with the DOH QA Officer and Program Manager directly.

Appendix A: Standard Operation Procedure
Field Sampling with Hand-held Instruments

Introduction

The mission of Hui O Ka Wai Ola is to generate quality-assured coastal water-quality data, and to provide this data to HIDOH, other resource agencies, non-governmental organizations, researchers and the public.

Specific goals of Hui O Ka Wai Ola are to 1) increase community capacity for long-term monitoring water quality in Maui coastal waters; 2) generate quality-assured reliable data that can be used to assess coastal water quality conditions and detect temporal trends that can augment HIDOH-CWB beach monitoring program sampling; 3) thereby empowering community and government mangers to take action to improve coastal water quality, benefiting the coral reef ecosystem and people alike.

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Chapter 1: Preparation

Safety

One of the most critical considerations for a citizen monitoring program is the safety of its volunteers. All volunteers are trained in safety procedures and should carry a set of safety instructions and the phone number of their monitoring team leader. Safety precautions cannot be overemphasized.

The following are some basic safety rules. At the site:

- Always monitor with at least one partner. Always let your monitoring team leader know where you are, when you intend to return, and what to do if you do not come back at the appointed time. Do not rely on cell phones, as a site may lack adequate reception.
- Know any important medical conditions of team members (e.g., heart conditions or allergic reactions to bee stings).
- Listen to weather reports. Never compromise your safety if severe weather is predicted or if a storm occurs while at the site.
- Use caution when entering the water. Never turn your back to the surf and waves. You should not be sampling in water greater than knee deep. If you are uncomfortable with the level of surf and are concerned for your safety do not go in the water! The most important thing is your safety. Data can be collected at another time.
- If you drive, park in a safe location. Ensure your car does not pose a hazard to other drivers and do not block traffic.
- Never cross private property without the permission of the landowner. For sites requiring access via private property, Hui O Ka Wai Ola will obtain permission for our volunteers but you may need to check-in before you monitor such a site.

Field equipment pickup

Before packing up the equipment, check the calibration log to ensure that all calibrations are up to date on the meters and the probes. In addition, make sure the battery power for each meter is sufficient for the field sampling session. If necessary, put new batteries in the meters and reset the date and time before leaving the regional laboratory.

In addition to the measurement equipment, collect supplies that may be required for collection and measurement of the in-situ water quality parameters (Chapter 3), for water quality filtration (Chapter 4) and for packaging samples for *Enterococcus* analysis (Chapter 5). The following list can serve as a guideline:

1. 1.5 gallon bucket
2. 100 ml bottles for turbidity samples
3. Distilled water
4. Field guide and equipment user manuals
5. Field notebook
6. Data sheets and clipboard
7. Chain of custody forms
8. Cooler with blue ice
9. Ziplocks for chain of custody forms
10. Extra batteries for meters
11. Pens for filling in data sheets, sharpies for writing labels
12. Label tape
13. Kim-wipes and paper towels
14. Gloves

15. Scissors
16. Camera
17. First aid kit

The following equipment is necessary for **in-situ measurements**:

1. Digital thermometer
2. Hach 2100Q turbidimeter
3. Hach HQ40d meter with the following electrodes:
    a. IntelliCAL LDO101 DO sensor
    b. IntelliCAL CDC401 conductivity probe
    c. IntelliCAL PHC101 pH electrode

The following equipment is necessary for **field water sample collection for nutrient sampling**:

1. Sample bottles (clear, HDPE, 125mL, acid-washed)
2. Filters (GF/F, 25mm)
3. 60-mL syringe with luer locks

The following equipment is necessary for collecting bacterial information with the Enterolert system:

1. Whirlpack bags
2. Gloves

Labeling

Any samples that will be brought back to the local laboratory either for testing or shipping to an analysis lab must be labeled. It is always best to label bottles and samples *before* you get to the field, if possible. Hui O Ka Wai Ola has a strict labeling scheme to prevent sample mix-ups.

Each sample collected will be labeled with the following information prior to or during the collection of the sample:

a. a unique sample number,
b. sample type,
c. name of collector,
d. date and time of collection, and
e. place of collection

The sample number will follow this code: 3-letter site location code, two-digit year, two-digit month, two-digit day – sample type code (N for nutrients, S for suspended sediment) – sample number. Letters are used for sample duplicates. For instance, a sample at Honokowai Beach Park might be: HBP150601-N-1. The initials of the sampler will be listed separate from the sample ID. For field measurements, list the sample number at the top of your sheet.

Observations

On the field data sheet, include observations including the tidal information, time of day, wind speed (see Table 1) and direction and wave state. Note the moon phase if possible, and the number of swimmers in the water near the sample site.
Note the nearest **low tide** for tidal information.

Table 1: Beaufort wind scale

Estimating Wind Speed			
knots		**Effects Observed at Sea**	**Effects Observed on Land**
under 1	calm	Sea like a mirror	Calm; smoke rises vertically
1-3	light air	Ripples with appearance of scales; no foam crests	Smoke drift indicates wind direction; vanes do not move
4-6	light breeze	Small wavelets; crests of glassy appearance, not breaking	Wind felt on face; leaves rustle; vanes begin to move
7-10	gentle breeze	Large wavelets; crests begin to break, scattered whitecaps	Leaves and small twigs in constant motion; light flags extended
11-16	moderate breeze	Small waves 2-4 feet high, becoming longer; numerous whitecaps	Dust, leaves, and loose paper raised up; small branches move
17-21	fresh breeze	Moderate waves 4-8 feet high taking longer form; many whitecaps; some spray	Small trees in leaf begin to sway
22-27	strong breeze	Larger waves 8-13 feet high forming; whitecaps everywhere; more spray	Larger branches of trees in motion; whistling heard in wires

Chapter 2: Calibration

PRINCIPLE:

Calibration and verification are essential to the quality assurance program, and are performed regularly.

A. Calibration

Calibration involves adjusting the instrument to read a true value. This is usually done by digitally adjusting the instrument per the instruction manual. Each sensor is calibrated according to the schedule presented in Table 2. Only standards that have not expired will be used. Calibration values before and after the calibrations will be recorded in a lab notebook, along with calibration coefficients associated with each sensor.

Table 2: Calibration schedule for each of the five field parameters measured.

Instrument	Parameter	Schedule	Calibration standards
NSIT-traceable waterproof digital thermometer	Temperature	None (factory-calibrated)	n/a
Hach HQ40d meter, IntelliCAL CDC401 conductivity probe	Salinity/ conductivity	Quarterly or as needed	0 ppt, 35 ppt
Hach HQ40d meter, IntelliCAL LDO101 luminescent/optical DO sensor	Dissolved oxygen	Yearly	Air (100% saturation)
Hach HQ40d meter, IntelliCAL PHC101 pH Electrode	pH	Monthly	Buffer solutions at pH 4, 7, 10
Hach 2100Q turbidometer	Turbidity	Yearly or as needed	Stable Cal calibration standards (20, 100, 800 NTU); Deionized/turbidity-free bank < 0.25 NTU

B. Verification

Instrument verification uses secondary standards or known values to assess whether the instrument is still performing within a specified range. Verification does not change the readings of the instrument.

Sensors are verified before and after each week's sampling efforts (within 7 days) and logged on the form presented in Appendix C.

The Hach 2100Q turbidimeter should be checked with the secondary Gelex standards before and after each field session.

Table 3: Verification for each of the five field parameters measured.

Instrument	Parameter	Field-check acceptance criteria
NSIT-traceable waterproof digital thermometer	Temperature	Within 1C of the NIST value
Hach HQ40d meter, IntelliCAL CDC401 conductivity probe	Salinity/ conductivity	± 3% (for a 35 ppt sample)
Hach HQ40d meter, IntelliCAL LDO101 luminescent/optical DO sensor	Dissolved oxygen	Between 80 and 120%
Hach HQ40d meter, IntelliCAL PHC101 pH Electrode	pH	± 5 % of calibration solution
Hach 2100Q turbidometer	Turbidity	± 5 % of Gelex standards (5, 50, 500 NTU). Deionized/turbidity-free bank < 0.25 NTU

B. METHODS: VERIFICATION

Because turbidity is a sensitive parameter, turbidity is field-verified before and after each sampling day. Temperature, pH, DO and salinity are verified in the lab at the beginning and end of each week of sampling. The following instructions are to be repeated for all probes verified.

Turbidimeter verification check

1. Use the Gelex secondary standards to perform QC check of the turbidimeter.
2. Handle the Gelex standards by the lid. Avoid touching the sides of the glass vial.
3. Power the turbidimeter on, insert the calibrated Gelex standard into the well, close the door on the sample cell, and push the READ button.
4. Record the reading on the data sheet for that particular Gelex standard.
5. Repeat the process with all three of the Gelex standards.
6. Insert a sample cell with distilled water into the turbidimeter and take a reading of the distilled water to use as a field blank. Record this reading on the data sheet.

Water quality probe verification check

1. Use the check standards on the pH (page 49 in the user's manual), conductivity (page 65 in the user's manual), and dissolved oxygen probes (air) to verify the probes are within standards before leaving the regional laboratory.

If any of the acceptance criteria are not met:

1. Try again. Attempt verification again using the same secondary standards.
2. If the second verification fails, the probe may have a physical or chemical defect. Contact the lab manager. Do not use the probe for field work until the issue is resolved.
3. Continue on with the next probe or instrument. If that also fails, there could be an issue with the instrument or with the standards.

Chapter 3: Water collection for in-situ measurements

PRINCIPLE:

It is important that the water collection for in situ measurements happens at the *same place, same time* and from the *same pool of water* each time.

MATERIALS AND EQUIPMENT

- 1.5 gallon bucket
- Sample bottles

METHODS:

1. Submerge the bucket/bottle 6 to 12 inches below the surface facing into the oncoming waves.

2. Cap the turbidity bottle while it is still under the water.

PROCEDURAL NOTES:

General sampling techniques for in-situ measurements:

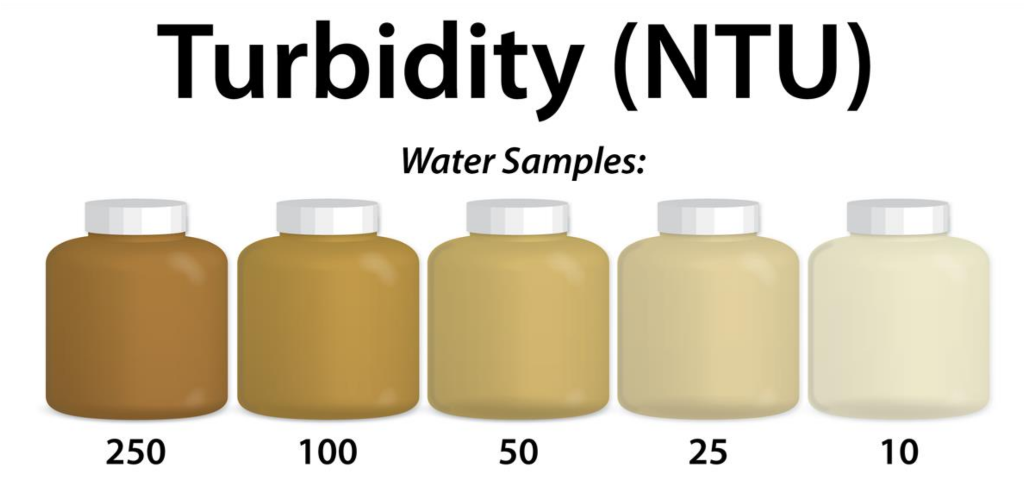
Because it can be hazardous to stand in the ocean where the surf is breaking while attempting to use a hand-held meter, water for four of the in-situ measurements ***will be collected in a 1.5 gallon bucket and taken back away from the ocean to conduct the measurements for temperature, salinity, pH, and dissolved oxygen*****.** Water for the turbidity measurements will be collected in a smaller bottle that can be re-agitated to provide the most accurate turbidity measurements.

In general, you should always collect water samples with the water moving towards you. Always face away from the shoreline at a depth no more than knee deep and rinse the bucket/turbidity bottle three times with the water to be tested. When collecting the sample, avoid disturbing any silt that may have settled on the bottom.

Measurements on water samples should be made in a shady area if possible, avoiding direct sunlight. The samples should be tested as quickly as possible once the water is removed from the water body being sampled.

Turbidity measurements

A turbidity meter consists of a light source that illuminates a water sample and a photoelectric cell that measures the intensity of light scattered at a 90 degree angle by the particles in the sample. It measures turbidity in nephelometric turbidity units (NTU). The meter can measure turbidity over a wide range from 0 to 1000 NTUs. These values can jump into hundreds of NTUs during runoff or flood events.



MATERIALS AND EQUIPMENT:

- Hach 2100Q turbidimeter
- Distilled water in squirt bottle
- Cloth to clean sample bottles

METHODS:

1. Review the general techniques for turbidity measurements in the turbidimeter user guide as required. Pay particular attention to handling of the sample cell to avoid compromising the measurements.

2. Empty the distilled water from a clean sample cell.

3. Gently agitate the water sample to be tested to ensure that any sediment that may have fallen out of suspension is re-suspended in the sample.

4. Rinse the clean sample cell 3 times with the water sample, taking care to handle the sample cell by the top of the cell to avoid getting fingerprints on the sample cell glass.

5. Fill the sample cell to the line taking with the water to be sampled.

6. Insert the sample cell into the turbidimeter sample compartment with the arrows lined up on the cell and the meter.
7. Close the instrument sample compartment door.
8. Make sure the instrument is measuring in NTUs and averaging is on.
9. Press the READ button and record the reading on the data sheet.
10. Remove the sample cell from the instrument compartment and discard the water sample. Rinse the sample cell 3 times with distilled water, taking care to avoid getting water on the outside of the sample cell. Any excess water can be gently blotted with a Kim-wipe cloth. Fill the sample cell to the line with distilled water and test the distilled water to ensure the sample cell is clean. The reading should be < 0.1 NTU. If necessary, repeat the rinse and re-test until the cell is clean. Sample cells should be stored with distilled water.

PROCEDURAL NOTES:

- The turbidimeter (Hach 2100Q) should be placed on a dry flat surface while making measurements.

Grab samples:
How to collect a "grab" sample for turbidity

- If needed, label the bottle with the site number, date, time and your name or initials. Use waterproof pen.
- Remove the cap from the bottle just before sampling. Avoid touching the inside of the bottle or the cap. In high flows, use a sampling pole. Rinse the sampling bottle on the pole 3 times prior to decanting water into sample bottle.
- It is best to collect samples while standing on a rock. If you need to wade, try to disturb as little bottom sediment as possible. Be careful not to collect water that contains bottom sediment. Collect the water sample in front of you (towards the ocean).
- Hold the bottle near its base and immerse it (opening upwards) below the water surface. Collect a water sample 6 to 12 inches (~0.3m) beneath the surface or mid-way between the surface and the bottom if the water level is shallow.
- Turn the bottle underwater into the current and away from you in an upstream direction. Fill the bottle completely and make sure there is no headspace in the container.
- Check off the test on your appropriate field data sheet and record the time. This is important because it tells the monitoring coordinator that this sample has been collected from your site.
- The hold time for turbidity is 24 hours

Salinity (Conductivity), pH and Dissolved Oxygen

PRINCIPLE:

Salinity (Conductivity)

Salinity is a key factor affecting the physical make-up of an estuary, and is defined as the concentration of dissolved salts in the water, usually expressed in parts of salt per thousand parts of water (ppt). Seawater averages 35 ppt (3.5% by weight) in the open ocean and 27 to 33 ppt (2.7 to 3.3% by weight) in coastal waters. Fresh water contains few salts - drinking water usually has a salinity of less than 0.5 ppt. A liter of Casco Bay water would typically contain 28 to 34 grams of dissolved salts. In other words, a quart would contain about an ounce of salts.

The surface salinity levels within the Bay, especially near the coast, vary with many factors, including the tides and the volume of fresh water flowing into the Bay. Salinity tends to decrease in the spring when heavy rainfall, the release of groundwater, and melting snow combine to greatly increase the amount of fresh water flowing in. In late summer and fall, particularly during periods of drought, higher levels of salinity may extend farther up some reaches of the estuary as the fresh water flow decreases. Some decreases in salinity can be attributed to human activities which reduce the water-holding capacity of the land (such as paving or removal of vegetation) or directly accelerate fresh water discharge (such as storm sewers). On the other hand, excessive withdrawals of water from the fresh water portion of a tributary (for agricultural use, drinking water, etc.) can elevate salinity near the mouth of this tributary.

Salinity levels also vary vertically from top to bottom. In general, salinity increases with depth. The fresh water coming down river is less dense than the heavier seawater, so the entering fresh water tends to float on top of the seawater and may not mix immediately. The volume of entering fresh water is also the greatest closest to land. The net result is a wedge of lighter fresh water lying over the heavier seawater, with poorly defined edges that are continually mixed by wind, waves, and tides. In shallow waters, the mixing of top and bottom layers can obscure this "wedge" completely.

Dissolved Oxygen

Dissolved oxygen (DO) is one of the most important indicators of the quality of water for aquatic life. It is essential for the basic metabolic processes of animals and plants inhabiting our coastal waters. Dissolved oxygen is measured in milligrams per liter (mg L^{-1}). When oxygen levels fall below about 3 to 5 mg L^{-1}, fish and many other marine organisms are stressed and some can not survive. Dissolved oxygen is a particularly sensitive constituent because other chemicals present in the water, certain biological processes, and physical factors such as temperature and water clarity exert a major influence on its availability throughout the year.

The maximum amount of oxygen water can hold depends a great deal on its temperature and salinity. A DO test (using a meter or chemical kit) tells you how much oxygen is dissolved in the water, but it does not tell you how much oxygen the water is capable of holding at the temperature and salinity at which it was tested. Warmer water holds less dissolved oxygen; as water approaches its boiling point, it can hold almost no oxygen. Dissolved oxygen also decreases with increasing salinity. When water holds all the dissolved oxygen that it can at a given temperature and salinity, it is said to be 100 percent saturated with oxygen. If water holds only half that amount of DO at the same temperature and salinity, it is said to be 50 percent saturated. The table below shows this relationship for various temperatures and salinities.

Table 3: Potential dissolved oxygen levels in milligrams per liter (mg/l) at sea level

TEMPERATURE	SALINITY			
°C	FRESH WATER 0 PPT	BRACKISH WATER 5 PPT	NEARSHORE WATER 32 PPT	OPEN OCEAN 35 PPT
0	14.6	14.1	11.6	11.3
5	12.8	12.4	10.3	10.1
10	11.3	11.0	9.2	9.0
15	10.2	9.9	8.4	8.3
20	9.2	9.0	7.6	7.5
25	8.4	8.2	7.0	6.9
30	7.6	7.4	6.2	6.1

pH

pH is a measure of how acidic or basic a solution is. Pure distilled water has a pH of 7.0 and is said to be neutral - but pure distilled water is rarely found in nature. The pH values of natural waters are controlled by the salts and gases dissolved in them. Seawater typically has a pH of 8.1 to 8.3. Because its pH is greater than 7.0, it is said to be basic or alkaline (the two terms are synonymous). The pH of seawater is fairly stable because it's highly buffered - that is, the water contains pairs of ions which react to damp down changes in pH (for more information on buffers, see the box on page 19).

The strong buffering and constant motion of seawater tend to minimize variations in pH. Short-lived, local variations may be caused by intense phytoplankton blooms, or at locations where industrial discharges and sewer outflows enter the ocean, or where there are large influxes of fresh water. Natural fresh water typically has a lower pH than seawater. Rain water usually has a pH of 5.6 to 5.8. Because its pH is less than 7.0, even unpolluted rain water is said to be acidic. So-called "acid rain" has an even lower pH due to atmospheric pollutants.

pH is defined as the negative logarithm of the concentration of hydrogen ions; the higher the concentration, the lower the pH. In any given aqueous solution, a certain proportion of water molecules dissociate to form hydrogen (H+) and hydroxyl (OH-) ions:

$$H2O \rightarrow H^{+} + OH^{-}$$

Materials and Equipment

- Hach HQ40D probe

Methods:

Before attaching any probes, make sure the date and time are set correctly on the Hach HQ40d meter. If the date and time are not set properly before the probes are attached for the first time, the probes will retain the incorrect date and time for the remainder of their service lives. Therefore it is essential that the date and time be checked before starting to use the meter. Without connecting the probes to the meter, place all 3 probes in the bucket with the collected water sample so that the probes come to the ambient temperature of the sample. Allow the probes to sit in the water for at least 5 minutes before connecting them to the meter to take measurements of the sample. While the probes are soaking in the sample, the turbidity measurements can be made.

Review the instructions in the users manual for the hand-held meter and data probes as required.

1. Two probes at a time can be attached to the meter. **Begin with the pH and conductivity/salinity probes.**

2. Switch the meter display so that the pH probe data i**s displayed. To measure the pH, place the probe in** the sample and press the GREEN/RIGHT key under Read. Once the measurement has stabilized, the lock icon will appear and you can record the measurement on the data sheet.

3. Simultaneously, the conductivity probe can be placed in the sample. Once the pH reading has stabilized switch the meter to display the conductivity probe. To measure salinity, press the GREEN/RIGHT key under Read. When the measurement has stabilized, the lock icon will appear and you can record the measurement on the data sheet.

4. Remove the probes from the water sample and rinse the probe with distilled or de-ionized water. Blot the probes with a Kimwipe to remove any remaining water droplets. Place the pH probe back in the 3M KCl solution vial. Make sure to wipe any water that might have gotten on the meter off and store the meter and probes back in their case for transport.

5. **Be sure to log your results both in the field notebook**

Water temperature

PRINCIPLE:

Water temperature in Hawaii fluctuates with the season, as shown in Table 2 (in Fahrenheit). Given the frequency of bleaching events in 2015 and 2016, collecting water temperature can help track localized variations between sites.

Table 4: Water Temperature Table of the Hawaiian Island Coast

Location	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Honolulu Oahu Island	76	76	76	78	79	80	80	81
Hilo Hawaii Island	72	71	72	72	74	74	75	75
Kahului Maui Island	75	75	76	78	79	79	80	80
Kawaihae Hawaii Island	77	77	78	79	80	81	81	80
Mokuoloe, Oahu Island	74	74	75	77	79	79	80	80
Nawiliwili Kauai Island	77	77	78	79	81	82	82	83

MATERIALS:

- Hach WQ40D
- Digital thermometer

METHODS:

1. **Presoak:** Presoak the thermometer with 1” of water, in the shade, upright in a container for at least 10 minutes, with the power off. Be sure the water level stays below the digital display on the thermometer.

2. **Take measurements**: Preferably dip the thermometer into the water. If the sample is being taken directly from the water, stand so that a shadow is cast upon the site for temperature measurement. If you are using a sampling arm, acquire a fresh sample of river water, stand in the shade, and stir gently. The thermometer should be held by its top and immersed into the water. Allow the thermometer to stabilize for at least one minute, then without removing the thermometer from the water, read the temperature to the nearest 0.1°Cand record.

3. The digital thermometer should be used for quality control of the Hach temperature meter, and follow the same process described above.

PROCEDURAL NOTES:

Note: It is best to begin soaking the thermometer in and leave it while the rest of the measurements are taken – up to 10 to 15 minutes – to get an accurate reading. If one waits longer, the water will equilibrate with the air temperature.

Keep the bucket out of the sun to more accurately measure temperature.

Data quality

When to take a 4th measurement:

- Temperature: If there is a difference of 1ºC or greater between any of your three measurements
- pH: If there is a difference of 0.2 or greater between any of your three measurements
- Conductivity: If there is a difference of greater than 10 uS between any of your three measurements
- Dissolved Oxygen: If there is a difference of 0.4 ppm or greater between any of your three measurements
- Turbidity: If there is a difference of 0.2 NTU or greater between any of your three measurements

The cap of the pH probe always needs to be filled with 3M KCl solution to keep the sensor moist.

Chapter 4: Nutrient sample processing

PRINCIPLE:

"Nutrients" describe nitrogen and phosphorus-based compounds that are used by microalgae and bacteria for growth. The coastal waters of Hawaii are considered to be nutrient-limited – meaning that nutrients are the limiting factor for the growth of phytoplankton. Measuring nutrient concentrations accurately can help to track potential sources of nutrients.

Nutrients in Hawaii are often sorbed on to sediments, so it is important to filter the sample to remove the potential for sediments to bind to nutrients. For this reason, we also use acid washed bottles in order to minimize binding with the side walls of the bottle.

MATERIALS AND EQUIPMENT

- 125 mL HDPE acid-washed sample bottle
- In laboratory or field filtration equipment, including filter, filter forceps, filter housing and vacuum device.

METHODS:

1. Collect a sample from the wash zone (approximately knee height) in the 125 mL HDPE sample bottles, as directed above.

Filter the sample into the bottle being used for water quality (nutrient) analysis.

2. Hook up a 60-mL syringe to a prepared Swinx filter housing with filter.
3. Prepare an acid-washed 125-mL HDPE bottle to collect the filtrate into.
4. Place a filter in the filter housing using forceps (this can either be a Nalgene 500mL rig or a 25mm Swinnex holder combined with a 60-mL syringe.

For Nalgene rig:

5. Pour ~ 250 mL of the sample water into the reservoir atop the filter rig, and begin pumping until vacuum occurs and flow is continuous. Vacuum pumping can either be with a hand pump or with a vacuum pump. In either case, make sure that the vacuum line is attached to the filter housing.
6. Make sure that the seal is working. Add an additional 250 mL until the total 500 mL sample is processed. Collect ~80mL of the filtrate (bottom part) into the 125 mL bottle. Label the sample as described in Chapter 1.
7. Once the entire 50 mL volume has passed through the filter, disassemble the filter rig

For Swinnex hand filtration:

8. Place a filter (white, not blue paper) in the Swinnex with forceps. Be sure that the o-rings are in place. Use a smalled spray of DI water to make sure the filter stays in place.

9. Remove the plunger for a 60mL syringe, and attached the Swinnex on the syringe. Carefully pour 50mL of water to be filtered in the syringe. Use the plunger to filter the water into a 125mL bottle.

If particulate N and C are to be analyzed:

a. Using a set of tweezers, carefully fold the 0.2um filter and place in a folded up piece of aluminum foil. The foil can then be placed in a plastic filter holder or Ziploc bag for labeling.

b. Label the filter with P for particulate N and particulate C. Label the filtrate (the water that has been filtered) using N for the sample type code.

Store the sample:

10. Store the nutrient sample upright at -20°C in a cooler with wet or blue ice – after frozen it does not need to be upright anymore.

11. Store the filter and sample once back in the regional laboratory in a freezer kept at -20°C.

12. Record the temperature of the water and other specifications in the log book and on the chain of custody form. Copy the salinity from the in-situ measurement and volume of the sample.

PROCEDURAL NOTES:

- The above procedure can be done in the field or in the lab, but the lab may be a more controlled environment and easier to work in.
- Be careful of changing water conditions when collecting sample. Wear gloves to prevent contamination.
- To collect the sample water for nutrient analysis use a 1-L HDPE bottle that you can pour into smaller bottles.
- For suspended sediment, use a 500-mL HDPE bottle.
- Remove the cap from the bottle just before sampling.
- Avoid touching the inside of the bottle or the cap.
- In high flows, use a sampling pole.
- Rinse the sampling bottle on the pole 3 times prior to decanting water into sample bottle.
- Collect the sample from wading depth. Try to disturb as little bottom sediment as possible. Be careful not to collect water that contains bottom sediment. Stand facing upstream. Collect the water sample in front of you (upstream).

- Hold the bottle near its base and immerse it (opening upwards) below the water surface. Collect a water sample 6 to 12 inches beneath the surface or mid-way between the surface and the bottom if the stream reach is shallow.
- Turn the bottle underwater into the current and away from you in an upstream direction. Fill the bottle completely and make sure there is no headspace in the container.

QUALITY CONTROL PROCEDURES

- Collect split field samples every 20 samples.

Chapter 5: Suspended-sediment sample processing

PRINCIPLE:

Sediments act as both primary and secondary pollutants in the coastal environment. Sediments, especially fine sediments, can reduce water clarity and reduce the amount of light that is available for photosynthesis in coral reef ecosystems.

The suspended sediment concentration (SSC) method described here accounts for both terrestrial and marine-originated sediments. SSC in the coastal zone can also include suspended solids of biological origin.

The reason we are interested in suspended sediment as a variable is that we want to correlate the turbidity measurements we are doing with field instruments in real time with laboratory data.

MATERIALS AND EQUIPMENT:

- 500 mL filtration units
- 47 mm filters (GF/F)
- Drying oven at 70°C
- Analytical balance
- Filter forceps
- 47mm petri dishes
- Aluminum foil

PROCEDURE:

1. Collect the sample as described above for nutrient analysis. For suspended sediment, use a 500-mL or 1000-mL HDPE bottle.
2. After the sample is collected, store the sample on ice until the sample is either
   a. Shipped to S-LABS for analysis or
   b. Analyzed in a satellite lab on Maui.

   The procedure below describes the protocol for all laboratories.

Prepare the filters:

3. Pre-weigh a 47 mm GF/F filter using the analytical balance. Weigh each filter three times, and record each value. Store the filter in a dry place and use within one week. Humidity can affect the weight of the filters.
4. Place the pre-weighed filter in its own 47 mm petri dish or similar plastic container.

5. Write the average of the three values on the cover of the petri dish.

Filter the sample:

6. Use the filter forceps to place a pre-weighed 45um filter on the filter pad of the filtration unit.

7. Use a small drop of deionized water to wet the filter.

8. Secure the unit together by twisting the top on to the bottom of the unit.

9. Attach the vacuum tubing to the unit and turn on the vacuum. Listen or look for possible leaks.

10. Pour the entire bottle (~500mL) into the top portion of the rig. Use the vacuum pump to create suction.

    a. Measure the filtrate and record the exact amount filtered. Note that the filter itself with absorb some amount of water and this will be corrected in the final data analysis.

    b. If there is an additional 500 mL, empty the bottom part of the rig into the sink (this is waste) and use the same filter to filter the next 500 mL.

11. Turn off the vacuum and release the pressure slowly by opening one of the small valves.

12. Using forceps, collect the filter in an aluminum foil piece by folding it first in quarters. Write the sample number of the foil using the special pen that can go into the oven.

Dry the sample in the oven:

13. Store the aluminum foil package in a plastic container for filters and dry for 24 hours at 70°C.

Weigh the sample

14. Samples should be allowed to cool and stabilize after being removed from the oven.

15. Weigh the samples three times on an analytical balance, recording the value on the appropriate form or lab notebook.

16. For a single filter, wait an hour and record a new value. If the value disagrees more than 10% from the original weight, wait until the samples acclimate to the lab and stabilize in weight.

PROCEDURE NOTES

- Gloves are recommended to maintain the quality of the samples.

- If the vacuum is not suctioning correctly, check the various o-rings that are part of the filtration units.

Quality Control Procedures

- For each sample site, duplicates will be analyzed.
- Samples will be weighed three times before and after drying. An average of each will be used in the final calculation.
- Blanks will be run every 20 samples. Blanks that have readings above the resolution of the scale will be have readings discarded, and the QA officer and lab manager will be notified.

References

Standard Methods for Examination of Water and Wastewater, 18th Edition, APHA.

Chapter 6: *Enterococcus* sample collection and measurement using the IDEXX Enterolert and Quanti-tray system

PRINCIPLE:

Importance of Bacteria
Enterococcus bacteria are generally not harmful by themselves but do indicate the possible presence of pathogenic (disease-causing) bacteria, viruses, and protozoans that also live in human and animal digestive systems. Elevated levels of these bacteria can cause health problems (including ear infections, stomach upset and urinary tract infections in women), cloudy water, unpleasant odors, and an increased oxygen demand (the amount of oxygen consumed by microorganisms in breaking down waste). The EPA recommends *Enterococcus* as an indicator of health risk from water contact in recreational waters.

MATERIALS:

- Sterile 100 mL sample bottle or whirlpack
- Cooler with blue ice
- Enterolert™ (Idexx) reagent snap-packs
- 90 mL sterile DI water blanks
- Quanti-Tray 51-well trays
- Quanti-Tray heat sealer

METHOD:

Collect a Bacteria Sample:

1. Label the bottle or Whirlpack with the site number, date, time and your name.
2. Remove the cap from the bottle just before sampling. Avoid touching the inside of the bottle or the cap. If you accidentally touch the inside of the bottle, please report it to the monitoring coordinator and write it on data sheet. Our sterile bottles sometimes contain a pellet of sodium thiosulfate. This is for tap water samples, not river water samples. It can be left inside. Its presence is not important.
3. Wade in and try not to disturb the bottom or collect water with bottom sediment. Stand facing the water, or collect while kneeling on a rock.
4. Hold the bottle near its base and immerse it into the vertical water column with the opening upward. Collect a water sample 8 to 12 inches beneath the surface or mid-way between the surface and the bottom if the stream reach is shallow.
5. Turn the bottle underwater into the current and away from you in an upstream direction.

6. Fill to the black line. Do not fill the bottle completely so that the sample can be shaken just before analysis. Recap the bottle carefully, remembering not to touch the inside.

7. If you are assigned a WhirlPak, be sure it is labeled and wear gloves.

8. Tear off the top seal on the perforated line. Pull the short White tabs to open the pak; tightly grab the yellow tabs and fill the pak with river water facing upstream, in the middle of the water column. It must be filled to the 4 oz line.

9. Holding the yellow tabs, spin the pak away from you to close the opening, pull tight and TWIST the yellow tabs tightly to seal the pak. Hold the pak upside down and squeeze gently, NO WATER should leak out.

10. Store the pak upright in the cooler to avoid leaking.

11. Indicate bacteria collected on your field data sheet with the time collected.

12. Place samples in the cooler with blue ice for transport to the local Maui lab.

Bacterial Sample Processing with Enterolert:

1. Turn on IDEXX Quantitray sealer. Allow about 10 minutes for it to warm-up. Sealer is ready when the green light is lit on the front of the sealer.

2. Check the incubator temperature and adjust if not 41°C ± 0.5°C

3. Wash hands with soap and water and don powder-free disposable gloves for protection.

4. Sterilize laboratory working surface with isopropyl alcohol.

5. Place unopened seawater sample bottles or cups with unopened WhirlPaks on work surface. Be sure each sample container is marked with the sample source location. (Samples must be no older than 6 hours and must have been stored on ice.)

6. Place unopened 100 mL sterile sample bottles on work surface and label each with the corresponding sample source location.

7. Remove the correct number of Enterolert media packets from refrigerator storage and place on the work surface.

8. Process each sample and corresponding laboratory data sheet separately.

9. Fit a new sterile pipette to the pipette gun. Open a seawater sample container and transfer 10 ml of sample water to the corresponding sterile 100 ml sample bottle to make a 1:10 dilution. (*If you must put the bottle cap down, place it open side down on the sterile work surface.*) Place the pipette on the work surface in case you have to make a second attempt with THIS sample.

10. Add 90 ml of distilled or deionized water to the sample bottle. (Fill to the 100 ml line.)

11. Take one Enterolert packet, tap it to settle contents, and snap it open away from you. (*Do not breathe any Enterolert dust.*) Add the contents to the sample bottle, being careful not to insert your fingers or the packet into the bottle.

12. Replace the bottle cap and gently swirl the bottle until the Enterolert dissolves. (*About one minute.*) Do not shake the bottle and make bubbles.

13. Mark a Quantitray with the following information. Use a marking pen to avoid puncturing the fragile Quantitray backing. (*If this step is performed in advance for all of the samples, be sure to match the sample with the proper Quantitray.*)

    - Sampler's name
    - Tester's name
    - Date
    - Time collected
    - Sample site
    - Time into incubator
    - Time out of incubator (Next day)

    Results next day:

    - Number of positive small wells
    - Number of positive large wells

    MPN * number from IDEXX MPN Table 10 x MPN

    * MPN = Most Probable Number of Colony Forming Units

14. After the Enterolert has dissolved, open the sample bottle. Pick up the appropriate Quantitray in one hand and gently bow it to form a gap between the cells and the backing. The backing tab may be used to assist this, but do not insert fingers into the Quantitray. (*If the backing rips, it will not seal.*) Gently pour the sample into the Quantitray. Gently tap the Quantitray to remove any bubbles.

15. Place the Quantitray on top of the sealer's orange rubber mat. Run the mat and Quantitray through the sealer with the small wells first.

16. If the Quantitray seals without damage, discard the pipette and the remaining seawater sample, and return to **step 9** for the next sample, if any.

17. Place the sealed Quantitray(s) in the 41°C ± 0.5°C incubator for 24 hours (28 hours maximum). At this point, the Quantitrays are biohazardous material.

Clean up:

18. Clean the work area and dispose of gloves, sample bottles, pipettes, and empty packets in regular trash. Turn off the Quantitray sealer. (Note: Pipettes can be autoclaved and reused.

19. Remove the Quantitrays from the incubator and read each one with an ultraviolet lamp. Mark each positive (blue) cell with a marking pen and record the number of small and large positive cells.

Read the data after 24-28 hours:

20. Read the results by placing a 6-W, 365 nm wavelength UV light within 5 in of the tray in a darkened environment. Blue fluourescence indicates the presence of enterococci.

21. Read the IDEXX MPN Table by going across to the right by the number of positive small cells and down by the number of positive large cells. Record this number as the MPN.

22. Multiply by 10 the MPN just entered (to account for the dilution). This is the real MPN because you diluted the sample during preparation. Record the date and time read.

23. Transfer all of the data from each Quantitray to the corresponding laboratory data sheet.

Clean up:

24. Place used Quantitrays in standard red biohazard bags for autoclaving and disposal.

25. Ensure that the work area is clean and the ultraviolet light is turned off.

PROCEDURE NOTES:

- Wearing gloves is mandatory to prevent sample contamination and for your safety for either container.
- Be sure that the UV light is facing away from your eyes and towards the tray.
- If the sample is inadvertently incubated over 28 hours with out observation, the following guidelines apply: Lack of fluorescence after 28 hours is a valid negative. Fluorescence after 28 hours is an invalid test result.

QUALITY ASSURANCE:

The following QC should be performed on each lot of Enterolert reagent. Organisms used for Enterolert QC:

- *Enterococcus faecalis* ATCC 29212
- *Enterococcus faecium* ATCC 35667

- *Serratia marcescens* ATCC 8100
- *Aerococcus viridans* ATCC 11563

Chapter 7: Shipping and Handling

Sample delivery to the laboratory:

All samples collected in the field should be put on ice in the cooler as soon as they are collected. These samples should be brought to the local laboratory as soon as all of the assigned sample sites have been tested for the day. If enterococcus samples have been collected, they must be brought to the local laboratory for testing as soon as possible. The total time between collection and testing of enterococcus should not exceed 6 hours. Samples collected for nutrient analysis should also be stored on ice as soon as they are collected and filtered. Nutrient samples will be frozen once they are brought to the local laboratory until they are shipped to the analysis laboratory. Samples collected for suspended sediment will be processed at the local laboratory and should also be kept on ice until brought to the local laboratory.

The regional team leader is responsible for shipping nutrient samples to the analysis laboratory. Samples will be shipped to the S-Lab within 14 days of collection to ensure they are received and analyzed within the specified holding times for each analyte. The team leader will include the shipping number on the chain of custody form when the samples are shipped. Samples will be shipped frozen with blue ice in coolers to preserve the samples for analysis.

Receipt and logging of sample:

In the laboratory, the sample custodian inspects the condition and seal of the sample and reconciles label information and seal against the chain of custody record before the sample is accepted for analysis. After acceptance, the custodian assigns a laboratory number, logs sample in the laboratory log book and stores it in a secured storage room or cabinet or refrigerator at the specified temperature until it is ready for analysis. Once the sample is in the laboratory, the supervisor or analyst is responsible for its care and custody.

Disposal: Hold samples for the prescribed amount of time for the project or until the data have been reviewed and accepted. Document the disposition of samples. Ensure that disposal is in accordance with local, state, and U.S. EPA approved methods.

Appendix B: Site list

Hui ID	Area	Location Name	DOH Storet No	Lat	Long
2001	Northwest Maui	Honolua	000707	21.013058	-156.638340
2002	Northwest Maui	Mokuleia	000721	21.011111	-156.642560
2003	Northwest Maui	Fleming North DT beach park	000674	21.005000	-156.650840
2004	Northwest Maui	Oneloa	000722	21.004056	-156.658940
2005	Northwest Maui	Fleming South Kapalua Bay	000650	20.998636	-156.666670
2006	Northwest Maui	Napili (south end)	000723	20.994222	-156.667417
2007	Northwest Maui	Napili (north end)		20.996580	-156.666140
2008	Northwest Maui	Ka'opala	000692	20.981967	-156.673080
2009	Northwest Maui	Pohaku 2		20.968376	-156.681003
2010	Northwest Maui	Pohaku	000724	20.967083	-156.681390
2022	Polanui	505 Front Street		20.867320	-156.676050
2023	Polanui	Lindsey Hale		20.864850	-156.673740
2024	Polanui	Lahaina Town	000726	20.863560	-156.672970
2025	Polanui	Makila Point		20.858840	-156.669330
2026	Olowalu to Pali	Olowalu surf break		20.823780	-156.631500
2027	Olowalu to Pali	Olowalu shore front	000663	20.809160	-156.622890
2028	Olowalu to Pali	Camp Olowalu		20.809860	-156.613690
2029	Olowalu to Pali	Mile Marker 14		20.809150	-156.606610
2030	Olowalu to Pali	Teen Challenge	000697	20.810050	-156.608900
2031	Olowalu to Pali	Ukumehame Bridge		20.799830	-156.592440

2032	Olowalu to Pali	Ukumehame Beach	000698	20.794480	-156.581420
2033	Olowalu to Pali	Papalaua	000728	20.793480	-156.574920
2034	Olowalu to Pali	Papalaua Pali		20.792690	-156.568720
2035	South Maui	Ahihi Kina'u		20.618450	-156.437480
2036	South Maui	Kalama Park	000679	20.731220	-156.453880
2037	South Maui	Kō'ie'ie Fishpond	000712	20.763870	-156.459080
2038	South Maui	Kihei Pier	000701	20.781150	-156.462830
2039	South Maui	Haycraft Park	000687	20.796570	-156.501730
2040	North Shore Maui	MECO		20.797023	-156.494285
2041	North Shore Maui	Kahului Harbor Canoe Hale		20.892119	-156.469484
2042	North Shore Maui	Kahului Harbor Pier1 and Pier 2		20.895767	-156.465103
2043	North Shore Maui	Kahului Harbor Pier 2 stream		20.894046	-156.467804
2044	North Shore Maui	Boat ramp		20.896339	-156.477878
2045	North Shore Maui	Kahului WWRF		20.897078	-156.456264
2046	North Shore Maui	Harbor lights DOH site	000706	20.891374	-156.473608
2047	North Shore Maui	DOH site 2	000654	20.891308	-156.471494
2048	North Shore Maui	Waihee Kalepa	000668	20.933892	-156.503223
2049	North Shore Maui	Waiehu Golf course		20.927878	-156.495496

2050	North Shore Maui	Waiehu stream	000667	20.918357	-156.491816
2051	North Shore Maui	Wailuku stream	000690	20.910498	-156.484707
2052	North Shore Maui	Kaa point		20.898254	-156.447280
2053	North Shore Maui	Papaula	000708	20.908397	-156.427644
2054	North Shore Maui	Sugar Cove		20.909365	-156.409301
2055	North Shore Maui	Wawau	000700	20.912710	-156.403140
2056	North Shore Maui	Kailua nui	000689	20.913837	-156.393691
2057	North Shore Maui	McGregor Point		20.777306	-156.522318
2058	North Shore Maui	Beach		20.785001	-156.516267
2059	North Kihei	Waterfront	000659	20.792030	-156.509604
2060	North Kihei	Kealia river mouth		20.795668	-156.488647
2061	North Kihei	Kealia		20.791179	-156.477859
2062	North Kihei	Sugar Beach		20.785885	-156.468678
2063	North Kihei	Waiohuli		20.782492	-156.464369
2064	Hana	Hana Bay Wharf		20.755772	-155.982094
2065	Hana	Helene Hall Cesspool Discharge		20.755292	-155.983369
2066	Hana	Pavilion		20.755339	-155.983733
2067	Hana	Ranch/Residential Runoff		20.756103	-155.984572

2068	Hana	Hana Kai Condo	20.759664	-155.986628
2069	Hana	Holoinawawae Stream	20.761517	-155.985908
2070	Hana	Hana Landfill Discharge	20.768078	-155.984278
2071	WM Ridge to Reef	Kaanapali Shores	20.949331	-156.691124
2072	Polanui	Launiupoko	20.842360	-156.653035
2073	Olowalu to Pali	Peter Martin Hale	20.808444	-156.619697
2074	Polanui	Puamana	20.859233	-156.669442
2075	North Maui, Surf	Pe'ahi shoreline	20.940953	-156.299172
2076	North Maui, Surf	K Bay	20.942239	-156.318086
2077	North Maui, Surf	Maliko Bay	20.936194	-156.339161
2078	North Maui, Surf	Hookipa Beach Park E	20.934069	-156.356622
2079	North Maui, Surf	Hookipa Beach Park W	20.933519	-156.357594
2080	North Maui, Surf	Mama’s Beach	20.929565,	-156.367104
2081	North Maui, Surf	Kuau Bay	20.922344	-156.374183
2082	North Maui, Surf	Paia Bay	20.915669	-156.385783
2083	North Maui, Surf	Baldwin Beach	20.913989	-156.393739
2084	North Maui, Surf	Baby Beach	20.912772	-156.402925
2086	North Maui,	Kanaha Beach	20.903278	-156.435917

	Surf			
2089	North Maui, Surf	Kahului Harbor	20.891192	-156.473478
2092	North Maui, Surf	Waihe’e Beach Park	20.932534	-156.498876

APPENDIX C: FORMS

BACTERIAL SAMPLING:

Team:	Samplers:	Date:	Start time:	Finish time:

Sample No	Location Name	Time Collected	Time Processed (into incubator)	Time Read (out of incubator)	# of positive small wells	# of positive large wells	MPN * #Idexx table	10* MPN	Comments	Grab sample?

Transport comments: Laboratory / Address where analyzed:

☐ Temperature of incubator (in) ☐ Temperature of incubator (out)

Date of media expiration:

FIELD EQUIPMENT VERIFICATION (PRE/POST A WEEKLY SAMPLING):

Session No:	Verifiers:	Pre date:	Pre time:	Post: Date:	Post time:

QA/QC Check	Inst #	Probe #	Last Cal Date	Verification Standard		PRE: Verification Value		POST: Verification Value		Acceptable Range (Check range)	Comments/ Notes	QA?
Temperature			n/a							± 1°C of NIST	Within 1°C	
			n/a									
			n/a									
Salinity										± 3%, blank	33.95 – 36.05	
Dissolved Oxygen				100%						Post-check ± 5 % of pre-check (0-100%)	80 – 120 %	
pH				7	10					± 3 % of calibration solution (6-8)	6.79 – 7.21	

Notes:

Sensor No: ______________ Instrument No: ______________

QA /QC Check	Last cal date	Time	Cal Standard	Cal Value
Turbidity, Stable Cal			20	
			100	
			800	
			20	
			100	
			800	
Salinity			0	
			35	
Dissolved Oxygen			100	
pH			4	
			7	
			10	

Sensor No: ______________ Instrument No: ______________

QA /QC Check	Last cal date	Time	Cal Standard	Cal Value
Turbidity, Stable Cal			20	
			100	
			800	
			20	
			100	
			800	
Salinity			0	
			35	
Dissolved Oxygen			100	
pH			4	
			7	
			10	

Sensor No: ______________ Instrument No: ______________

QA /QC Check	Last cal date	Time	Cal Standard	Cal Value
Turbidity, Stable Cal			20	
			100	
			800	
Temperature	n/a		n/a	
Salinity			0	
			35	
Dissolved Oxygen			100	
pH			4	
			7	
			10	

Sensor No: ______________ Instrument No: ______________

QA /QC Check	Last cal date	Time	Cal Standard	Cal Value
Turbidity, Stable Cal			20	
			100	
			800	
			20	
			100	
			800	
Salinity			0	
			35	
Dissolved Oxygen			100	
pH			4	
			7	
			10	

IN-SITU READINGS:

Team:	Samplers:	Instrument #	Probe #s	pH	DO	Salinity	Date:	Start time:	Finish time:
R2R		40d:	40d:						
		2100q	2100q						

Location Name	Time	Temp (C)	Sal (ppt)	DO (mg/L)	DO Saturation (%)	pH	Turbidity[1] (NTU)			Comments		
										Waves	Swimmers	Wind
Pohaku RPO												
Kaanapali Shores RKS												
Airport Beach RAB												
Canoe Beach RCB												
Wahikuli RWA												

Turbidity Verification Pre:	Blank:		Low: 0-10		Med: 10-100		High: 100-1000		Comment
Post:	Blank:		0-10		10-100		100-1000		

COASTAL AND ENVIRONMENTAL CONDITION NOTES

Most recent low tide (Lahiana station)

Moon: 2

Cloud Cover:

Wind conditions (general):

Rain Conditions (general):

WATER QUALITY SAMPLING:

Team:	Samplers:	Date:	Start time:	Finish time:

Sample No	Location Name	Time	Vol (mL)	Nutrient Bottle?	SSC ?	Quality control notes	Grab sample?
RPO161129-N-1	Pokahu		125	X		Washed, rinsed syringes; acid washed bottles; 0.7 um filters; washed rinsed filter holders	☐
RPO161129-S-1	Pokahu		500		X		☐
RKS161129-N-1	Kaanapali Sh		125	X		Washed, rinsed syringes; acid washed bottles; 0.7 um filters; washed rinsed filter holders	☐
RKS161129-N-2	Kaanapali Sh		125	X		Washed, rinsed syringes; acid washed bottles; 0.7 um filters; washed rinsed filter holders	☐
RKS161129-S-1	Kaanapali Sh		500		X		☐
RAB161129-N-1	Airport Beach		125	X		Washed, rinsed syringes; acid washed bottles; 0.7 um filters; washed rinsed filter holders	☐
RAB161129-S-1	Airport Beach		500		X		☐
RCB161129-N-1	Canoe Beach		125	X		Washed, rinsed syringes; acid washed bottles; 0.7 um filters; washed rinsed filter holders	☐
RCB161129-S-1	Canoe Beach		500		X		☐
RWA161129-N-1	Wahikuli		125	X		Washed, rinsed syringes; acid washed bottles; 0.7 um filters; washed rinsed filter holders	☐
RWA161129-S-1	Wahikuli		500		X		☐
							☐
							☐
							☐
							☐
							☐

CHAIN OF CUSTODY:

Teams:	Samplers:	Start Date:	Finish Date

	Sampler Initials	Sample No	Location Name	Vol (mL)	Nutrient Bottle?	Filtered?	SSC?	Quality control notes	Grab sample?
1									☐
2									☐
3									☐
4									☐
5									☐
6									☐
7									☐
8									☐
9									☐
10									☐
11									☐

	Relinquished by (Print):	Signature	Date and Time	Delivery Method (circle)
Maui Lab				Hand-over Car FedEx Other
Packager / Transport				Car Flight FedEx Other
Receiver				Hand-over Car FedEx Other

Transport comments:

Preparation/Analyses requested: ☐ Filtration ☐ Dissolved inorg nutrients ☐ Dissolved organic nutrients
☐ Suspended sediment concentration
☐ Other

Received by (Name, Facility): Date and Time Received: Date and Time Package Opened:

☐ Fully frozen
☐ Partially frozen
☐ Not frozen

☐ Improper sample container
☐ Seal broken (sample # _________)

APPENDIX D: QUALITY CONTROL INFORMATION TO BE EVALUATED DURING DATA QUALITY ASSESSMENT

The Hui o Ka Wai Ola QA officer will evaluate all laboratory reported QC information and non-conformances in accordance with this guidance. Non-conformances that are noted in the semi-annual and annual report. QC reviews conducted by the QA officer are documented for all datasets that are evaluated, and the evaluation is available to the HIDOH available on request.

The information below summarizes standard, required deliverables to obtain data. The QC information that is reviewed during the data quality assessment by the QA officer includes, but is not limited to the following:

Standard Deliverables

Field Report Inspection

Goal: Determine if all field worksheets are provided and complete for each sample:
Tasks: Review field data sheets

Laboratory Report Inspection

Goal: Determine if all laboratory deliverables are provided and complete:
Tasks:

- Review the laboratory report to determine that the following items are present for all sample batches:
  - Narrative identifying QC non-conformances;
  - Analytical results;
  - Chain of Custody Form; and,
  - Quality control results, including but not limited to:
    - Method Blanks;
    - Laboratory Control Samples (LCS);
    - Surrogates (as appropriate for method); and,
    - Other QC results and information provided in the laboratory report.

- Review the laboratory narrative to identify QC non-conformances:
  - Review the narrative for significant findings (i.e., QC non-conformances that could affect usability of the reported results) and request additional information from the laboratory, if applicable.

- Review the Chain of Custody Form for completeness and correctness:
  - Review Chain of Custody Form to ensure form is complete and correct;
  - Verify sample identification numbers and collection information;
  - Verify that there is an acceptance signature for each relinquished signature documenting the delivery of the samples to the laboratory facility. Check for errors in noted dates and times;
  - Contact the laboratory for help or clarification if needed.

Chain of Custody (COC) Evaluation

Goal: Evaluate the information presented on the Chain of Custody Form to determine if any QC issues or nonconformances are present.
Tasks:

- Determine whether Handling Time was met;
- Determine if samples appropriately preserved/refrigerated/iced; and,
- Determine if samples were received by the laboratory an appropriate temperature.

Sample Result Evaluation

Goal: Determine if sample results have been properly reported.
Tasks: Evaluate the sample results:

- Determine that reporting limits (RLs) were noted;
- Verify that concentrations greater than the RL were reported;
- Verify that concentration reported below the RLs are qualified
- Verify that results for aqueous samples are reported in mg/L;
- Check dilution factor to see if a dilution was performed and if so, the RL adjusted accordingly;;
- Determine that RLs are less than, or equal to the regulatory criteria; and,
- Determine if sample results are provided for the each requested analysis

Sample Preservation and Holding Times Evaluation

Goal: Determine if samples were preserved properly and analyzed within holding times.
Tasks:

- Review the chain of custody and or narrative to determine if the samples were preserved in accordance with the requirement of the QAPP.
- Review the narrative to determine if the holding time specified in the QAPP was met.

Method, Field or Trip Blank Evaluation

Goal: Determine the existence and magnitude of contamination resulting from laboratory or field activities.
Task: Review all blank data and narratives for possible contamination.

Field Duplicates and Laboratory Duplicates

Goal: Evaluate Precision
Task: Review all duplicate sample information.

Laboratory Control Samples Evaluation

Goal: Evaluate accuracy of laboratory method.
Task: Review the narrative to determine if nonconformances were noted in the laboratory narrative.

Common Data Qualifiers

Inorganics:

- P The data is provisional and has not yet been quality controlled
- A The data is accepted, with or without qualifiers
- H The sample exceeded holding times
- Q QC analyses are outside control limits. This includes sample receipt issues, sample containers or sample preservation. An explanatory note should be included in a comments section.
- B There was a nonconformance with the field or lab blanks for a group of samples. The analyte is found in the associated method blank.
- D The reported value is from a dilution greater than 1.
- U1 The result was less than the MDL.
- U2 The sample exceeded the calibration range.

Bacterial:

- MB1 Too numerous to count
- MB2 Target organism not detected in method blank
- T1 Sample incubation time exceeded the method requirement
- T2 Sample incubation time was shorter than the method requirement

This list was adapted from the Arizona Department of Health Services and the USEPA Contract Laboratory Program Statement of Work for Inorganic Superfund Methods

APPENDIX E

GLOSSARY OF QUALITY ASSURANCE AND RELATED TERMS

Acceptance criteria — Specified limits placed on characteristics of an item, process, or service defined in requirements documents. (ASQC Definitions)

Accuracy — A measure of the closeness of an individual measurement or the average of a number of measurements to the true value. Accuracy includes a combination of random error (precision) and systematic error (bias) components that are due to sampling and analytical operations; the EPA recommends using the terms *"precision"* and *"bias"*, rather than "accuracy," to convey the information usually associated with accuracy. Refer to *Appendix D, Data Quality Indicators* for a more detailed definition.

Activity — An all-inclusive term describing a specific set of operations of related tasks to be performed, either serially or in parallel (e.g., research and development, field sampling, analytical operations, equipment fabrication), that, in total, result in a product or service.

Assessment — The evaluation process used to measure the performance or effectiveness of a system and its elements. As used here, assessment is an all-inclusive term used to denote any of the following: audit, performance evaluation (PE), management systems review (MSR), peer review, inspection, or surveillance.

Audit (quality) — A systematic and independent examination to determine whether quality activities and related results comply with planned arrangements and whether these arrangements are implemented effectively and are suitable to achieve objectives.

Audit of Data Quality (ADQ) — A qualitative and quantitative evaluation of the documentation and procedures associated with environmental measurements to verify that the resulting data are of acceptable quality.

Authenticate — The act of establishing an item as genuine, valid, or authoritative.

Bias — The systematic or persistent distortion of a measurement process, which causes errors in one direction (i.e., the expected sample measurement is different from the sample's true value). Refer to *Appendix D, Data Quality Indicators*, for a more detailed definition.

Blank — A sample subjected to the usual analytical or measurement process to establish a zero baseline or background value. Sometimes used to adjust or correct routine analytical results. A sample that is intended to contain none of the analytes of interest. A blank is used to detect contamination during sample handling preparation and/or analysis.

Calibration — A comparison of a measurement standard, instrument, or item with a standard or instrument of higher accuracy to detect and quantify inaccuracies and to report or eliminate those inaccuracies by adjustments.

Calibration drift — The deviation in instrument response from a reference value over a period of time before recalibration.verify, and recognize the competence of a person, organization, or other entity to perform a function or service, usually for a specified time.

Chain of custody — An unbroken trail of accountability that ensures the physical security of samples, data, and records.

Characteristic — Any property or attribute of a datum, item, process, or service that is distinct, describable, and/or measurable.

Check standard — A standard prepared independently of the calibration standards and analyzed exactly like the samples. Check standard results are used to estimate analytical precision and to indicate the presence of bias due to the calibration of the analytical system.

Collocated samples — Two or more portions collected at the same point in time and space so as to be considered identical. These samples are also known as field replicates and should be identified as such.
Comparability — A measure of the confidence with which one data set or method can be compared to another.

Completeness — A measure of the amount of valid data obtained from a measurement system compared to the amount that was expected to be obtained under correct, normal conditions. Refer to *Appendix D, Data Quality Indicators*, for a more detailed definition.

Confidence Interval — The numerical interval constructed around a point estimate of a population parameter, combined with a probability statement (the confidence coefficient) linking it to the population's true parameter value. If the same confidence interval construction technique and assumptions are used to calculate future intervals, they will include the unknown population parameter with the same specified probability.

Confidentiality procedure — A procedure used to protect confidential business information (including proprietary data and personnel records) from unauthorized access.

Configuration — The functional, physical, and procedural characteristics of an item, experiment, or document.

Conformance — An affirmative indication or judgment that a product or service has met the requirements of the relevant specification, contract, or regulation; also, the state of meeting the requirements.

Consensus standard — A standard established by a group representing a cross section of a particular industry or trade, or a part thereof.

Contractor — Any organization or individual contracting to furnish services or items or to perform work.

Corrective action — Any measures taken to rectify conditions adverse to quality and, where possible, to preclude their recurrence.

Data Quality Assessment (DQA) — The scientific and statistical evaluation of data to determine if data obtained from environmental operations are of the right type, quality, and quantity to support their intended use. The five steps of the DQA Process include: 1) reviewing the DQOs and sampling design, 2) conducting a preliminary data review, 3) selecting the statistical test, 4) verifying the assumptions of the statistical test, and 5) drawing conclusions from the data.

Data Quality Indicators (DQIs) — The quantitative statistics and qualitative descriptors that are used to interpret the degree of acceptability or utility of data to the user. The principal data quality indicators are bias, precision, accuracy (bias is preferred), comparability, completeness, representativeness.

Data Quality Objectives (DQOs) — The qualitative and quantitative statements derived from the DQO Process that clarify study's technical and quality objectives, define the appropriate type of data, and specify tolerable levels of potential decision errors that will be used as the basis for establishing the quality and quantity of data needed to support decisions.

Data Quality Objectives (DQO) Process — A systematic strategic planning tool based on the scientific method that identifies and defines the type, quality, and quantity of data needed to satisfy a specified use. DQOs are the qualitative and quantitative outputs from the DQO Process.

Data reduction — The process of transforming the number of data items by arithmetic or statistical calculations, standard curves, and concentration factors, and collating them into a more useful form. Data reduction is irreversible and generally results in a reduced data set and an associated loss of detail.

Data usability — The process of ensuring or determining whether the quality of the data produced meets the intended use of the data.

Deficiency — An unauthorized deviation from acceptable procedures or practices, or a defect in an item.

Demonstrated capability — The capability to meet a procurement's technical and quality specifications through evidence presented by the supplier to substantiate its claims and in a manner defined by the customer.

Design — The specifications, drawings, design criteria, and performance requirements. Also, the resultof deliberate planning, analysis, mathematical manipulations, and design processes.

Design change — Any revision or alteration of the technical requirements defined by approved and issued design output documents and approved and issued changes thereto.

Design review — A documented evaluation by a team, including personnel such as the responsible designers, the client for whom the work or product is being designed, and a quality assurance (QA) representative but excluding the original designers, to determine if a proposed design will meet the established design criteria and perform as expected when implemented.

Detection Limit (DL) — A measure of the capability of an analytical method to distinguish samples that do not contain a specific analyte from samples that contain low concentrations of the analyte; the lowest concentration or amount of the target analyte that can be determined to be different from zero by a single measurement at a stated level of probability. DLs are analyte- and matrix-specific and may be laboratory-dependent.

Distribution — 1) The appointment of an environmental contaminant at a point over time, over an area, or within a volume; 2) a probability function (density function, mass function, or distribution function) used to describe a set of observations (statistical sample) or a population from which the observations are generated.

Document control — The policies and procedures used by an organization to ensure that its documents and their revisions are proposed, reviewed, approved for release, inventoried, distributed, archived, stored, and retrieved in accordance with the organization's requirements.

Duplicate samples — Two samples taken from and representative of the same population and carried through all steps of the sampling and analytical procedures in an identical manner. Duplicate samples are used to assess variance of the total method, including sampling and analysis. See also *collocated sample*.

Environmental conditions — The description of a physical medium (e.g., air, water, soil, sediment) or a biological system expressed in terms of its physical, chemical, radiological, or biological characteristics.

Environmental data — Any parameters or pieces of information collected or produced from measurements, analyses, or models of environmental processes, conditions, and effects of pollutants on human health and the ecology, including results from laboratory analyses or from experimental systems representing such processes and conditions.

Environmental data operations — Any work performed to obtain, use, or report information pertaining to environmental processes and conditions.

Environmental monitoring — The process of measuring or collecting environmental data.

Environmental processes — Any manufactured or natural processes that produce discharges to, or that impact, the ambient environment.

Environmental programs — An all-inclusive term pertaining to any work or activities involving the environment, including but not limited to: characterization of environmental processes and conditions; environmental monitoring; environmental research and development; the design, construction, and operation of environmental technologies; and laboratory operations on environmental samples.

Environmental technology — An all-inclusive term used to describe pollution control devices and systems, waste treatment processes and storage facilities, and site remediation technologies and their components that may be utilized to remove pollutants or contaminants from, or to prevent them from entering, the environment. Examples include wet scrubbers (air), soil washing (soil), granulated activated carbon unit (water), and filtration (air, water). Usually, this term applies to hardware-based systems; however, it can also apply to methods or techniques used for pollution prevention, pollutant reduction, or containment of contamination to prevent further movement of the contaminants, such as capping, solidification or vitrification, and biological treatment.

Estimate — A characteristic from the sample from which inferences on parameters can be made.

Evidentiary records — Any records identified as part of litigation and subject to restricted access, custody, use, and disposal.

Expedited change — An abbreviated method of revising a document at the work location where the document is used when the normal change process would cause unnecessary or intolerable delay in the work.

Field blank — A blank used to provide information about contaminants that may be introduced during sample collection, storage, and transport. A clean sample, carried to the sampling site, exposed to sampling conditions, returned to the laboratory, and treated as an environmental sample.

Field (matrix) spike — A sample prepared at the sampling point (i.e., in the field) by adding a known mass of the target analyte to a specified amount of the sample. Field matrix spikes are used, for example, to determine the effect of the sample preservation, shipment, storage, and preparation on analyte recovery efficiency (the analytical bias).

Field split samples — Two or more representative portions taken from the same sample and submitted for analysis to different laboratories to estimate interlaboratory precision.

Financial assistance — The process by which funds are provided by one organization (usually governmental) to another organization for the purpose of performing work or furnishing services or items. Financial assistance mechanisms include grants, cooperative agreements, and governmental interagency agreements.

Finding — An assessment conclusion that identifies a condition having a significant effect on an item or activity. An assessment finding may be positive or negative, and is normally accompanied by specific examples of the observed condition.

Goodness-of-fit test — The application of the chi square distribution in comparing the frequency distribution of a statistic observed in a sample with the expected frequency distribution based on some theoretical model.

Grade — The category or rank given to entities having the same functional use but different requirements for quality.

Graded approach — The process of basing the level of application of managerial controls applied to an item or work according to the intended use of the results and the degree of confidence needed in the quality of the results. (See also *Data Quality Objectives (DQO) Process.*)

Guidance — A suggested practice that is not mandatory, intended as an aid or example in complying with a standard or requirement.

Guideline — A suggested practice that is not mandatory in programs intended to comply with a standard.
Hazardous waste — Any waste material that satisfies the definition of hazardous waste given in 40 CFR 261, "Identification and Listing of Hazardous Waste."

Holding time — The period of time a sample may be stored prior to its required analysis. While exceeding the holding time does not necessarily negate the veracity of analytical results, it causes the qualifying or "flagging" of any data not meeting all of the specified acceptance criteria.

Identification error — The misidentification of an analyte. In this error type, the contaminant of concern is unidentified and the measured concentration is incorrectly assigned to another contaminant.
Independent assessment — An assessment performed by a qualified individual, group, or organization that is not a part of the organization directly performing and accountable for the work being assessed.
Inspection — The examination or measurement of an item or activity to verify conformance to specific requirements.

Internal standard — A standard added to a test portion of a sample in a known amount and carried through the entire determination procedure as a reference for calibrating and controlling the precision and bias of the applied analytical method.

Laboratory split samples — Two or more representative portions taken from the same sample and analyzed by different laboratories to estimate the interlaboratory precision or variability and the data comparability.

Limit of quantitation — The minimum concentration of an analyte or category of analytes in a specific matrix that can be identified and quantified above the method detection limit and within specified limits of precision and bias during routine analytical operating conditions.

Management — Those individuals directly responsible and accountable for planning, implementing, and assessing work.

Management system — A structured, nontechnical system describing the policies, objectives, principles, organizational authority, responsibilities, accountability, and implementation plan of an organization for conducting work and producing items and services.

Management Systems Review (MSR) — The qualitative assessment of a data collection operation and/or organization(s) to establish whether the prevailing quality management structure, policies, practices, and procedures are adequate for ensuring that the type and quality of data needed are obtained.
Matrix spike — A sample prepared by adding a known mass of a target analyte to a specified amount of matrix sample for which an independent estimate of the target analyte concentration is available. Spiked samples are used, for example, to determine the effect of the matrix on a method's recovery efficiency.
Mean (arithmetic) — The sum of all the values of a set of measurements divided by the number of values in the set; a measure of central tendency.

Mean squared error — A statistical term for variance added to the square of the bias.

Measurement and Testing Equipment (M&TE) — Tools, gauges, instruments, sampling devices, or systems used to calibrate, measure, test, or inspect in order to control or acquire data to verify conformance to specified requirements.

Memory effects error — The effect that a relatively high concentration sample has on the measurement of a lower concentration sample of the same analyte when the higher concentration sample precedes the lower concentration sample in the same analytical instrument.

Method — A body of procedures and techniques for performing an activity (e.g., sampling, chemical analysis, quantification), systematically presented in the order in which they are to be executed.

Method blank — A blank prepared to represent the sample matrix as closely as possible and analyzed exactly like the calibration standards, samples, and quality control (QC) samples. Results of method blanks provide an estimate of the within-batch variability of the blank response and an indication of bias introduced by the analytical procedure.

Mid-range check — A standard used to establish whether the middle of a measurement method's calibrated range is still within specifications.

Mixed waste — A hazardous waste material as defined by 40 CFR 261 Resource Conservation and Recovery Act (RCRA) and mixed with radioactive waste subject to the requirements of the Atomic Energy Act.

Must — When used in a sentence, a term denoting a requirement that has to be met.

Nonconformance — A deficiency in a characteristic, documentation, or procedure that renders the quality of an item or activity unacceptable or indeterminate; nonfulfillment of a specified requirement.

Objective evidence — Any documented statement of fact, other information, or record, either quantitative or qualitative, pertaining to the quality of an item or activity, based on observations, measurements, or tests that can be verified.

Observation — An assessment conclusion that identifies a condition (either positive or negative) that does not represent a significant impact on an item or activity. An observation may identify a condition that has not yet caused a degradation of quality.

Organization — A company, corporation, firm, enterprise, or institution, or part thereof, whether incorporated or not, public or private, that has its own functions and administration. **Organization structure** — The responsibilities, authorities, and relationships, arranged in a pattern, through which an organization performs its functions.

Outlier — An extreme observation that is shown to have a low probability of belonging to a specified data population.

Parameter — A quantity, usually unknown, such as a mean or a standard deviation characterizing a population. Commonly misused for "variable," "characteristic," or "property."

Peer review — A documented critical review of work generally beyond the state of the art or characterized by the existence of potential uncertainty. Conducted by qualified individuals (or an organization) who are independent of those who performed the work but collectively equivalent in technical expertise (i.e., peers) to those who performed the original work. Peer reviews are conducted to ensure that activities are technically adequate, competently performed, properly documented, and satisfy established technical and quality requirements. An in-depth assessment of the assumptions, calculations, extrapolations, alternate interpretations, methodology, acceptance criteria, and conclusions pertaining to specific work and of the documentation that supports them. Peer reviews provide an evaluation of a subject where quantitative methods of analysis or measures of success are unavailable or undefined, such as in research and development.

Performance Evaluation (PE) — A type of audit in which the quantitative data generated in a measurement system are obtained independently and compared with routinely obtained data to evaluate the proficiency of an analyst or laboratory.

Pollution prevention — An organized, comprehensive effort to systematically reduce or eliminate pollutants or contaminants prior to their generation or their release or discharge into the environment.

Precision — A measure of mutual agreement among individual measurements of the same property, usually under prescribed similar conditions expressed generally in terms of the standard deviation. Refer to *Appendix D, Data Quality Indicators,* for a more detailed definition.

Procedure — A specified way to perform an activity.

Process — A set of interrelated resources and activities that transforms inputs into outputs. Examples of processes include analysis, design, data collection, operation, fabrication, and calculation.

Project — An organized set of activities within a program.

Qualified data — Any data that have been modified or adjusted as part of statistical or mathematical evaluation, data validation, or data verification operations.

Qualified services — An indication that suppliers providing services have been evaluated and determined to meet the technical and quality requirements of the client as provided by approved procurement documents and demonstrated by the supplier to the client's satisfaction.

Quality — The totality of features and characteristics of a product or service that bears on its ability to meet the stated or implied needs and expectations of the user.

Quality Assurance (QA) — An integrated system of management activities involving planning, implementation, assessment, reporting, and quality improvement to ensure that a process, item, or service is of the type and quality needed and expected by the client.

Quality Assurance Program Description/Plan — See *quality management plan*.

Quality Assurance Project Plan (QAPP) — A formal document describing in comprehensive detail the necessary quality assurance (QA), quality control (QC), and other technical activities that must be implemented to ensure that the results of the work performed will satisfy the stated performance criteria. The QAPP components are divided into four classes: 1) Project Management, 2) Measurement/Data Acquisition, 3) Assessment/Oversight, and 4) Data Validation and Usability. Requirements for preparing QAPPs can be found in EPA QA/R-5.

Quality Control (QC) — The overall system of technical activities that measures the attributes and performance of a process, item, or service against defined standards to verify that they meet the stated requirements established by the customer; operational techniques and activities that are used to fulfill requirements for quality. The system of activities and checks used to ensure that measurement systems are maintained within prescribed limits, providing protection against "out of control" conditions and ensuring the results are of acceptable quality.

Quality control (QC) sample — An uncontaminated sample matrix spiked with known amounts of analytes from a source independent of the calibration standards. Generally used to establish intra laboratory or analyst-specific precision and bias or to assess the performance of all or a portion of the measurement system.

Quality improvement — A management program for improving the quality of operations. Such management programs generally entail a formal mechanism for encouraging worker recommendations with timely management evaluation and feedback or implementation.

Quality management — That aspect of the overall management system of the organization that determines and implements the quality policy. Quality management includes strategic planning, allocation of resources, and other systematic activities (e.g., planning, implementation, and assessment) pertaining to the quality system.

Quality Management Plan (QMP) — A formal document that describes the quality system in terms of the organization's structure, the functional responsibilities of management and staff, the lines of authority, and the required interfaces for those planning, implementing, and assessing all activities conducted.

Quality system — A structured and documented management system describing the policies, objectives, principles, organizational authority, responsibilities, accountability, and implementation plan of an organization for ensuring quality in its work processes, products (items), and services. The quality system provides the framework for planning, implementing, and assessing work performed by the organization and for carrying out required quality assurance (QA) and quality control (QC).

Radioactive waste — Waste material containing, or contaminated by, radionuclides, subject to the requirements of the Atomic Energy Act.

Readiness review — A systematic, documented review of the readiness for the start-up or continued use of a facility, process, or activity. Readiness reviews are typically conducted before proceeding beyond project milestones and prior to initiation of a major phase of work.

Record (quality) — A document that furnishes objective evidence of the quality of items or activities and that has been verified and authenticated as technically complete and correct. Records may include photographs, drawings, magnetic tape, and other data recording media.

Recovery — The act of determining whether or not the methodology measures all of the analyte contained in a sample. Refer to *Appendix D, Data Quality Indicators,* for a more detailed definition. **Remediation** — The process of reducing the concentration of a contaminant (or contaminants) in air, water, or soil media to a level that poses an acceptable risk to human health.

Repeatability — The degree of agreement between independent test results produced by the same analyst, using the same test method and equipment on random aliquots of the same sample within a short time period.

Reporting limit — The lowest concentration or amount of the target analyte required to be reported from a data collection project. Reporting limits are generally greater than detection limits and are usually not associated with a probability level.

Representativeness — A measure of the degree to which data accurately and precisely represent a characteristic of a population, a parameter variation at a sampling point, a process condition, or an environmental condition. See also *Appendix D, Data Quality Indicators.*

Reproducibility — The precision, usually expressed as variance, that measures the variability among the results of measurements of the same sample at different laboratories.

Requirement — A formal statement of a need and the expected manner in which it is to be met. **Research (applied)** — A process, the objective of which is to gain the knowledge or understanding necessary for determining the means by which a recognized and specific need may be met.

Research (basic) — A process, the objective of which is to gain fuller knowledge or understanding of the fundamental aspects of phenomena and of observable facts without specific applications toward processes or products in mind.

Research development/demonstration — The systematic use of the knowledge and understanding gained from research and directed toward the production of useful materials, devices, systems, or methods, including prototypes and processes.

Round-robin study — A method validation study involving a predetermined number of laboratories or analysts, all analyzing the same sample(s) by the same method. In a round-robin study, all results are compared and used to develop summary statistics such as interlaboratory precision and method bias or recovery efficiency.

Ruggedness study — The carefully ordered testing of an analytical method while making slight variations in test conditions (as might be expected in routine use) to determine how such variations affect test results. If a variation affects the results significantly, the method restrictions are tightened to minimize this variability.

Scientific method — The principles and processes regarded as necessary for scientific investigation, including rules for concept or hypothesis formulation, conduct of experiments, and validation of hypotheses by analysis of observations.

Self-assessment — The assessments of work conducted by individuals, groups, or organizations directly responsible for overseeing and/or performing the work.

Sensitivity — the capability of a method or instrument to discriminate between measurement responses representing different levels of a variable of interest. Refer to *Appendix D, Data Quality Indicators,* for a more detailed definition.

Service — The result generated by activities at the interface between the supplier and the customer, and the supplier internal activities to meet customer needs. Such activities in environmental programs include design, inspection, laboratory and/or field analysis, repair, and installation.

Shall — A term denoting a requirement that is mandatory whenever the criterion for conformance with the specification permits no deviation. This term does not prohibit the use of alternative approaches or methods for implementing the specification so long as the requirement is fulfilled.

Significant condition — Any state, status, incident, or situation of an environmental process or condition, or environmental technology in which the work being performed will be adversely affected sufficiently to require corrective action to satisfy quality objectives or specifications and safety requirements.

Software life cycle — The period of time that starts when a software product is conceived and ends when the software product is no longer available for routine use. The software life cycle typically includes a requirement phase, a design phase, an implementation phase, a test phase, an installation and check-out phase, an operation and maintenance phase, and sometimes a retirement phase.

Source reduction — Any practice that reduces the quantity of hazardous substances, contaminants, or pollutants.

Span check — A standard used to establish that a measurement method is not deviating from its calibrated range.

Specification — A document stating requirements and referring to or including drawings or other relevant documents. Specifications should indicate the means and criteria for determining conformance.

Spike — A substance that is added to an environmental sample to increase the concentration of target analytes by known amounts; used to assess measurement accuracy (spike recovery). Spike duplicates are used to assess measurement precision.

Split samples — Two or more representative portions taken from one sample in the field or in the laboratory and analyzed by different analysts or laboratories. Split samples are quality control (QC) samples that are used to assess analytical variability and comparability.

Standard deviation — A measure of the dispersion or imprecision of a sample or population distribution expressed as the positive square root of the variance and has the same unit of measurement as the mean.

Standard Operating Procedure (SOP) — A written document that details the method for an operation, analysis, or action with thoroughly prescribed techniques and steps and that is officially approved as the method for performing certain routine or repetitive tasks.

Supplier — Any individual or organization furnishing items or services or performing work according to a procurement document or a financial assistance agreement. An all-inclusive term used in place of any of the following: vendor, seller, contractor, subcontractor, fabricator, or consultant.

Surrogate spike or analyte — A pure substance with properties that mimic the analyte of interest. It is unlikely to be found in environmental samples and is added to them to establish that the analytical meyhod has been performed properly.

Surveillance (quality) — Continual or frequent monitoring and verification of the status of an entity and the analysis of records to ensure that specified requirements are being fulfilled.

Technical review — A documented critical review of work that has been performed within the state of the art. The review is accomplished by one or more qualified reviewers who are independent of those who performed the work but are collectively equivalent in technical expertise to those who performed the original work. The review is an in-depth analysis and evaluation of documents, activities, material, data, or items that require technical verification or validation for applicability, correctness, adequacy, completeness, and assurance that established requirements have been satisfied.

Technical Systems Audit (TSA) — A thorough, systematic, on-site qualitative audit of facilities, equipment, personnel, training, procedures, record keeping, data validation, data management, and reporting aspects of a system.

Traceability — The ability to trace the history, application, or location of an entity by means of recorded identifications. In a calibration sense, traceability relates measuring equipment to national or international standards, primary standards, basic physical constants or properties, or reference materials. In a data collection sense, it relates calculations and data generated throughout the project back to the requirements for the quality of the project.

Trip blank — A clean sample of a matrix that is taken to the sampling site and transported to the laboratory for analysis without having been exposed to sampling procedures.

Validation — Confirmation by examination and provision of objective evidence that the particular requirements for a specific intended use have been fulfilled. In design and development, validation concerns the process of examining a product or result to determine conformance to user needs. See also *Appendix G, Data Management.*

Variance (statistical) — A measure or dispersion of a sample or population distribution.

Verification — Confirmation by examination and provision of objective evidence that specified requirements have been fulfilled. In design and development, verification concerns the process of examining a result of a given activity to determine conformance to the stated requirements for that activity.

SOEST Lab for Analytical Biogeochemistry

Quality Assurance Project Plan

October 1, 2016

1. Introduction

Do you have a normal introduction to the history of the lab?

2. Project Management

The laboratory is managed under the guidance of the University of Hawaii at Manoa, School of Ocean and Earth Sciences. The lab is staffed by a lab manager and a minimum of one technician.

Data is stored in multiple spreadsheets that are backed up to the cloud.

3. Measurement and Data Acquisition

The S-LAB at the University of Hawai'i Mānoa analyses samples for dissolved nutrient and silicate analyses, and particulate analyses for nitrogen and carbon. Results from an annual demostrations of proficiency in the comparison of unknown samples provided by a commercially available, nationally accredited proficiency testing provider are available attached to this report.

3.1. Analytical methods

For nutrient and silicate analysis, S-LABs uses an AA3 Nutrient Autoanalyzer from Sea Analytical. The S-LAB utilizes methods and procedures outlined by Seal Analytical that are, optimized for the AA3 Nutrient Autoanalyzer; references and procedures for each constituent are listed below. The EPA methods used are presented in Table 1.

Table 1: Analytical methods used in water quality analysis.

Parameter	Method number or description	Method/instrument	Units
NH_4	EPA Method 350.1	GF/F-filtered grab samples, SEAL Analytical AA3 autoanalyzer	µg N/L
NNN	EPA Methods 353.2	GF/F-filtered grab samples, SEAL Analytical AA3 autoanalyzer	µg N/L
DRP	EPA 365.1	GF/F-filtered grab samples, SEAL Analytical AA3 autoanalyzer	µg P/L
TDN	UV-Digestion, EPA 353.2, Rev.2	GF/F-filtered grab samples, SEAL Analytical AA3 autoanalyzer	µg N/L
TDP	EPA Method 365.1	GF/F-filtered grab samples, SEAL Analytical AA3 autoanalyzer	µg P/L
Silicate	EPA Method 366.0	GF/F-filtered grab samples, SEAL Analytical AA3 autoanalyzer	µg/L
PN	EPA Method 440.0	GF/F-filters, Exeter Elemental Analyzer	% by mass
PC	EPA Method 440.0	GF/F-filters, Exeter Elemental Analyzer	% by mass

[1] Mean detection limit – reported as three times the standard deviation of the blank (n=15) for autoanalyzer samples

Ammonium

Ammonium is measured fluorometrically following the method of Kerouel and Aminot (1997). The sample is reacted with o-phthalaldehyde (OPA) at 75°C in the presence of borate buffer and sodium sulfite to form a fluorescent species in a quantity that is proportional to the ammonium concentration. Fluorescence is measured at 460 nm following excitation at 370 nm.

Nitrate and Nitrite

Nitrate and Nitrite are analyzed via the diazo reaction based on the methods of Armstrong et al (1967) and Grasshoff (1983). This automated procedure involves reduction of nitrate to nitrite by a copper-cadmium reductor column. The nitrite then reacts with sulfanilamide under acidic conditions to form a diazo compound, which then couples with N-1-naphthylethylene diamine dihydrochloride to form a purple azo dye. The concentration is determined colorimetrically at 550 nm.

Silicate

Silicate measurement is based on the reduction of silicomolybdate in acidic solution to molybdenum blue by ascorbic acid (Grashoff and Kremling 1983). Oxalic acid is introduced to the sample stream before the addition of ascorbic acid to minimize interference from phosphates. The concentration is determined colorimetrically at 820 nm.

Orthophosphate (DRP)

This automated procedure for the determination of orthophosphate is based on the colorimetric method of Murphy and Riley (1962) in which a blue color is formed by the reaction of orthophosphate, molybdate ion and antimony ion followed by reduction with ascorbic acid at a pH of 1. The reduced blue phospho-molybdenum complex is determined colorimetrically at 880 nm.

Total Phosphorus

Following the method developed by the University of Hamburg in co-operation with the Ocean University of Qingdao, this automated procedure for the determination of dissolved phosphorus in seawater takes place in three stages. First, the sample is irradiated in a UV digester. In this digestion step organically bound phosphorus is released. Second, acid persulfate is added, which further promotes breakdown of organic matter that persists after UV digestion, and polyphosphates are converted to ortho-phosphate by acid hydrolysis at 90°C. Third, the ortho-phosphate is determined by reaction with molybdate, antimony and ascorbic acid, producing a phospho-molybdenum blue complex which is determined colorimetricallyat 880 nm.

Total Nitrogen

Following the procedure developed by the University of Hamburg, inorganic and organic nitrogen compounds are oxidized to nitrate by persulfate under alkaline conditions in an on-line UV digestor. The nitrate is reduced to nitrite in a cadmium column and then determined using the sulfanilamide/NEDD reaction with colorimetric detection at 520 nm.

Particulate N and C

The Exeter Analytical model CE 440 elemental analyzer provides automated analysis of particulate carbon, hydrogen, nitrogen and sulfur following the general methodology outlined by Gordon (1969) and Sharp (1974).

4. **QA/QC Requirement**s

4.1. Instruments and equipment

Instrument maintenance. S-LAB prepares and follows a maintenance schedule for each instrument used to analyze samples collected from the watershed areas. All instruments are serviced at scheduled intervals necessary to optimize factory specifications. Routine preventive maintenance and major repairs are documented in a maintenance logbook. An inventory of items to be kept ready for use in case of instrument failure will be maintained and restocked as needed. The list of spare parts includes equipment replacement parts subject to frequent failure, parts that have a limited lifetime of optimum performance, and parts that cannot be obtained in a timely manner.

Refrigerators and drying ovens. Refrigerator units must be maintained between 0 - 6 ºC. The temperature should be checked and recorded on the temperature log sheet once per day on each day of use (depending on the laboratory and frequency of analysis). The refrigerator unit should be cleaned monthly and all materials identified and dated. All outdated materials should be disposed of properly and no food or drinks should be stored in the refrigerator unit. Similarly, ovens for drying filters are inspected before each use to ensure cleanliness.

Analytical balances. Analytical balances are calibrated once per year, and certified as necessary by national certification boards. All maintenance records will be kept on file.

Reagent water. For the reagent water system, the lab checks daily the TOC (ppb) and MOhms. This is observed for passable standards prior to using water (18.2 MOhms, and <4 ppb TOC). Monthly, the system is checked for volume of water through each filter, rejection feed on the feed water, and temp of feed water. The S-LAB maintains three, six, and twelve month upkeep protocols documented for the reagent water maintenance.

Cleaning protocols. Bottles are rinsed three times and dried prior to their reuse in sampling.

Inspection for supplies and consumables. Once per year, an inventory of all consumables is conducted to evaluate the physical condition of bottles, hoses and equipment. Any equipment that is substandard will be discarded. Chemical reagents will be discarded properly if past their expiration date. These inspections are documented in the laboratory notebook for QA review, if necessary.

4.2. Laboratory Analyses

The S-LAB has a formal quality control program that includes blanks, known standards, duplicates and range checks. Each sample run includes a blank and mid-level calibration duplicates every 10-15 samples. Values that are out of range, as presented in Table 1, are corrected on site before the sample results are finalized. Results of the blanks and mid-level calibration duplicates are noted in the lab report when sample results are reported. In addition, the % recovery (RPD) of the mid standards is calculated for each run.

During each run, the lab also tests quality control samples collected from station ALOHA. The data from these samples is used to ensure precision between individual runs. Finally, during the run standardized nutrient seawater reference material from the National Meteorology Institute of Japan (NMIJ) is analyzed and the data is provided on the run sheet.

4.3. Assessment and Oversight

The S-LAB analysis program is externally evaluated annually for proficiency by ERA. Parameters that are evaluated include salinity, pH, inorganic nutrients and organic nutrients. The results of the most recent proficiency test are always available upon request.

Table 2: Acceptable analytical methods and quality control acceptance criteria. RPD: relative percent difference, based on duplicate samples.

Parameter	Method number or description	Method/instrument	Units	Minimum Detection Limit[1]	Sensitivity resolution	Accuracy
S-LAB Analyses						
NH4	EPA Method 350.1	GF/F-filtered grab samples, SEAL Analytical AA3 autoanalyzer	µg N/L	1.0 µg N/L	< 20% RPD	80% - 120%
NNN	EPA Methods 353.2	GF/F-filtered grab samples, SEAL Analytical AA3 autoanalyzer	µg N/L	0.8 / 2.4 µg N/L	< 20% RPD	80% - 120%
DRP	EPA 365.1	GF/F-filtered grab samples, SEAL Analytical AA3 autoanalyzer	µg P/L	0.56 µg P/L	< 20% RPD	80% - 120%
TDN	UV-Digestion, EPA 353.2, Rev.2	GF/F-filtered grab samples, SEAL Analytical AA3 autoanalyzer	µg N/L	0.8 / 2.4 µg N/L	< 30% RPD	80% - 120%
TDP	EPA Method 365.1	GF/F-filtered grab samples, SEAL Analytical AA3 autoanalyzer	µg P/L	0.56 µg P/L	< 30% RPD	80% - 120%
Silicate	EPA Method 366.0	GF/F-filtered grab samples, SEAL Analytical AA3 autoanalyzer	µg/L	9.8 / 35.7 µg/L	< 20% RPD	80% - 120%
PN	EPA Method 440.0	GF/F-filters, Exeter Elemental Analyzer	% by mass			99%
PC	EPA Method 440.0	GF/F-filters, Exeter Elemental Analyzer	% by mass			93-99%

5. Data Quality Assessment

5.1. Reconciliation with data quality assurance objectives

As soon as possible after each lab run, calculations are made and corrective action implemented, if needed. If data quality indicators do not meet the project's specifications, data may be discarded and resampling may occur. The cause of failure will be evaluated. If the cause is found to be equipment failure, calibration/ maintenance techniques will be reassessed and improved.

For analytical samples, the QA officer will document each of the QC samples and the QC purpose (controlling bias, accuracy, etc). If the data quality objectives are not met, additional QC samples will be used to identify where in the process there is room for improvement or changes.

Any limitations on data use are detailed in both interim and final reports, and other documentation as needed.

Final Report Results For Laboratory SOEST Laboratories for Analyti

2009 TNI Evaluation Report

Study: **WP-260**

ERA Customer Number: **S953278**

Laboratory Name: **SOEST Laboratories for Analyti**

Inorganic Results

WP-260 2009 TNI Evaluation Final Complete Report

ERA
A Waters Company

Danielle Hull
SOEST Laboratories for Analyti
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EPA ID: Not Reported
ERA Customer Number: S953278
Report Issued: 10/31/16
Study Dates: 09/12/16 - 10/27/16

TNI Analyte Code	Analyte	Units	Reported Value	Assigned Value	Acceptance Limits	Performance Evaluation	Method Description	Analysis Date	Z Score	Study Mean	Study Standard Deviation	Analyst Name
WP pH (cat# 577, lot# P260-977)												
1900	pH	S.U.	7.41	7.44	7.24 - 7.64	Acceptable	EPA-842-B-06-003 pH Metrohm titrando	10/27/2016	-0.874	7.46	0.0554	
WP Simple Nutrients (cat# 584, lot# P260-505)												
1515	Ammonia as N	mg/L	6.197	6.17	4.83 - 7.53	Acceptable	SEAL ANALYTICAL: G-171-96 (MT19) 14	10/26/2016	0.0673	6.17	0.445	
1820	Nitrate + Nitrite as N	mg/L	4.823	4.75	3.88 - 5.57	Acceptable	SEAL ANALYTICAL: G-172-96 (MT19) 15	10/26/2016	0.0865	4.80	0.221	
1810	Nitrate as N	mg/L		4.75	3.82 - 5.65	Not Reported				4.80	0.262	
1870	ortho-Phosphate as P	mg/L	2.533	2.73	2.32 - 3.14	Acceptable	SEAL ANALYTICAL: G-297-03 (MT19) 3	10/26/2016	-1.36	2.72	0.134	
WP Complex Nutrients (cat# 579, lot# P260-525)												
1795	Total Kjeldahl Nitrogen	mg/L	14.519	13.8	10.2 - 17.0	Acceptable	SEAL ANALYTICAL: G-218-98 (MT23) 10	10/24/2016	0.880	13.6	0.989	
1910	Total phosphorus as P	mg/L	2.83	2.81	2.30 - 3.30	Acceptable	SEAL ANALYTICAL: G-219-98 (MT23) 11	10/25/2016	-0.276	2.87	0.161	
WP Turbidity (cat# 893, lot# P260-777)												
2055	Turbidity	NTU	5.45	5.06	3.85 - 6.24	Acceptable	EPA 180.1 2 1993	10/27/2016	0.290	5.31	0.476	

CERTIFICATE OF EXCELLENCE

In recognition of the quality of your laboratory in proficiency testing for

WP-260

SOEST Laboratories for Analyti

is issued this certificate of achievement by ERA. This laboratory has been recognized as a Laboratory of Excellence for achieving 100% acceptable data in this study which included 548 participating laboratories. This achievement is a demonstration of the superior quality of the laboratory in evaluation of the standards listed below.

Complex Nutrients
pH
Simple Nutrients
Turbidity

Patrick Larson
Quality Officer

S953278