Pōhākea Watershed Plan

Maui County, HI
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ACRONYMS

AURORA	Autonomous Unmanned Remote Monitoring Robotic Airship
BMPs	Best Management Practices
BOD5	5-day Biological Oxygen Demand
CCAP	Coastal Change Analysis Program
CWA	Clean Water Act
CWB	Clean Water Branch
CDF	CDF Engineering, LLC
CDUA	Conservation District Use Application
CFR	Code of Federal Regulations
COVID19	Coronavirus Disease of 2019
CSC	Coastal Services Center
DAR	Department of Aquatic Resources
DEM	Digital Elevation Model
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
GPS	Global Positioning System
HAR	Hawaiʻi Administrative Rule
HDOH	Hawaiʻi Department of Health
HOKWO	Hui O Ka Wai Ola
HRS	Hawaiʻi Revised Statutes
HWMO	Hawaiʻi Wildfire Management Organization
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
LID	Low Impact Design/Development
LLC	Limited Liability Company
MEC	Maui Environmental Consulting, LLC
MECO	Maui Electric Company
MNMRC	Maui Nui Marine Resource Council
MOC	Maui Ocean Center
MS	Microsoft
N	Nitrogen
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
NSPECT	Nonpoint Source Pollution and Erosion Comparison Tool
NTU	Nephelometric Turbidity Unit – unit used to measure turbidity

PRCP	Polluted Runoff Control Program
PRISM	Parameter-elevation Regressions on Independent Slopes Model
PUC	Public Utility Commission
PWP	Pōhākea Watershed Plan
Pv	Volume of stormwater captured
QAPP	Quality Assurance Project Plan
RUSLE2	Revised Universal Soil Loss Equation – Version 2
SDWA	Safe Water Drinking Act
SMA	Special Management Area
SOP	Standard Operating Procedure
STEPL	Spreadsheet Tool for Estimating Pollutant Loads
SWCD	Central Maui Soil and Water Conservation District
TKN	Total Kjeldahl Nitrogen
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
Vsp	Surface ponding volume
Vs	Storage volume of soil/compost
Vg	Storage volume of gravel and/or stone/coral layer
WQC	Water Quality Certification
WQS	Water Quality Standard
WWII	World War II

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.

In 2018 at the request of Maui Nui Marine Resource Council (MNMRC), Maui Environmental Consulting, LLC (MEC), conducted a study to investigate and address land-based sources of pollution within Māʻalaea Bay and Māʻalaea Harbor. This area of land and its contributing waters make up the Pōhākea Watershed. The study focused on erosion and sediment transport caused by surface water flow during stormwater events. Any on-site observations of nutrient, pathogen, or other pollutant sources, as well as any other land management practices that may be contributing to water quality degradation in the watershed were identified. The results of this study were compiled into a document called the Pōhākea Stormwater Management Plan. Several projects proposed in the Pōhākea Stormwater Management Plan have already been implemented.

Since the production of the Pōhākea Stormwater Management Plan, the Central Maui Soil and Water Conservation District (SWCD) has updated and transformed that initial document into a full-scale watershed plan to address pollutants causing impairments to the watershed. Careful consideration was taken to research, collect, and analyze data, and to synthesize that information into what is now known as the Pōhākea Watershed Plan (Plan). This watershed plan has been developed by the SWCD to represent diverse stakeholder interests including local, state, and federal agencies; private landowners and other residents; and nonprofit organizations. It provides a path forward in managing the watershed in ways that satisfy both environmental and human health as well as economic interests.

From the summit of Hanaula in the West Maui Mountains at 4,616 feet and spanning southeast to the coast, the Pōhākea Watershed covers an area of 5,268 acres. There are four major streams (Pōhākea, Kanaio, Māʻalaea, and Malalowaiaole) within the watershed, as well as several other smaller gulches and ditches that flow into Māʻalaea Bay or Māʻalaea Harbor. All of these streams flow ephemerally or only during stormwater events. Conservation, Agriculture, and Urban land use districts and the activities associated with each land use have altered the landscape in ways that greatly impact the movement of water and sediment within the watershed. Sediment and nutrient contaminated stormwater runoff are the major sources of water pollution. Increased sedimentation and nutrient loading are detrimental to the nearshore coastal ecosystems and threaten the existence of coral reefs and the habitats they support.

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 a tourism enterprise. To manage the land is to protect the water, and all who live, work, and recreate within the watershed will benefit from measures to reduce pollution.

According to the Hawai‘i 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 Pōhākea watershed are listed as impaired for several parameters including ammonium, turbidity, chlorophyll-a, enterococcus, total nitrogen, and nitrate+nitrite at one or more sampling locations. Each of the three sample locations within the Pōhākea watershed lack adequate data for assessment of at least one or more water quality standard.

The goal of the Pōhākea Watershed Plan is to identify the various sources of pollution within the watershed and to provide best management practices that will prevent sediment-laden runoff and nutrients from entering the waterway. In considering the environment, economy, and community, this Plan aims to learn from the past and provide solutions that will restore and preserve the watershed into the future.

2.0 INTRODUCTION AND PURPOSE

Encompassing approximately 5,268 acres, the Pōhākea Watershed Plan (PWP) was developed to address land based pollution entering Māʻalaea Bay. The watershed begins at 4,616 feet at the summit of Hanaula in the West Maui Mountains, and extends southeast to the coast where its gulches and gullies drain into the waters of Māʻalaea Bay (Figure 1. Pōhākea Aerial Map). This Plan is a community-based watershed plan to protect and restore water quality. Pollutants such as nutrients, toxic chemicals, pathogens, and sediment originate from various sources within the watershed. These pollutants are transported via surface or groundwater to streams, wetlands, estuaries, and coastal waters, and pose a threat to environmental and human health. Nonpoint source pollution originates from diffuse sources associated with a variety of land uses including urban, agricultural, residential, and conservation. The combined effects of point and nonpoint source pollution can result in decreased water clarity, harmful or nuisance algae blooms, nutrient loading, toxic pollutants and pathogens, and an overall decline in the health of native ecosystems and aquatic organisms.

The PWP began as the Pōhākea Stormwater Management Plan to improve water quality within Māʻalaea Bay and Māʻalaea Harbor, and many projects included in the stormwater management plan are currently underway. Transition of the Pōhākea Stormwater Management Plan into a full-scale watershed plan will provide strategies for watershed coordinators, stakeholders, resource managers, policy makers, and community members to combat water pollution. The PWP will also create opportunities to secure funding for ongoing and future projects.

To meet water quality standards and to protect water resources within the planning area, watershed characterization, planning, and implementation guidelines put forth by the EPA were adhered to by the SWCD. Appropriate stakeholders were engaged to determine how to best manage the watershed to meet environmental and human health standards, and to satisfy economic interests. This Plan has been developed by the SWCD to focus on the watershed planning area designated by the State of Hawaiʻi as the Pōhākea Watershed.

2.1 Building Partnerships

2.1.1 Community Outreach

Watershed planning is the outcome of impaired water statuses caused by stormwater runoff contaminated with pollutants within the planning area. The brown water events that result from flooding further emphasize the need for land management to protect marine habitats. Community members, stakeholders, non-profits, landowners, and government entities share common interests of improving water quality within the watershed.

Maui Nui Marine Resource Council has played a major role in community engagement, public outreach, and education for Pōhākea Watershed. Several projects suggested in the Pōhākea Stormwater Management Plan have been implemented and are ongoing. MNMRC's initiatives include oyster bioremediation, low-impact design assessments, road improvements, vetiver planting, erosion monitoring, and nature-based solutions to cesspools and injection wells. Information regarding these topics is discussed during monthly seminars and on MNMRC's social media outlets, and volunteers are encouraged to participate in the planting efforts. More information about the Pōhākea Watershed Plan and an overview of future plans for surrounding watersheds is available on www.mauireefs.org and www.mauiwatershed.org. Implementation and execution of this plan will be a collaborative effort among all entities.

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

In 2018, Maui Nui Marine Resource Council, a non-profit working to protect coral reefs by ensuring clean ocean water, commissioned Maui Environmental Consulting, LLC to prepare the Pōhākea Stormwater Management Plan. That plan was the precursor to this document. In addition, a non-profit called the National Fish and Wildlife Foundation (NFWF) has been working with MNMRC supporting watershed management work. NFWF has funded several projects designed to improve water quality in Māʻalaea Harbor and Māʻalaea Bay. These projects have included maintaining and establishing new fuel and fire breaks, water quality monitoring, head cut monitoring, as well as other projects that will be discussed in detail later in this report.

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, Hanaula Ranch, Mahi Pono, Hope Builders, LLC, West Maui Construction, Inc., Maui Ocean Center, The Māʻalaea Village Association, and the Māʻalaea Triangle.

2.1.3 Key Stakeholders

In keeping with the EPA nonpoint source pollutant control (Section 319) grant requirements, the SWCD and MEC engaged with appropriate stakeholders within the community. Stakeholders representing diverse interests including local, state, and federal agencies; private landowners, nonprofit organizations, and community residences were invited to participate in the watershed planning effort. Several public meetings were held to discuss the process and gather input. Stakeholders were tasked with determining how to best manage the watershed in ways that satisfy environmental, human health, and economic interests.

The management measures executed from the Pōhākea Stormwater Management Plan have been a combined effort among various stakeholders within the watershed area. Much of this work was spearheaded by MNMRC.

Key stakeholders in the PWP include but are not limited to Maui County, Central Maui Soil and Water Conservation District, 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 Coast Guard, 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, Pacific Whale Foundation, Māʻalaea Harbor Shops, Māʻalaea Village Association, Māʻalaea Triangle, and all other residents and businesses in Māʻalaea , Goodfellow Bros., CDF Engineering, Maui Ocean Center, and many others.

While the Central Maui Soil and Water Conservation District is primarily responsible for implementing the Plan, the entire community falling within the watershed boundary is potentially affected by the implementation projects being proposed. Public health, water quality and clarity, flooding of public roads and private property, habitat for listed species and overall ecological health, the fishing and tourism industries, hotels, resorts, small businesses, and the community will be positively affected by implementation of the Plan.

Through meetings with individual entities and organizations, the SWCD reached out to stakeholders to provide and receive information on issues and concerns within the watershed. From the restorative work being by Maui Nui Marine Resource Council, to water quality testing in the coastal waters by the Hui O Ka Wai Ola, to small business owners who rely on healthy and clean coastal waters for their business, the SWCD has identified stakeholders that have knowledge of existing programs and can serve as resources of information. Numerous discussions with Maui County regarding the sale of the Spencer Property were held prior to Hope Builders, LLC and West Maui Construction, Inc. acquiring the 257-acre Spencer property. In addition, stakeholders such as the Hawaiʻi Department of Land and Natural Resources and the Māʻalaea Village Association can provide vital resources needed to implement the Plan. Some of these resources include, grants, monetary donations, volunteer work, fundraising, public outreach, educational opportunities, etc. 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 PWP (Table 1. Stakeholder Capacity in the Pōhākea Watershed Plan)

Table 1. Stakeholder Capacity in the Pōhākea Watershed 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	Stakeholder who can provide technical and financial assistance in implementing the Plan
Central Maui Soil and Water Conservation District	**X**				
Maui County		**X**	**X**	**X**	**X**
Hawai'i Department of Health Clean Water Branch Polluted Runoff Control Program			**X**	**X**	**X**
Hawai'i 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	Stakeholder who can provide technical and financial assistance in implementing the Plan
Mā‘alaea Village Association		**X**	**X**	**X**	**X**
Maui Nui Marine Resource Council		**X**	**X**	**X**	**X**
Rural Land Owners		**X**	**X**		**X**
Urban Land Owners		**X**	**X**		**X**
Small Businesses		**X**	**X**		**X**
Hawai‘i Tourism Authority		**X**	**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 residences were invited to participate in the watershed planning effort. Several public meetings were held to discuss the process and gather input. Early in the planning process the www.mauiwatershed.org website was developed. Stakeholders were tasked with determining how to best manage the watershed in ways that satisfy environmental, human health, and economic interests.

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.

2.1.6 Identify Possible Management Strategies

The Central Maui Soil and Water Conservation District divided the watershed by land use types and developed possible management strategies based on these distinct areas. Most of the land in the watershed is already designated as conservation land. Agricultural lands exist mauka of Honoapiʻilani Highway, at the inflection point between the steep slopes of Mauna Kahālāwai and the coastal plain associated with Māʻalaea Bay. For this reason, it was determined that management of sediment within the land recently acquired by Hope Builders, LLC and West Maui Construction, Inc. would be most beneficial to the overall reduction in sediment entering Māʻalaea Harbor and Māʻalaea Bay. In addition, management strategies were discussed for the urban portions of the watershed, with an emphasis placed on wastewater generated by the Māʻalaea Village Association condominiums. Within conservation lands, efforts should focus on ungulate fencing and native forest rehabilitation.

3.0 WATERSHED CHARACTERIZATION

The Pōhākea Watershed is comprised of 87 different Tax Map Keys (TMK) in Maui County, Hawai‘i, with the large landowners shown in the map below (Figure 2. Pōhākea TMK Map). Pōhākea Watershed 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 to the eastern ridge of Manawainui Gulch (project area). The makai portions of the watershed are approximately located between mile markers 4.5 and 9.25 along Honoapi‘ilani Highway (or from just west of Papawai Point to just north of the intersection of Honoapi‘ilani and Kūihelani Highways. Pōhākea extends east to approximately mile marker 1.5 along North Kihei Road and the western edge of Keālia Pond. The entire area is part of the West Maui Mountains land formation and discharges into the western portion of Mā‘alaea Bay (Figure 3. Location Map).

The approximately 5,268-acre watershed is composed of several different land formations. As stated above, the watershed begins at the summit of Hanaula within the West Maui Mountains at 4,616 feet above sea level. From here, the watershed flows south and east through several gulches that all discharge into Mā‘alaea Bay or Mā‘alaea Harbor. Hillslope is relatively steep at the upper portions of the West Maui Mountains, with grade leveling off considerably at approximately 400 feet and continuing to gradually drop along the coastal areas to the ocean (Figure 4. Poakea Quadrangle Map). Throughout this document the terms gulch and stream are used interchangeably.

Figure 1. Pōhākea Aerial

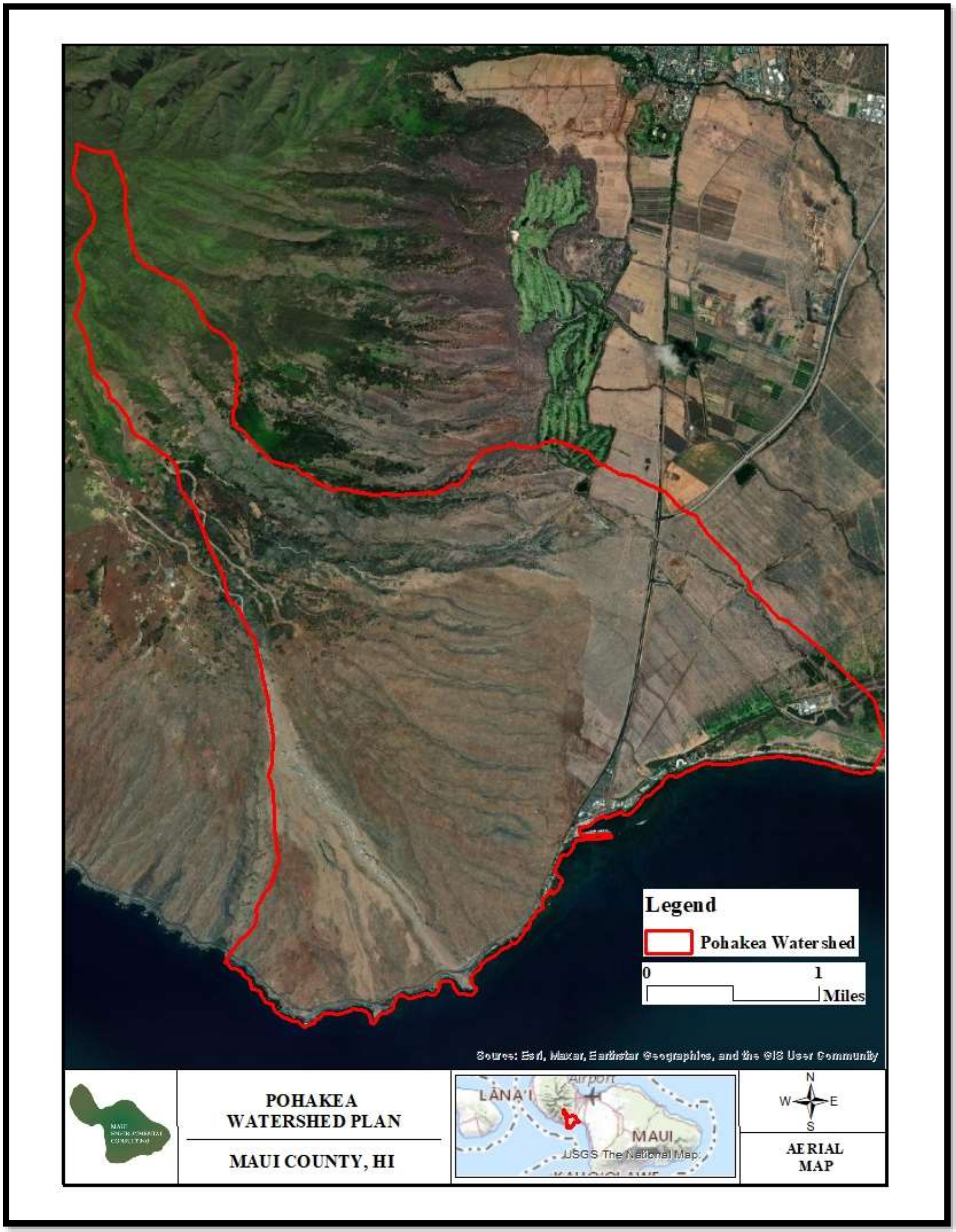


Figure 2. Pōhākea TMK Map

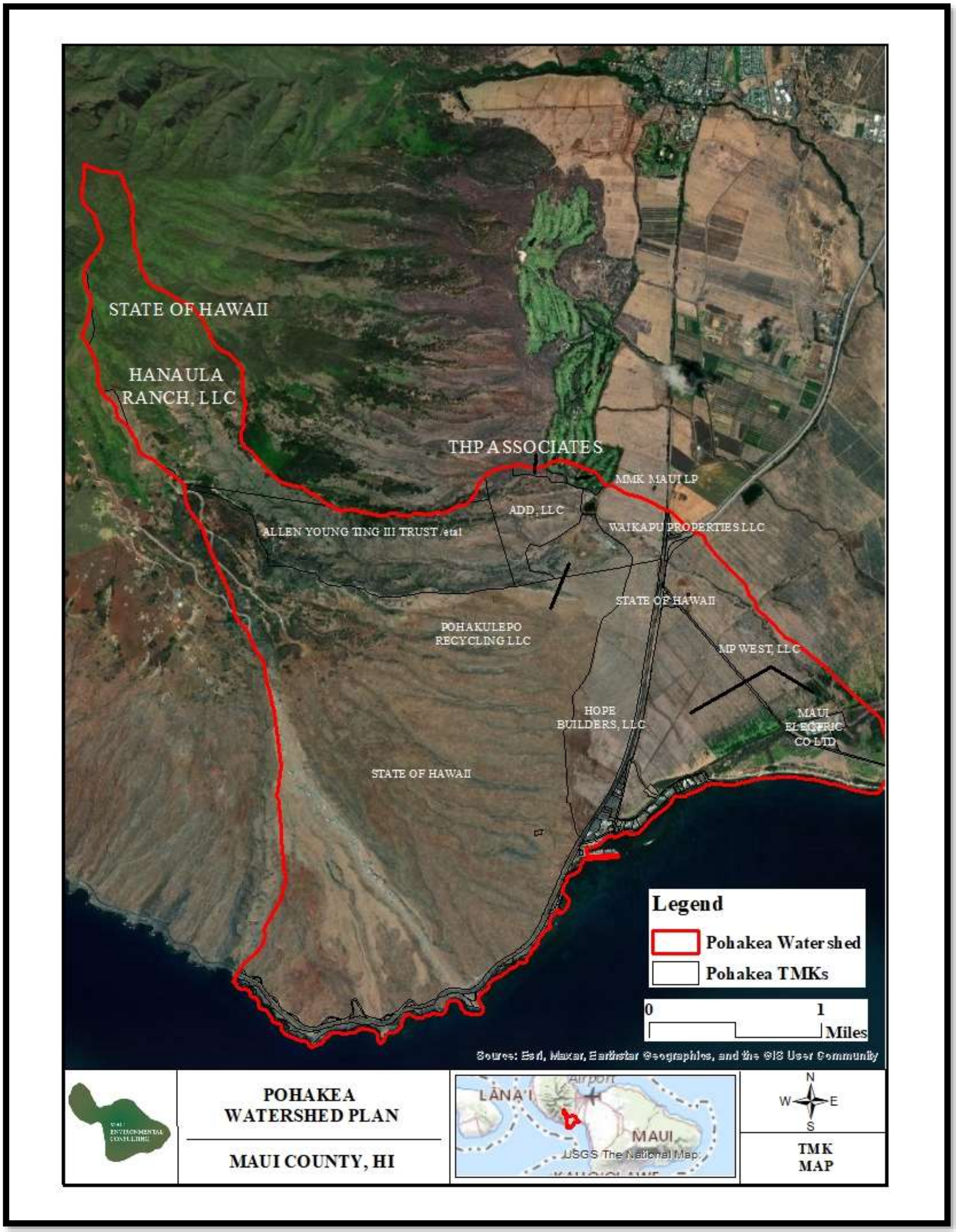


Figure 3. Pōhākea Location Map

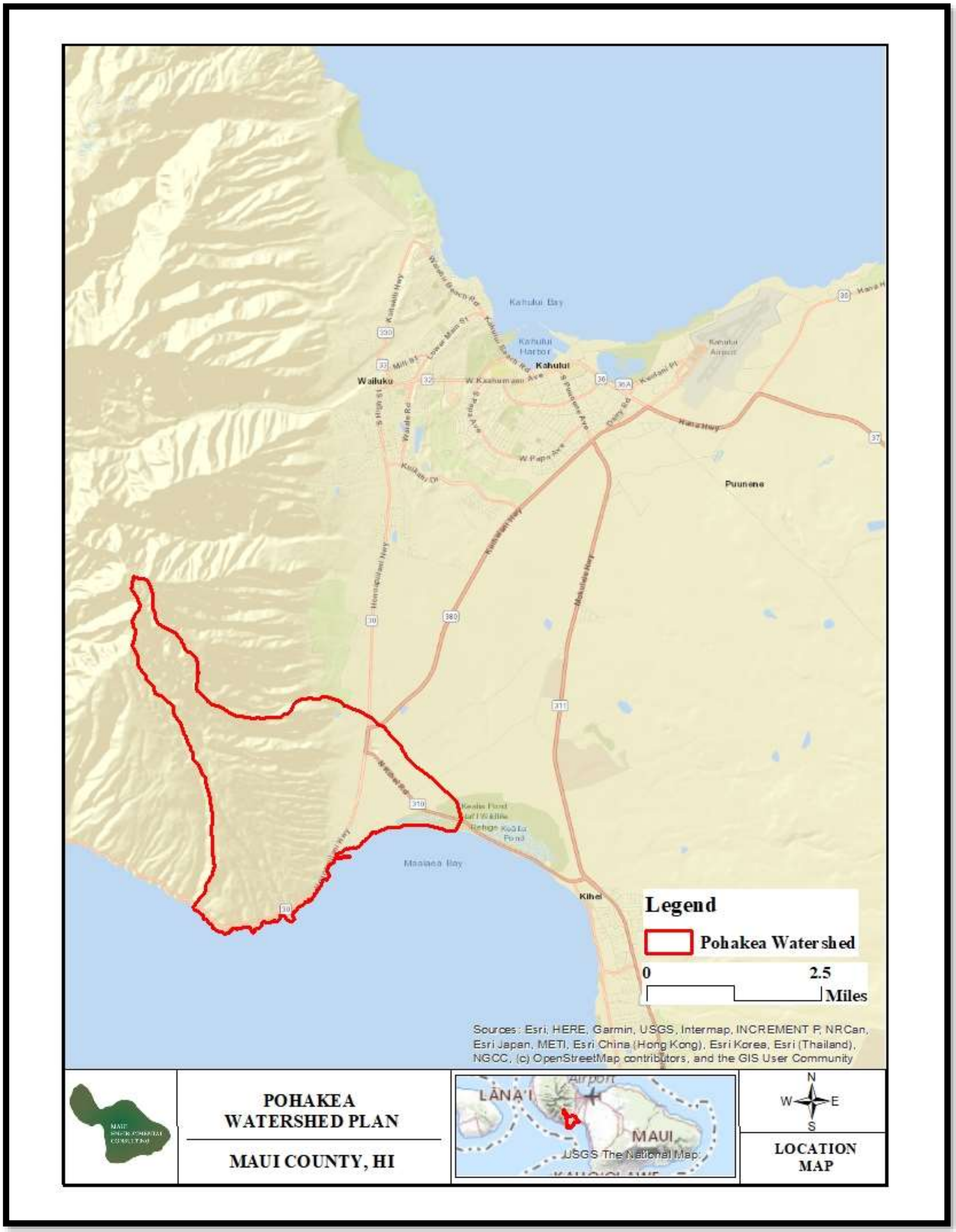
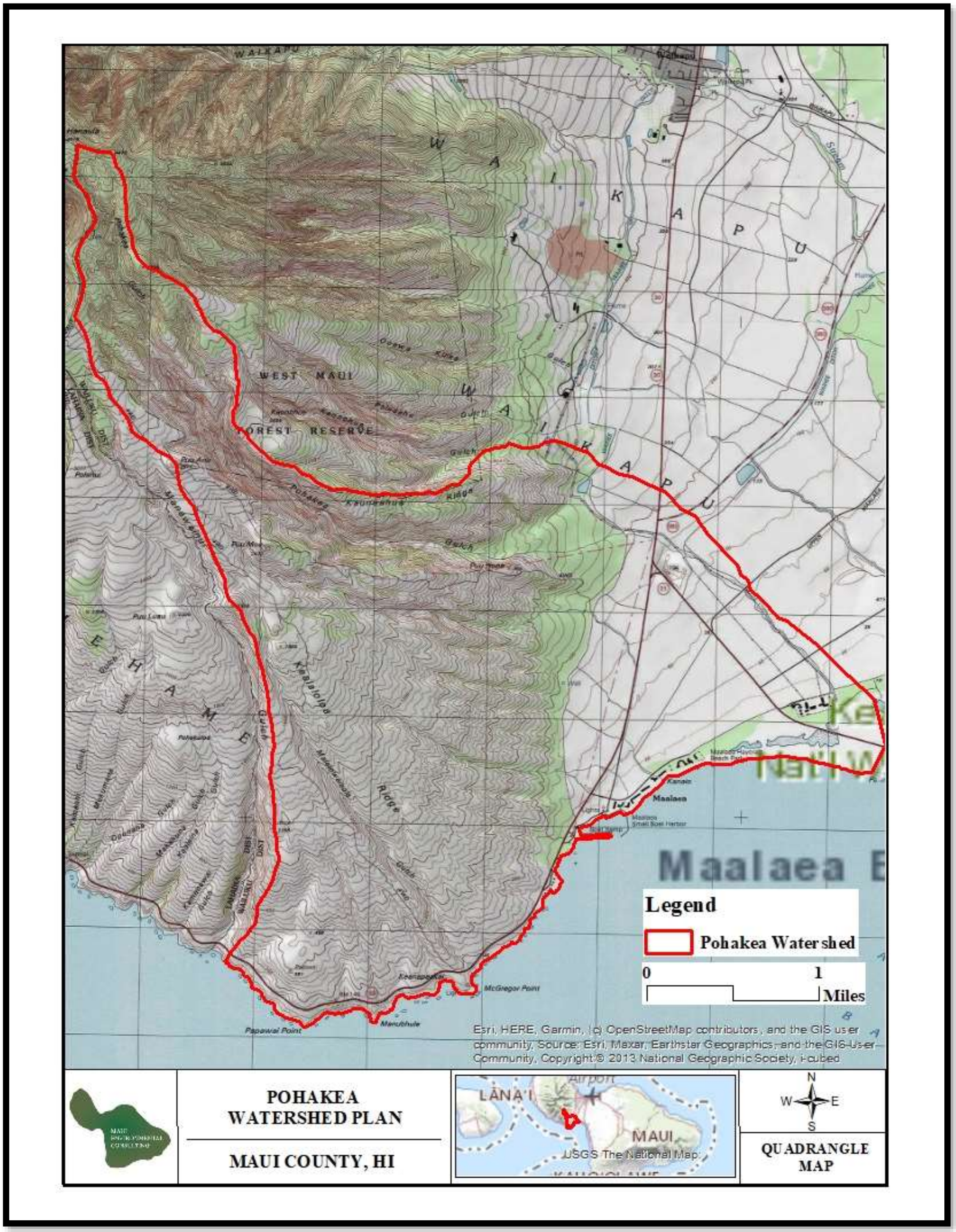


Figure 4. Pōhākea Quadrangle Map



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 & 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 & 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 & Lau, 2006). The boundaries of Pōhākea Watershed make up the southeastern edge of the West Maui Mountains and is dominated by the Wailuku volcanic series with the Honolua volcanic series transecting along the southern rift. Predominantly composed 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. The Honolua volcanic series contains some pahoehoe lava, but is mostly aʻa lava made up of trachyte, benmoreite, and some hawaiite (Macdonald, et al. 1983). The mountain range spans approximately 18 miles and is deeply dissected by stream erosion.

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 (Figure 4. Pōhākea Quadrangle Map). Steeper slopes are associated with higher elevations, along the steep ridges and sides of Pōhākea Gulch, and along the steep banks of Malalowaiaole, Māʻalaea, and Kanaio Gulches.

3.3 Soils

Based on the USDA/NRCS Soil Survey for Maui County (Version 15, October 3rd, 2017), 19 soil types are mapped within the Pōhākea Watershed (Figure 5. Pōhākea Soils Map). Listed below are the soil types found within Pōhākea Watershed and general descriptions of their characteristics.

Table 2. Pōhākea Watershed Soils

Soil Symbol	Soil Name	Mean Annual Precipitation (inches)	Elevation (feet)	Slope (percent)	Drainage Class	Runoff Class	Frequency of Flooding
BS	Beaches	10 to 75	0 to 10	1 to 5	Excessively Drained	Very Low	Frequent
CPI	Cinder Pit	NA	NA	NA	NA	NA	NA
EsB	Ewa Silty Clay	15 to 30	0 to 150	3 to 7	Well Drained	Medium	None
EtB	Ewa Cobbly Silty Clay	15 to 30	0 to 150	3 to 7	Well Drained	Medium	None

Soil Symbol	Soil Name	Mean Annual Precipitation (inches)	Elevation (feet)	Slope (percent)	Drainage Class	Runoff Class	Frequency of Flooding
KMW	Keālia Silt Loam	10 to 41	0 to 260	0 to 1	Poorly Drained	Negligible	Frequent
NAC	Naiwa Silty Clay Loam	45 to 95	600 to 3,030	13 to 45	Well Drained	High	None
OFC	Olelo Silty Clay	60 to 10	1,430 to 3,420	15 to 50	Well Drained	High	None
OMB	Oli Silt Loam	30 to 40	1,000 to 2,250	3 to 10	Well Drained	Medium	None
PpB	Pulehu Silt Loam	10 to 35	0 to 300	3 to 7	Well Drained	Low	Occasional
PrB	Pulehu Cobbly Silt Loam	10 to 35	0 to 300	3 to 7	Well Drained	Medium	Occasional
PsA	Pulehu Clay Loam	10 to 50	0 to 300	0 to 3	Well Drained	Low	Rare
PtA	Pulehu Cobbly Clay Loam	10 to 35	0 to 300	0 to 3	Well Drained	Low	Occasional
PtB	Pulehu Cobbly Clay Loam	10 to 35	0 to 300	3 to 7	Well Drained	Medium	Occasional
W	Water	NA	NA	NA	NA	NA	NA
rRK	Rock Land	15 to 60	0 to 6,000	0 to 70	Well Drained	Very High	None
rRO	Rock Outcrop	10 to 175	0 to 10,000	5 to 99	Well Drained	Very High	None
rRS	Rough Broken and Stony Land	20 to 200	0 to 4,000	40 to 70	Well Drained	Very High	Frequent
rRT	Rough Mountainou s Land	NA	0 to 6,000	50 to 99	Well Drained	Very High	None
rSM	Stony Alluvial Land	10 to 50	0 to 1,000	3 to 15	Well Drained	Medium	Frequent

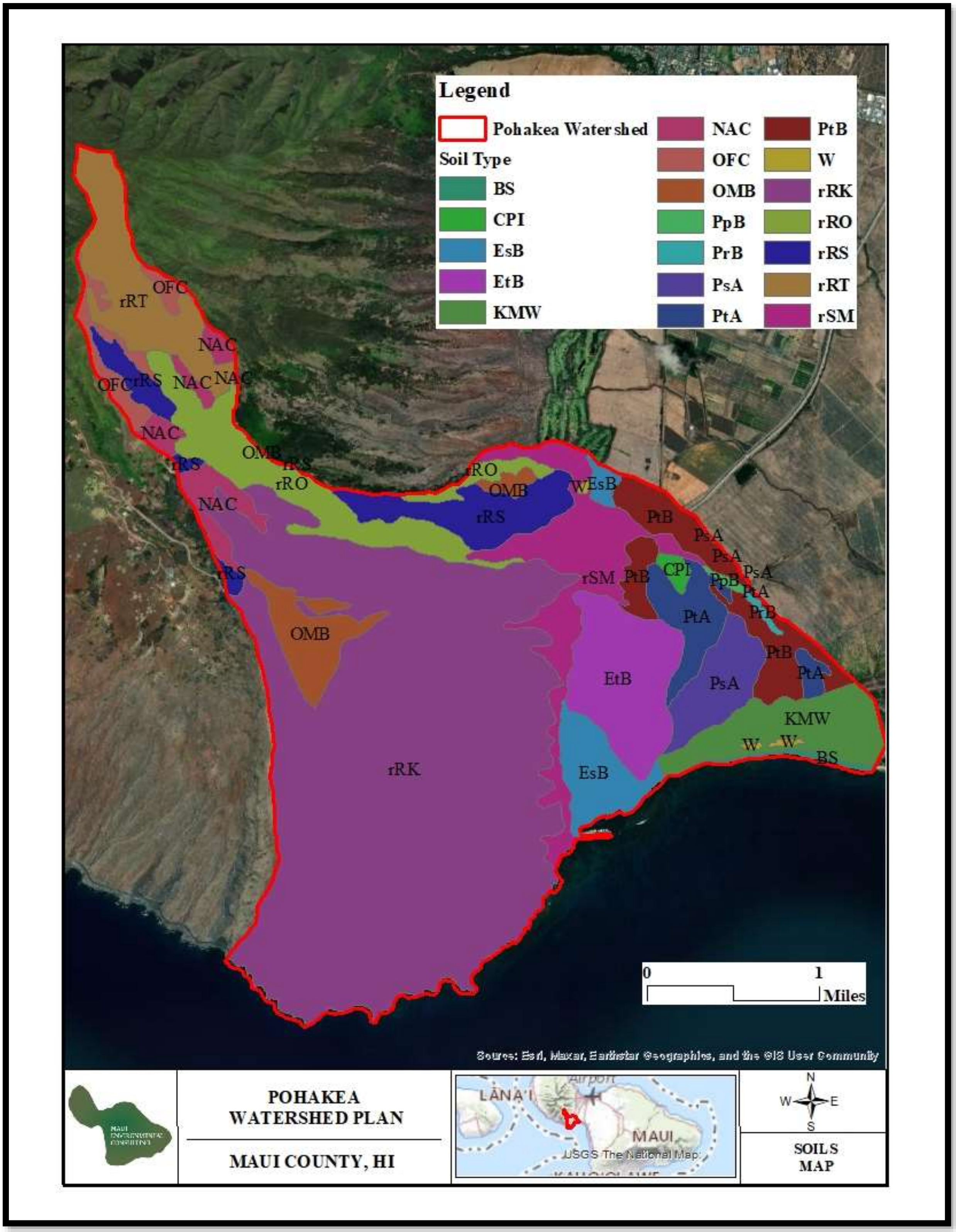
*Precipitation data is associated with the USDA,NRCS soil descriptions.

As seen in Figure 5. Pōhākea Soils Map, rRK – *Rock Land* is the dominant soil type within the Pōhākea Watershed. This soil type is considered well drained with very high runoff potential. This soil type was formed during pahoehoe lava flows. Pahoehoe flows are associated with low volume and low flow eruption events. Because these flows are slow, individual pahoehoe toes form along the flow, developing a smooth unbroken skin that cools by the air. Pahoehoe flows are therefore often characterized as smooth lava as opposed to a‘a which is considered rough lava (Carr, 1980). The parent material for Rock Land is basalt with silty clay loam found between zero to four inches of the surface, silty clay located between four to eight inches deep, and bedrock from eight to 20 inches of the surface. The restrictive feature is lithic bedrock and is usually encountered within four to ten inches of the surface. Depth to the water table is typically greater than 80 inches.

Similar soil types with high runoff potential include rRO – *Rock Outcrop*, rRS – *Rough Broken and Stony Land*, rRT – *Rough Mountainous Land*, and rSM – *Stony Alluvial Land* and 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 of the Pōhākea Watershed and have high runoff potential.

One hydric soil is found within the Pōhākea Watershed boundary. KMW – Keālia Silt Loam is associated with Keālia Pond which experiences frequent flooding and ponding. This soil type is found in tidal marshes and salt flats. The parent material is alluvium over beach sand. From the surface to three inches deep, this soil type consists of silt loam. Silt loam exists from three inches to 27 inches. Beyond 27 inches, fine sandy loam exists. This poorly drained soil has a depth to restrictive feature of over 80 inches. Depth to water is typically 12 to 42 inches depending on seasonal fluctuations in rainfall.

Figure 5. Pōhākea 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

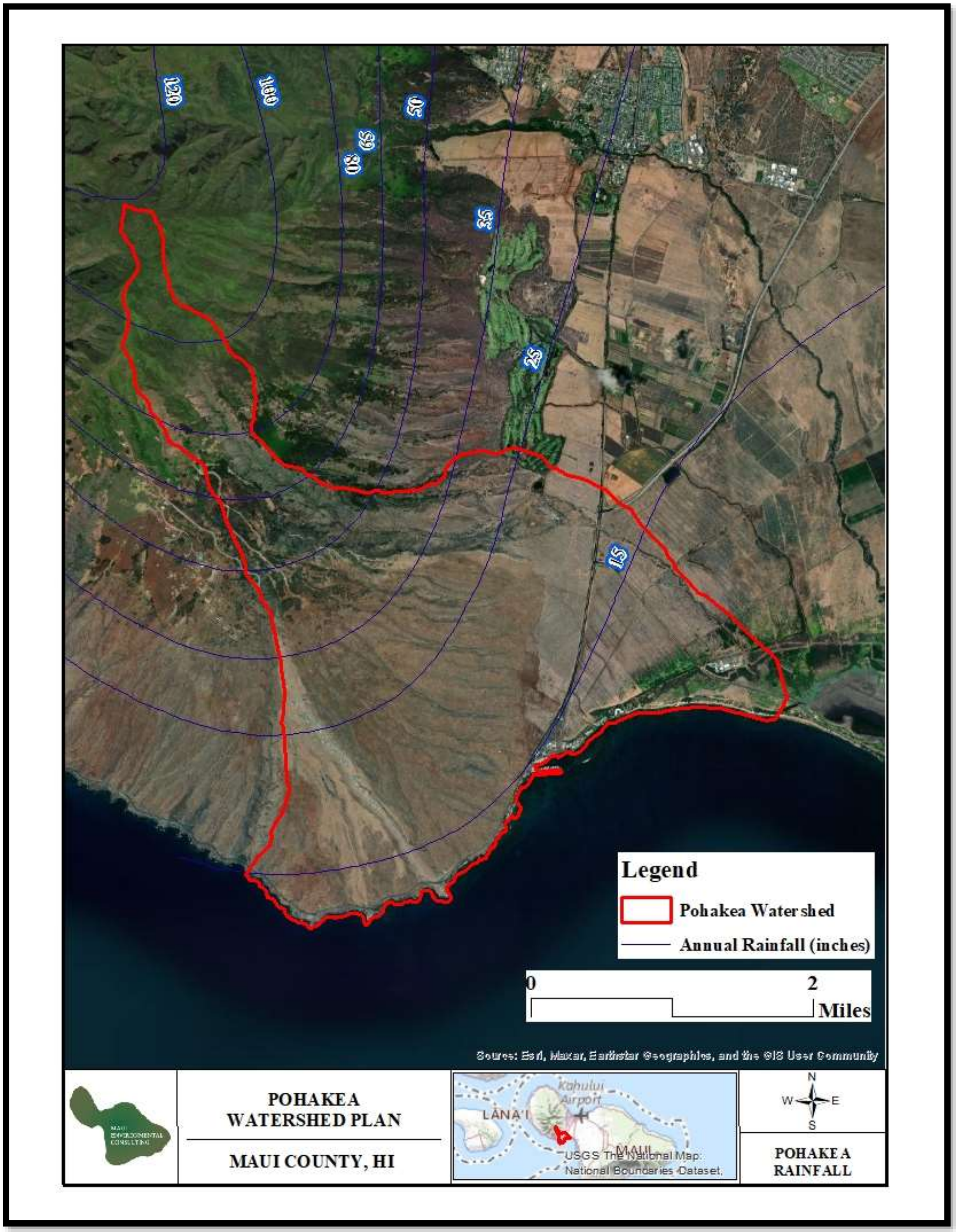
Rainfall data for Pōhākea watershed is limited. The nearest rain gauge is the Waikapu 390 rain gauge located at 20.8536 degrees latitude and -156.6088 degrees longitude. While this rain gauge is the nearest monitoring device, its lies outside of the Pōhākea watershed boundaries and represents a wetter microclimate. The period-of-record began 16 August 1916 and continues through present day. Additional rainfall data was reviewed from GIS generated isohyets. Data used to generate Figure 6. Pōhākea Rainfall Map was pulled from the State of Hawaiʻi, Office of Planning Geographic Information System Data Portal.

To capture recent rainfall trends associated with the Māʻalaea Triangle, the last five years (2017-2021) of rainfall data from the Waikapu 390 station was analyzed. The median and maximum rainfall was recorded for each month within the five-year dataset. As mentioned above, the location of this rain gauge receives more precipitation than the location of the Māʻalaea Triangle. Based on the isohyets provided, the Project receives less than 15 inches of annual rainfall while the median rainfall over the five-year period at Waikapu 390 was 23.94 inches. Knowing that this rain gauge is in a wetter location than the Project, designing projects to accommodate rainfall events recorded at Waikapu 390 produces conservative estimations when designing infrastructure to accommodate these stormwater capacities.

Table 3. Waikapu 390 Rainfall by Month from 2017 to 2021

Year	Monthly Rainfall												Totals
	January	February	March	April	May	June	July	August	September	October	November	December	
2017	5.77	4.28	4.55	No Data	1.30	0.33	0.77	0.31	0.24	3.86	3.14	10.83	35.38
2018	0.05	8.92	2.19	4.89	1.85	0.05	0.67	1.34	4.36	2.11	2.73	1.29	30.45
2019	2.56	6.49	0.75	No Data	1.24	0.00	0.08	0.44	0.01	0.29	0.28	0.61	12.75
2020	1.37	2.95	1.89	1.60	0.85	0.00	0.01	0.01	0.21	0.36	0.09	0.00	9.34
2021	5.61	1.75	4.51	2.03	0.07	0.02	0.00	0.24	0.02	0.12	0.42	9.15	23.94
Monthly Median Rainfall	2.56	4.28	2.19	2.03	1.24	0.02	0.08	0.31	0.21	0.36	0.42	1.29	23.94
Monthly Maximum Rainfall	5.77	8.92	4.55	4.89	1.85	0.33	0.77	1.34	4.36	3.86	3	10.83	35.38

Figure 6. Pōhākea Rainfall Map



3.6 Hydrology

3.6.1 Surface Water: Pōhākea Watershed Landscape and Major Drainageways

3.6.1.1 Pōhākea Gulch

As its name implies, the major landscape feature within the watershed is Pōhākea Gulch. This deeply incised gulch flows almost due east, passing just south of the Hawaiian Cement Quarry located at the end of Kūihelani Road and continuing across Honoapiʻilani Highway via a culvert system, north of the privately owned and now permanently closed Maui Construction and Demolition Landfill. Pōhākea continues to flow through agricultural fields, paralleled by Maui Electric (MECO) powerlines before wrapping around the northern boundary of the oil powered 212.1 megawatt MECO Māʻalaea Powerplant. From here, Pōhākea discharges into Keālia Pond National Wildlife Refuge and ultimately into Māʻalaea Bay.

3.6.1.2 Kanaio Gulch

Kanaio Gulch begins south of Pōhākea Gulch at the base of Puʻu Moe at approximately 2,400 feet. The gulch flows east toward Honoapiʻilani Highway. Historically, this stream continued across the highway and through what is now fallow agricultural land before terminating at what is today Haycraft Beach Park. Currently, the stream passes under the highway via culvert, and is then diverted into a box-cut concrete lined ditch (Waiheʻe Makai Ditch) on the makai side of Honoapiʻilani Highway. From here, Kanaio flows southwest to a confluence with an unnamed gulch that also crosses the highway via culvert. Flow from both systems and two additional unnamed ditches connected by culvert under the highway, continue south and east within Waiheʻe Makai Ditch. This section of the flow way has steep, nearly vertical walls before discharging into a detention basin mauka of Hauʻoli Street and the Maui Island Sands Resort. This detention basin has failed in the past due to large stormwater volumes and has required repairs. Water from both Kanaio and the unnamed gulches then passes under Hauʻoli Street via culvert, passing through a concrete lined drainageway in between Maui Island Sands Resort and the Māʻalaea Banyans before discharging into Māʻalaea Bay (Figure 8. Pōhākea Discharge Pathways).

3.6.1.3 Māʻalaea Gulch

Māʻalaea Gulch is located south of the unnamed gulch associated with Kanaio Gulch mentioned above. Māʻalaea gulch begins at approximately 1,800 feet, flowing east towards Honoapiʻilani Highway. From here, the gulch enters a culvert and remains underground until it discharges into Māʻalaea Harbor. In addition to Māʻalaea gulch, at least three other small unnamed gulches flow east to the highway before entering culvert systems that discharge into Māʻalaea Harbor makai of the intersection of Honoapiʻilani Highway and Māʻalaea Road.

3.6.1.4 Malalowaiaole Gulch

Malalowaiaole Gulch originates at approximately 2,000 feet. This gulch is at the eastern flank of Kealaloloa Ridge. This ridge is home to the Kaheawa Wind Power wind farm and its associated access road. Malalowaiaole Gulch flows southeast towards the base of the dirt access road. From here, the system enters large culverts as it passes under the dirt road before continuing along the

Honoapiʻilani Highway where it again enters a culvert system before finally discharging into coastal waters east of McGregor Point.

Beyond Malalowaiaole Gulch, three unnamed gulches discharge into coastal waters through culvert systems under Honoapiʻilani Highway. One discharges east of Manuohule Point and the other two flank the Papawai land formation, located at approximately 380 feet, discharging into coastal waters on either side of Papawai Point. Additional culverts exist west of Malalowaiaole Gulch where gullies and gulches run under the highway. Due to the unsafe conditions caused by heavy traffic and narrow road shoulders associated with the Pali, MEC staff did not record GPS positions of these culverts.

3.6.1.5 Waiheʻe Ditches

In addition, Waiheʻe Mauka Ditch runs north to south along the base of the West Maui Mountains, where steep hills transition to relatively flat coastal lands. This ditch discharges into Pōhākea Gulch before ultimately flowing into Keālia Pond. A second ditch, also named Waiheʻe Ditch, is referred to as Waiheʻe Makai Ditch in this report for clarity. Waiheʻe Makai Ditch historically flowed along the makai side of Kūihelani Highway, wrapping around the landfill before crossing under North Kihei Road and continuing on the makai side of Honoapiʻilani Highway. The ditch now appears to begin along the highway and continue south, connecting with Kanaio Gulch and three unnamed ditches before connecting through the detention basin mentioned in Section. 2.2.2 above before ultimately discharging into Māʻalaea Bay.

3.6.2 Stream Designations

As listed above, there are four major streams associated with the Pōhākea Watershed (Figure 7. Pōhākea Major Drainageways). Moving north to south, these include Pōhākea, Kanaio, Māʻalaea, and Malalowaiaole. Additional unnamed gulches also exist, and ditching associated with historical agricultural practices is also present on the landscape. All of these streams, unnamed gulches and ditches have ephemeral flow regimes. Even Pōhākea Gulch which is the largest conveyance in the watershed, typically only flows during stormwater events.

Figure 7. Pōhākea Major Drainageways

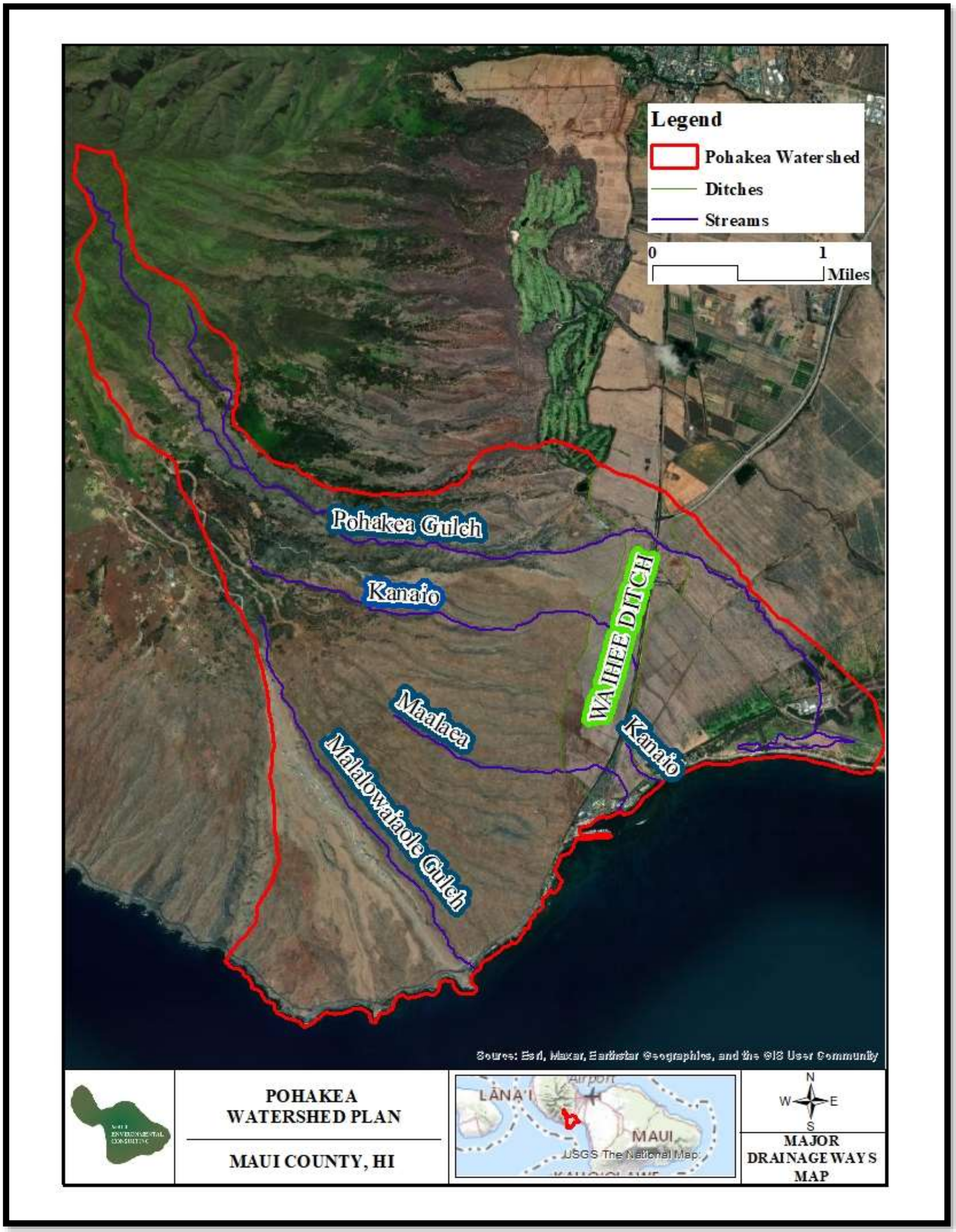
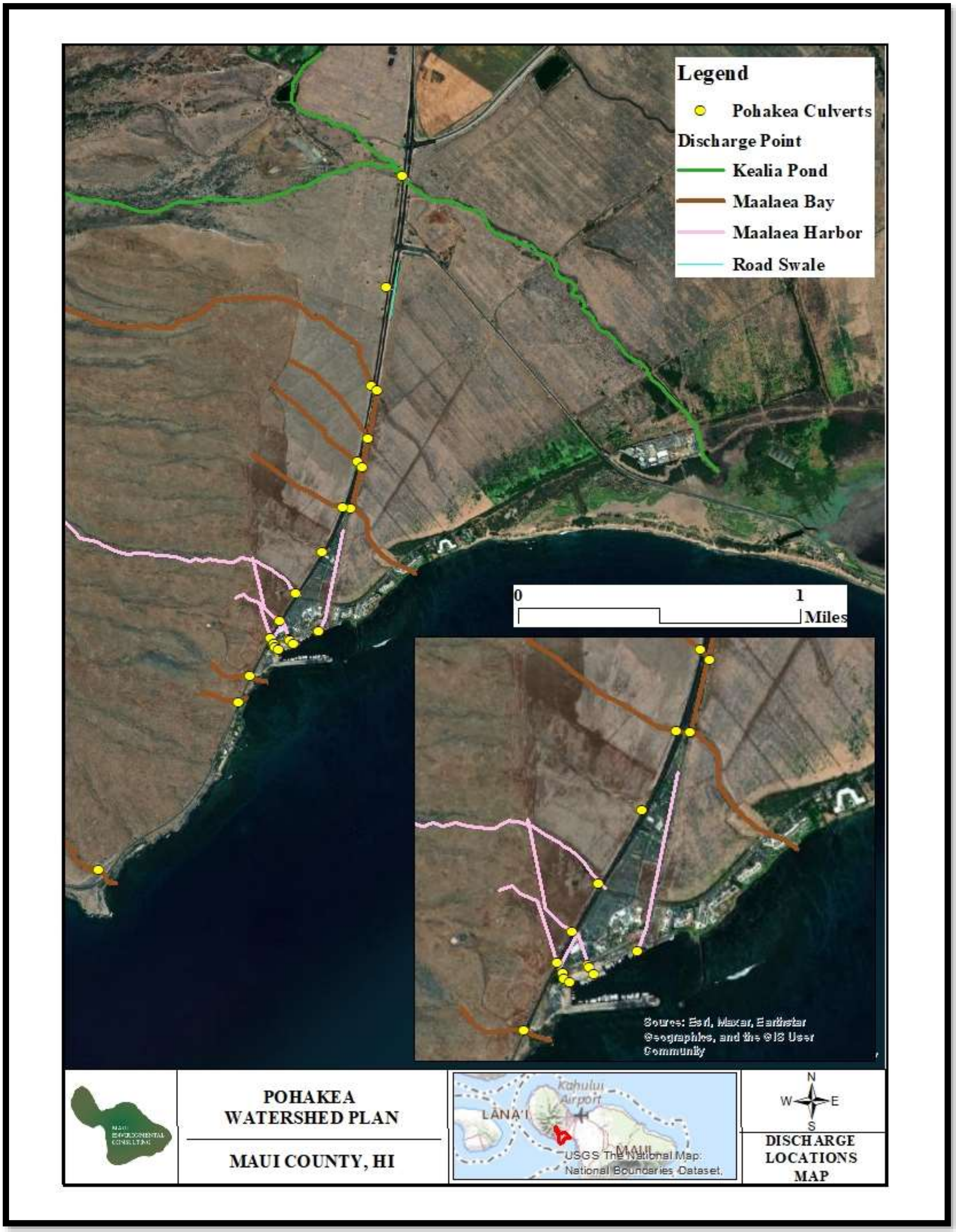


Figure 8. Pōhākea Discharge Pathways



3.6.3 Surrounding Watersheds

There are three watersheds surrounding the Pōhākea Watershed (Figure 9. Watershed Boundaries). These include Ukumehame to the north and west, Papalaua to the west, and Waikapu to the north and east. Ukumehame and Papalaua reside within the Lahaina District while Pōhākea and Waikapu Watersheds reside within the Wailuku District.

3.6.3.1 Papalaua Watershed

This watershed is smaller than Pōhākea at approximately 3,323 acres. Papalaua begins at the western boundary of Pōhākea and continues west along the coast for roughly 2.5 miles. It rises to its terminus at approximately 3,700 feet along the Hanaulauiki Ridge on its western boundary and Kealaloloa Ridge on its eastern boundary. While relatively short in reach, eight different gulches exist within the Papalaua Watershed. They include from west to east: Papalaua, Manawaipueo, Kamaohi, Opunaha, Mokumana, Makahuna, Kaalaina and Kamanawai gulches. All eight gulches are ephemeral and flow south-southwest.

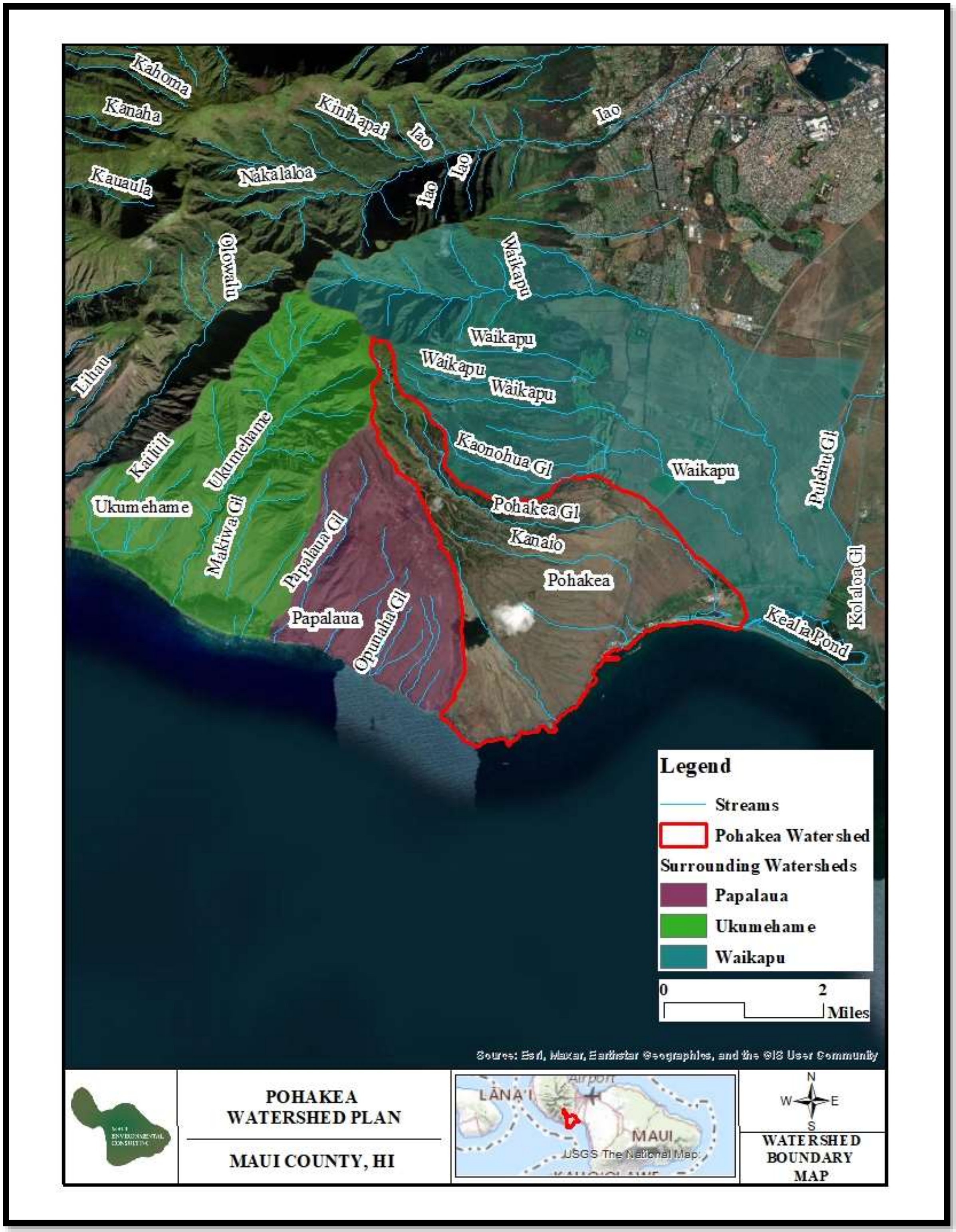
3.6.3.2 Ukumehame Watershed

The Ukumehame Watershed is slightly smaller than the Pōhākea Watershed at approximately 5,637 acres. It begins at the western edge of the Papalaua Watershed and extends along the coastline roughly 2.8 miles. It rises above both the Papalaua and Pōhākea Watersheds ending at the 4,000-foot ridge separating it from the Waikapu Watershed flowing east on the opposite side of the West Maui Mountains. Six gulches exist within the Ukumehame Watershed. All are ephemeral and generally flow southwest. They include from west to east: Kailiili, Ukumehame, a small gulch associated with Pu‘u Kauoha, Makiva, and Hanaula gulches.

3.6.3.3 Waikapu Watershed

The Waikapu Watershed is the largest of the three watersheds surrounding Pōhākea Watershed at approximately 11,167 acres. It is located north and east of the Pōhākea Watershed. Along the coastline it extends from the eastern boundary of Pōhākea less than a mile before heading north - northeast into the central isthmus of Maui. Near the Central Maui Base Yard, this watershed heads back towards the West Maui Mountains and the Kapilau Ridge before climbing to meet the Ukumehame Watershed. Five streams exist within the Waikapu Watershed. They include the Waikapu Stream, Waikapu Tributary, Ooawa Kilika Gulch, Paleaahu Gulch, and Kaonohua Gulch. Ooawa Kilika, Paleaau and Kaonohua converge at the Waihe‘e Mauka Ditch mentioned above. From here the system continues flowing east before converging with Waikapu Tributary. The flow way is referred to as Paleaahu Gulch for the remainder of its run as it discharges into Keālia Pond and ultimately into Mā‘alaea Bay. Waikapu stream is considered perennial while the rest of the streams are ephemeral, conveying flow only during storm events.

Figure 9. Watershed Boundaries



3.7 Terrestrial Habitat

The Pōhākea watershed is divided into three land use districts: conservation, agriculture, and urban. Of those three districts, conservation lands make up 3873.36 acres, or 73.3% of the project area. The remainder of the watershed is designated as 25% agriculture and 1.47% urban. The upper elevations of Pōhākea watershed are part of 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).

Feral ungulates such as axis deer can be found throughout the watershed. These animals 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.

Keālia Pond National Wildlife Refuge overlaps the eastern edge of the Pōhākea Watershed boundary. The pond provides critical habitat for many endangered bird species. The refuge protects some of the last remaining native wetland habitat in the State.

3.8 Benthic Habitat

The National Oceanographic and Atmospheric Administration (NOAA) has published benthic habitat data for the planning area (See Figure 11. Pōhākea Benthic Habitat). 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.

The coastal waters offshore from the Pōhākea Watershed are protected by various federal and state agencies (Figure 12. 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).

Coral reef exists directly offshore extending west from McGregor Point beyond the coastal boundary of the watershed. Coral reef begins east of Haycraft Park and extends to Keālia Pond and beyond (Figure 13. Pohakea Coral Reefs). 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 11. Pōhākea Benthic Habitat) (NOAA, 2007).

Figure 10. Pōhākea Terrestrial Habitat Map

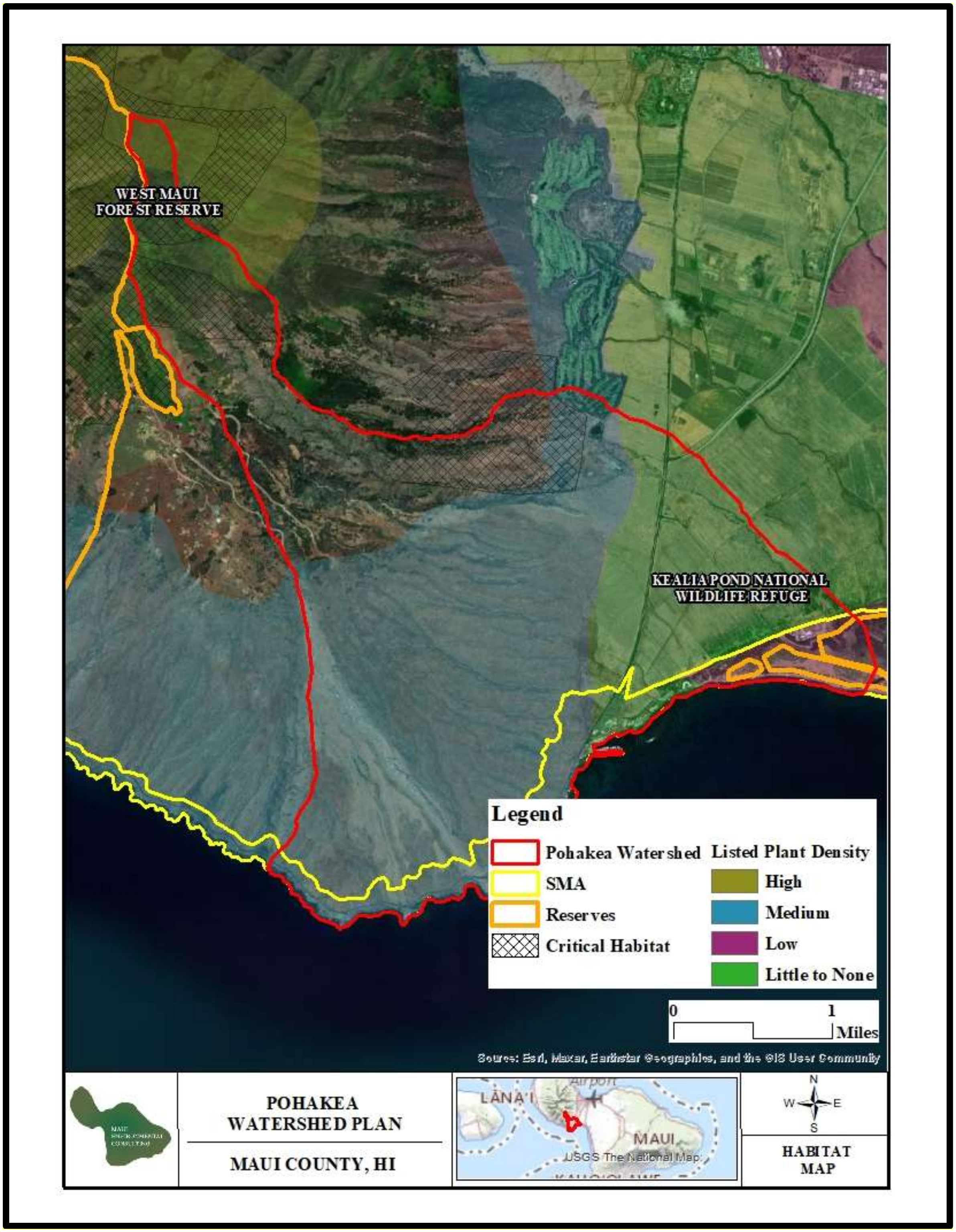


Figure 11. Pōhākea Benthic Habitat

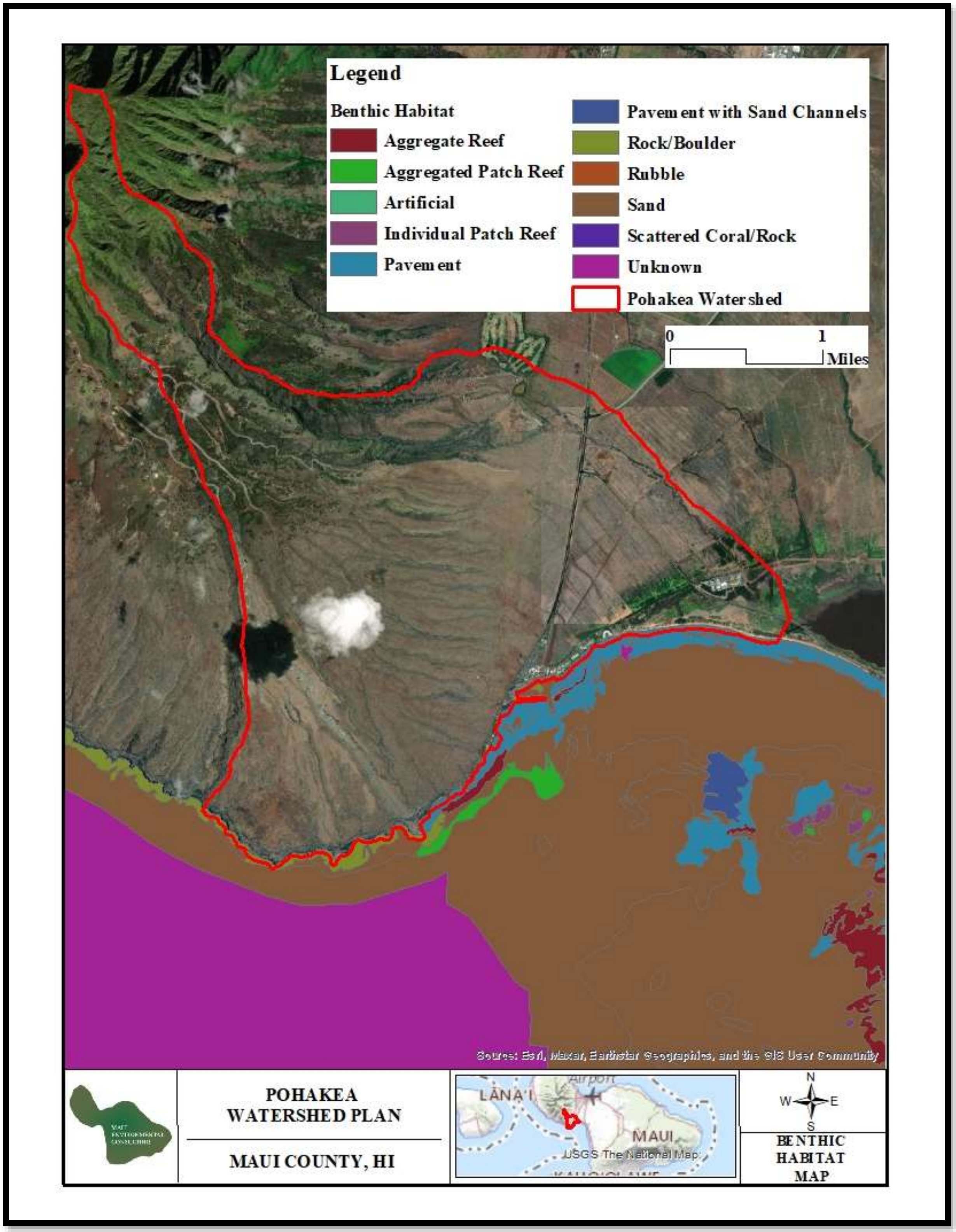


Figure 12. Marine Environments Map

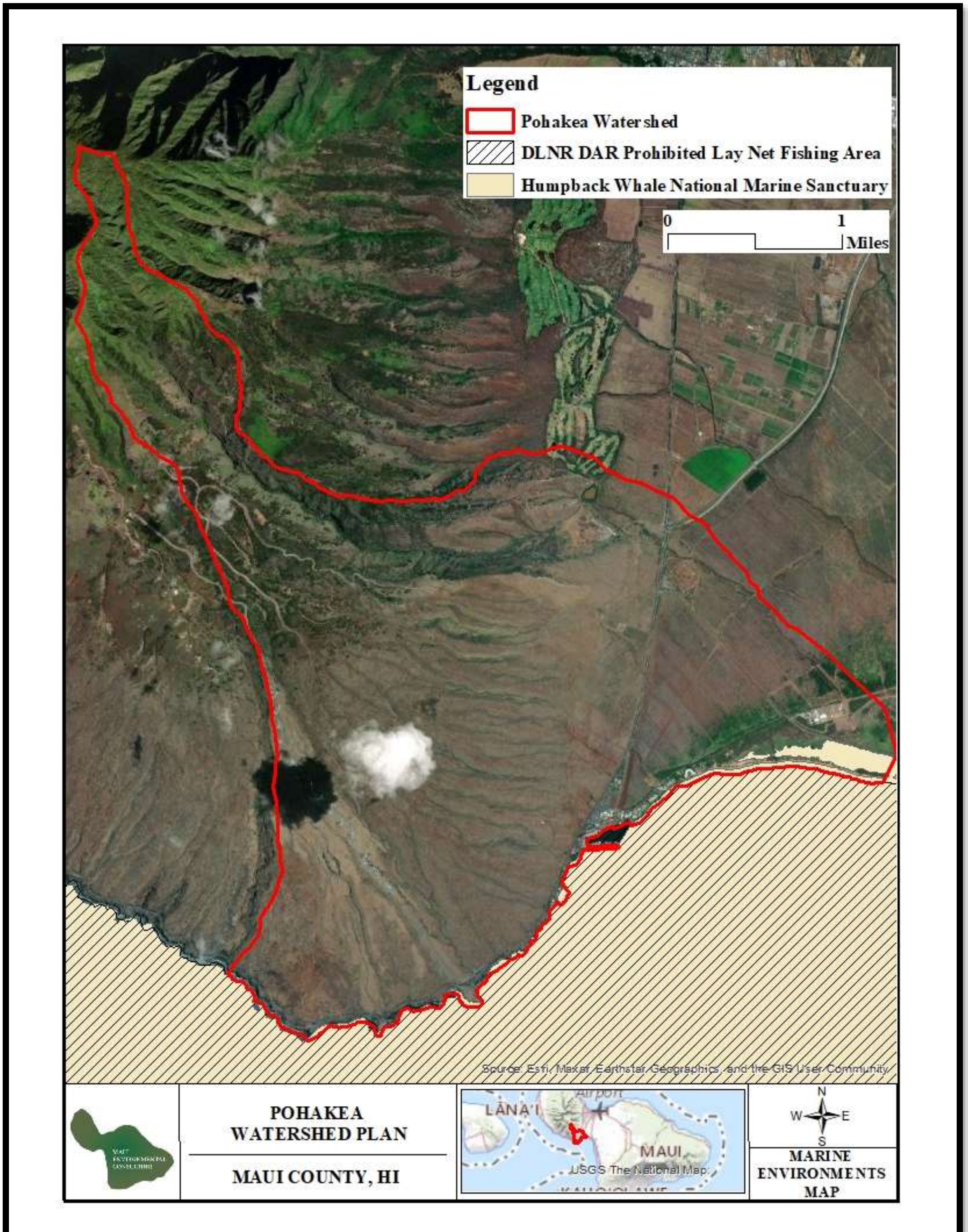
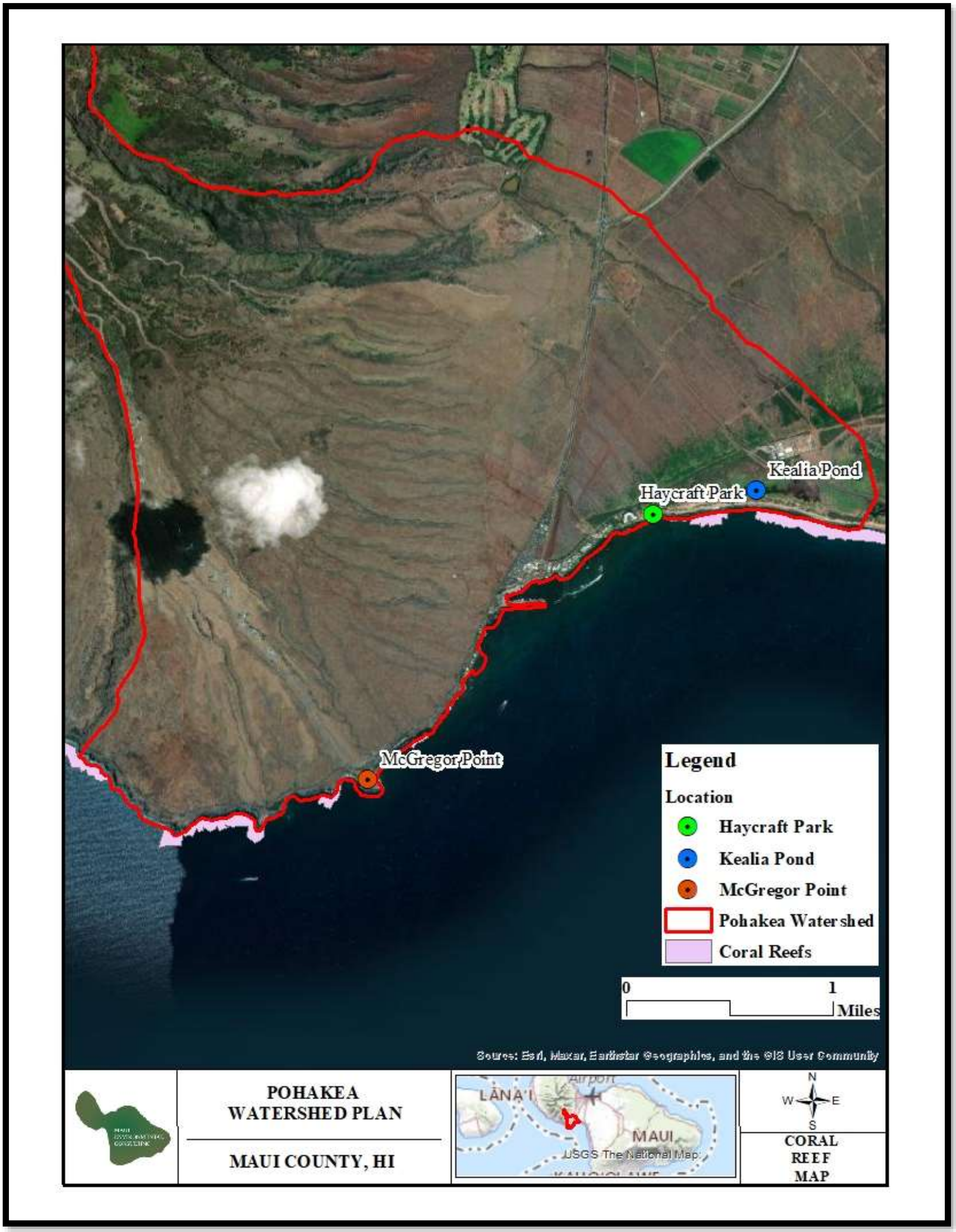


Figure 13. Pōhākea Coral Reefs



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. Pōhākea Gulch discharges 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.

4.0 LAND USE AND POPULATION

4.1 Land Use Districts

Three land use districts exist within the boundary of the Pōhākea Watershed: conservation, agriculture, and urban. The largest district being conservation lands at approximately 3,873 acres (Figure 14. Pōhākea State Land Use). This section of the watershed stretches from the summit of Hanaula within the West Maui Mountains, completely encompassing the western border of the watershed and the coastline, ending at the small coastal neighborhood along Māʻalaea Bay Place. From here, conservation lands head north following the mauka side of the aforementioned Waiheʻe Mauka Ditch. Agricultural lands make up 25 percent of the watershed. These lands are now largely comprised of fallow sugar cane fields. Urban land represents a relatively small portion within the watershed and is comprised of the business district associated with Māʻalaea Harbor. State land use boundaries were compiled by the State Land Use Commission and were most recently updated in 2020.

Table 4. Pōhākea Watershed Land Use Districts

Land Use District	Acres	Percent
Conservation	3873.36	73.53
Agriculture	1317.23	25.00
Urban	77.44	1.47

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 type. Within the Pōhākea Watershed boundary, six land cover types exist. These include Mixed Rangeland, Cropland and Pasture, Shrub and Brush Rangeland, Evergreen Forest Land, Non-forested Wetland, and Residential. Mixed Rangeland is the largest land cover type, making up nearly half of the watershed (Figure 15. Pōhākea State Land Use Classifications Map).

Table 5. Pōhākea Watershed Land Use Classifications

Land Cover	Description	Acres	Percent
33	Mixed Rangeland	2480.80	47.09
21	Cropland and Pasture	1044.25	19.82
32	Shrub and Brush Rangeland	932.69	17.70
42	Evergreen Forest Land	707.72	13.43
62	Non-Forested Wetland	72.72	1.38
11	Residential	29.85	0.57

Figure 14. Pōhākea State Land Use

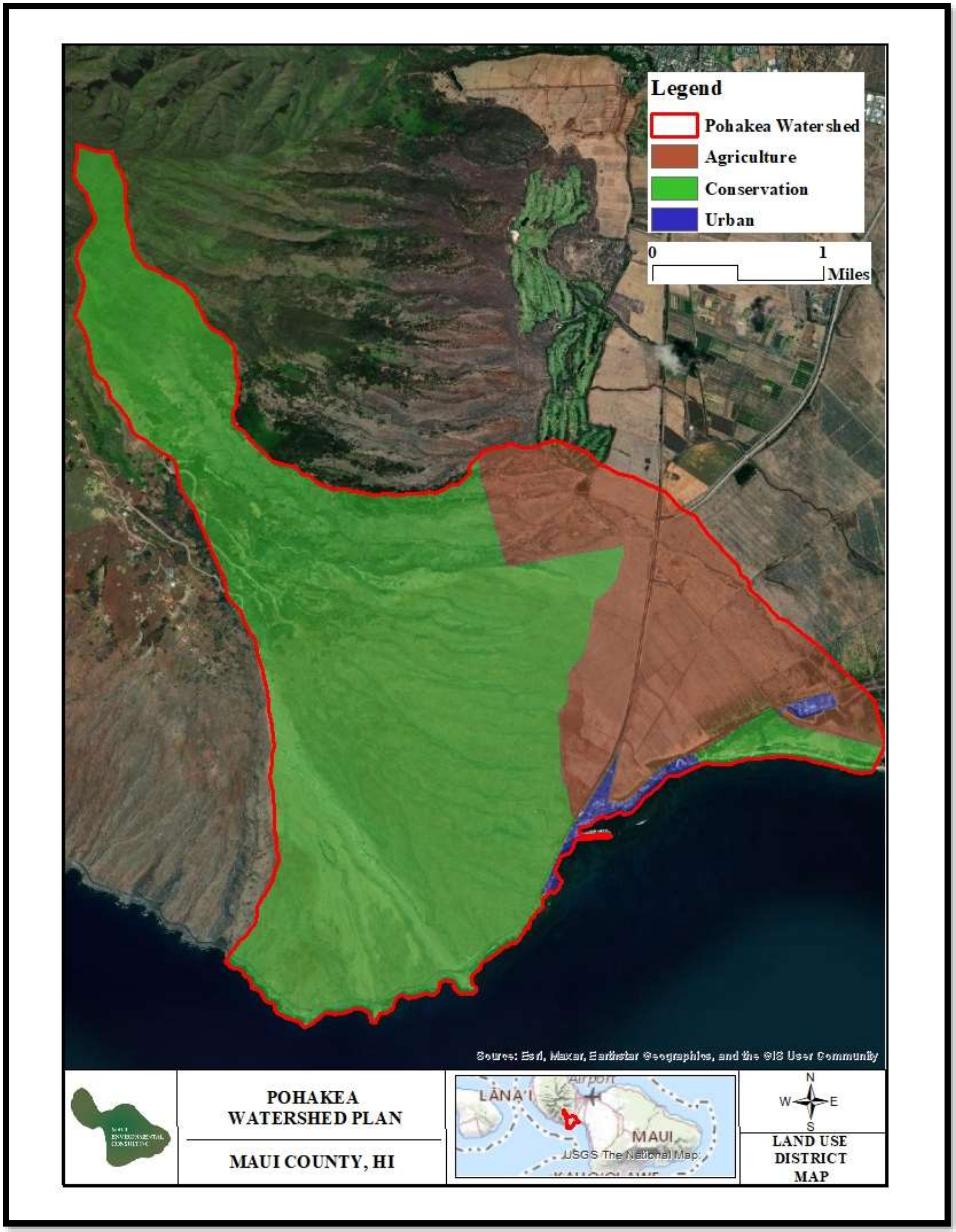
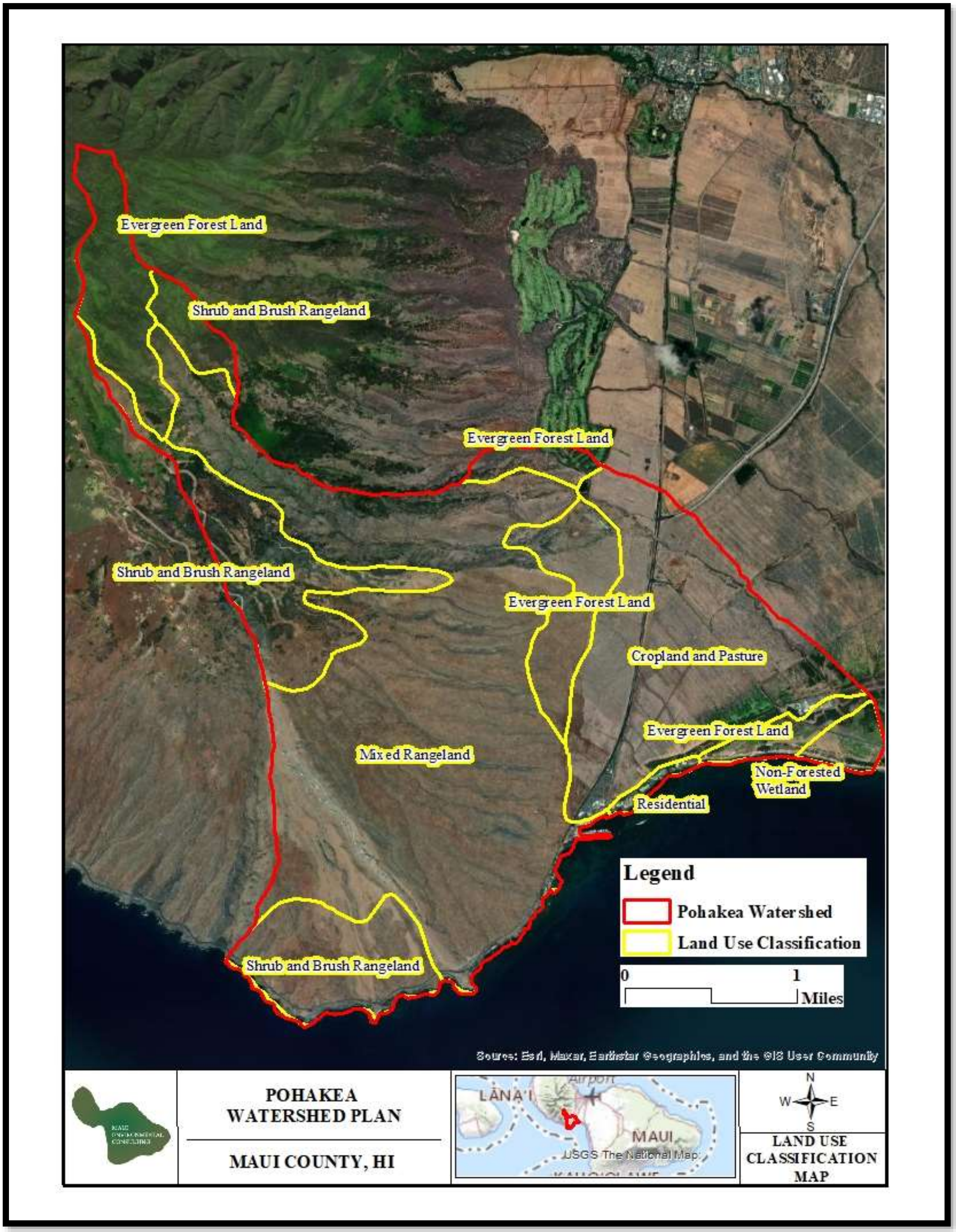


Figure 15. Pōhākea State Land Use Classifications Map



4.3 Fire Risks

Extremely windy conditions and aging infrastructure make powerline corridors vulnerable ignition sources for wildfires. The loss of vegetation and subsequent erosion resulting from wildfires is well documented in this area, and every effort should be made to prevent their occurrence in collaboration with Maui Electric Company.

The Hawaiʻi Wildfire Management Organization (HWMO) is a 501(c)(3) non-profit working in Hawaiʻi to protect the environment from wildfire damage. Its goals are to prevent wildfires, mitigate for their impacts, aid in post-fire recovery, and to provide for a collaborative environment. In 2016, HWMO made the following movie discussing the recent Māʻalaea wildfires and their effects on water quality in the watershed:
(https://www.youtube.com/watch?time_continue=18&v=ZtsG5fP-Z9Y)

After fires are extinguished, restoration activities should be coordinated and targeted to quickly stabilize newly burned areas with appropriate planting. Techniques such as hydro mulching with native plants, which have been piloted in West Maui by the Puʻu Kukui Watershed Preserve (https://www.puukukui.org/) have potential application in this regard, but further refining of the methods is needed within dry land contexts as well as further study of the overall ecological response of plant communities and vegetation regrowth following fires in this particular area.

4.3.1 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. The largest landowners in the planning area are the State of Hawaii, Hanaula Ranch, LLC, Allen Young Ting III Trust, Add LLC, Pohakulepo Recycling, Hope Builders, LLC, Māʻalaea C and D Landfill Condominium, Mahi Pono West, LLC, and Lualei Ten, LLC (See Figure 16. Pōhākea Large Landowners).

4.3.2 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 17. Pōhākea Impervious Surfaces).

Impervious surface areas, such as those shown in Figure 17, 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.

Figure 16. Pōhākea Large Landowners

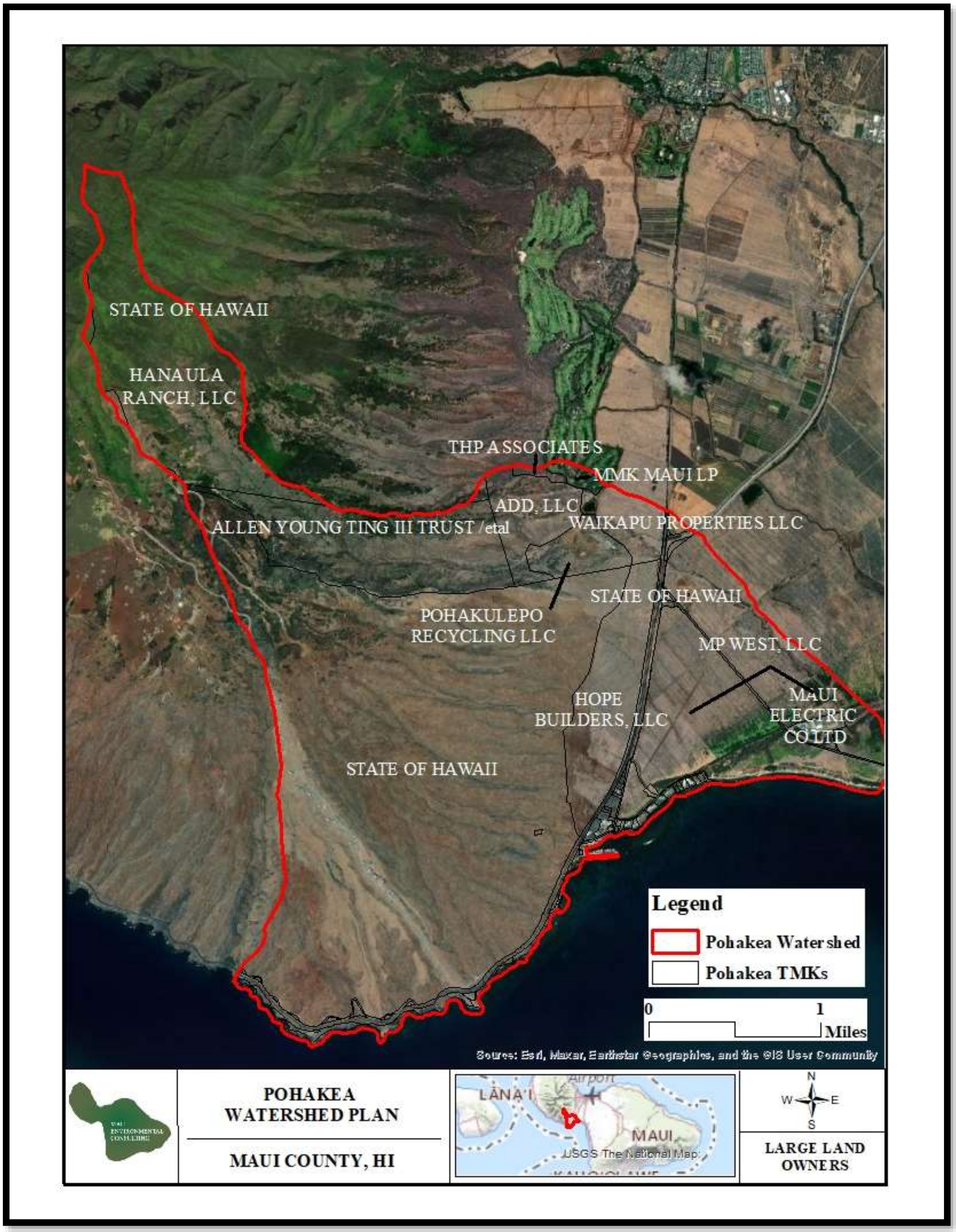
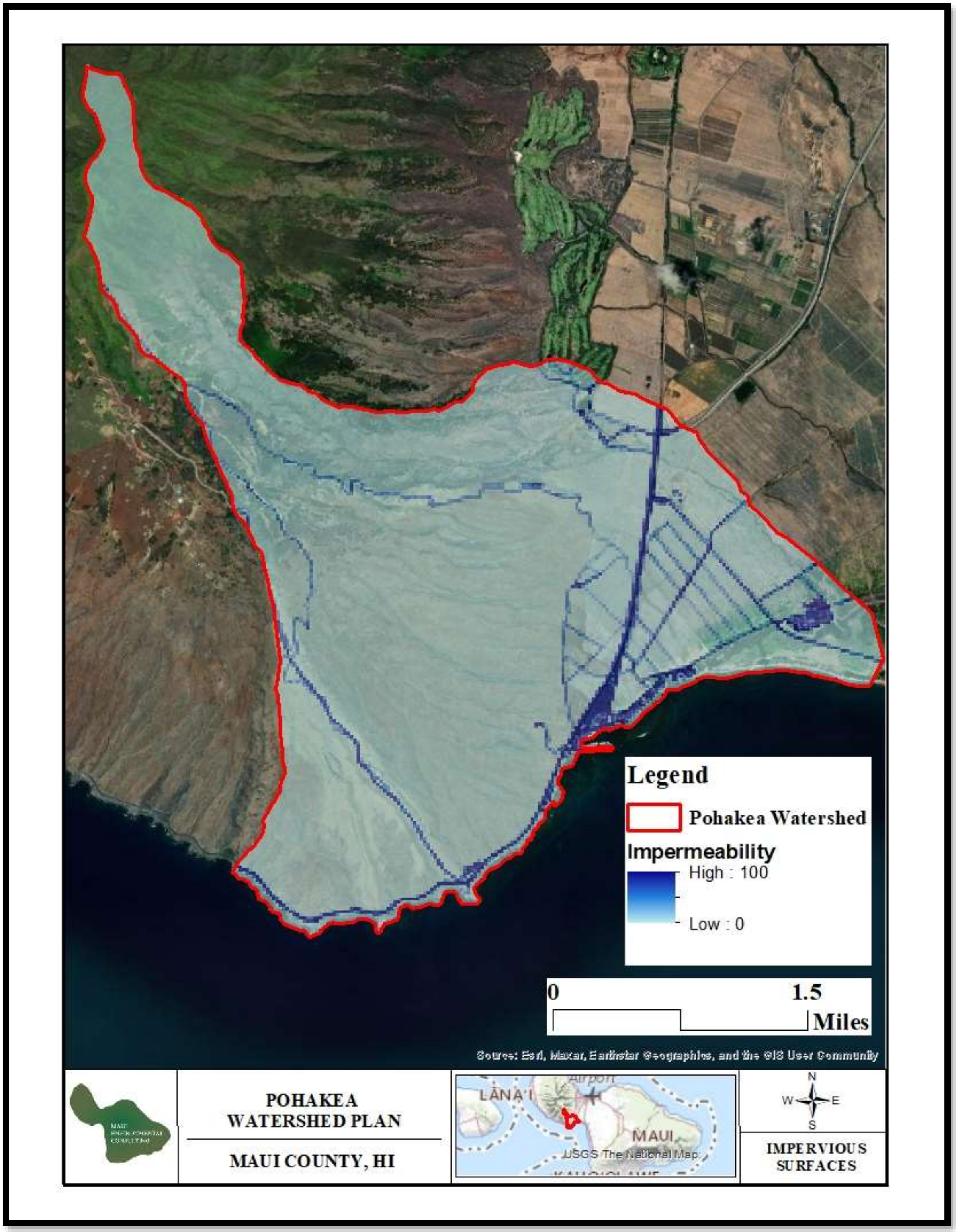


Figure 17. Pōhākea Impervious Surfaces



The historic and recent urbanization of Mā‘alaea has had an impact on the runoff and pollutant loads of both Mā‘alaea Bay and Mā‘alaea Harbor. Prior to urbanization the coastal lowlands were covered by coastal vegetation, wetlands, sand dunes, and varying low impact agriculture lands, and were able to act as flood plain filters. Now, most of the coastal zone is composed of condominiums, shopping plazas, restaurants, the aquarium, harbor infrastructure, and associated parking lots.

4.3.3 Planned Development

Future land use projects for the project area are notable because development increases the amounts of impervious surface areas within the watersheds. As stated earlier, these planned developments 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.

The County of Maui Planning Department (COM Planning) reported that there are at total of 279 acres of planned development projects within the Pōhākea Watershed. This accounts for roughly 5% of the entire watershed area. There are two projects (Figure 18. Pōhākea Proposed Development) in the Proposed/Need More Information stage of development and are not considered to be occurring in the near future.

The larger of these two proposed projects was recently sold from the Spencer family, who had been in negotiations to sell the property to Maui County. On May 6, 2022, Maui County Council approved $6.2 million to help the public acquire and protect the Spencer Property, which the County renamed the Pōhākea Watershed Lands, or Mā‘alaea Mauka. This plot of land makes up approximately 257-acres just mauka of Honoapi‘ilani Highway. On May 13, 2022, the state Board of Land and Natural Resources approved another $1 million for the purchase. In a surprise to the County, Peter Martin of Hope Builders, LLC and West Maui Construction, Inc. purchased all 257 acres for an undisclosed amount. The sale closed May 10, 2022, and plans for the parcel are unclear. At the time of this report, the Maui County Council is holding votes to decide whether to use eminent domain to purchase the land from Hope Builders, LLC.

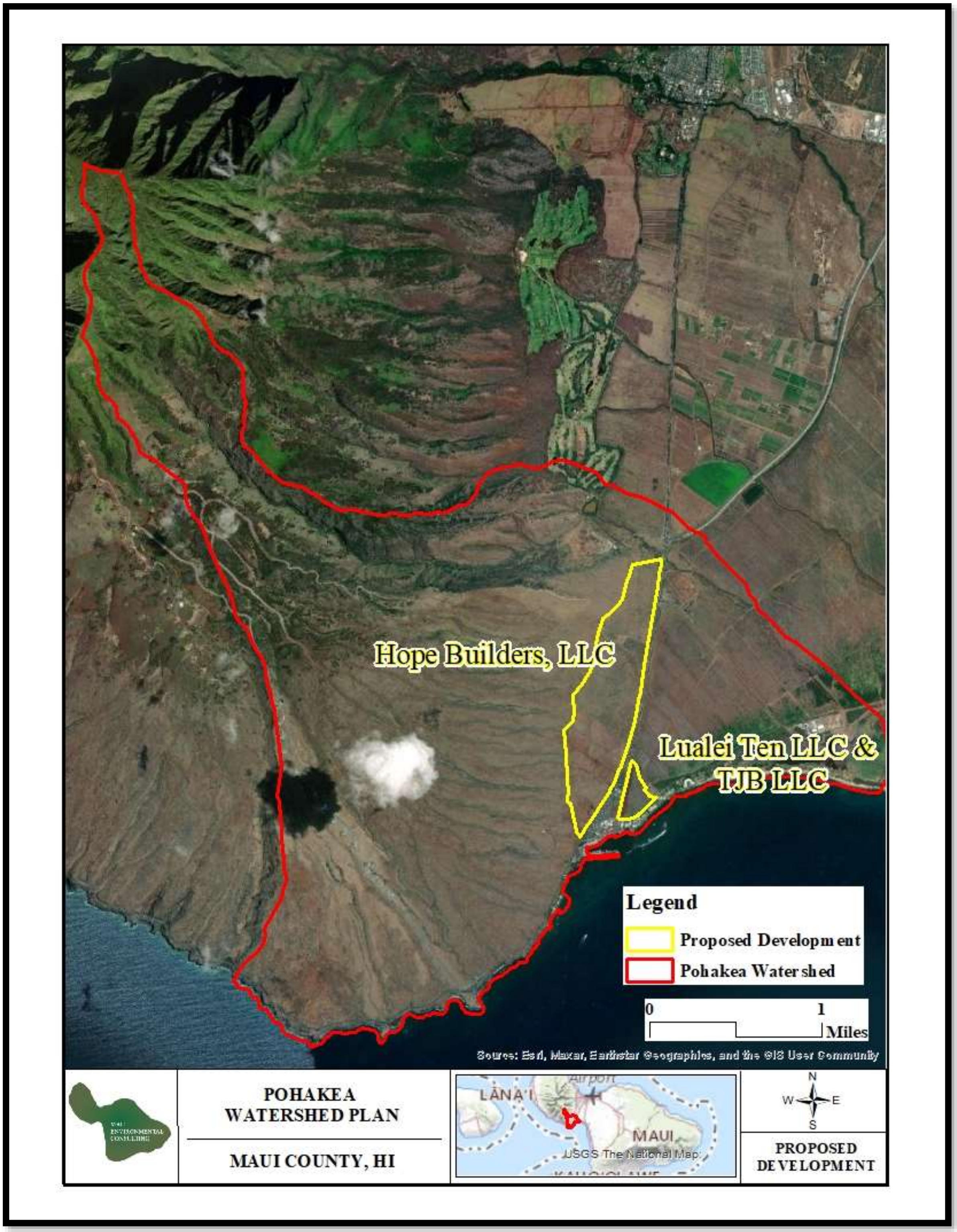
The other proposed project is approximately 21.7-acres. This land was sold by Alexander Baldwin to Lualei Ten and TJB LLCs in 2021. No other information on the proposed project is available at this time.

4.3.4 Historic Population Trends

The population within the Pōhākea watershed boundaries is minimal compared to other regions of the island. The nearest town is Waikapu, with all its residential area falling outside of the Pōhākea watershed boundaries. According to the most recent census in 2020, the population of Waikapu is 3,437 (U.S. Census Bureau, 2020). Ten condominium units adjacent to Mā‘alaea harbor provide housing for residents. The latest census data estimates the population of Mā‘alaea to be 310 (U.S. Census Bureau, 2020).

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 Hawai‘i. Maui’s population has risen to 144,444 in 2010, and to 164,754 in 2020, with projections of growth to continue (U.S. Census Bureau, 2020).

Figure 18. Pōhākea Proposed Development



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 Pōhākea Watershed. Furthermore, Maui Nui Marine Resource Council provided data on five additional sites located within Māʻalaea Harbor and Māʻalaea Bay, collected from May 2019 to September 2021.

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 embayments, open coastal waters, and oceanic waters. Marine bottom ecosystems receiving drainage from planning area watersheds include sand beaches, lava rock shoreline, reef flats, and soft bottom.

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 6. 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							

Designated Uses	Inland Waters			Marine Waters		Marine Bottom Ecosystem	
	Class 1a	Class 1b	Class 2	Class AA	Class A	Class I	Class II
Aesthetics	■	■		■	■	■	
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 PWP area include numerous ephemeral streams gulches and Keālia Pond.

<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.

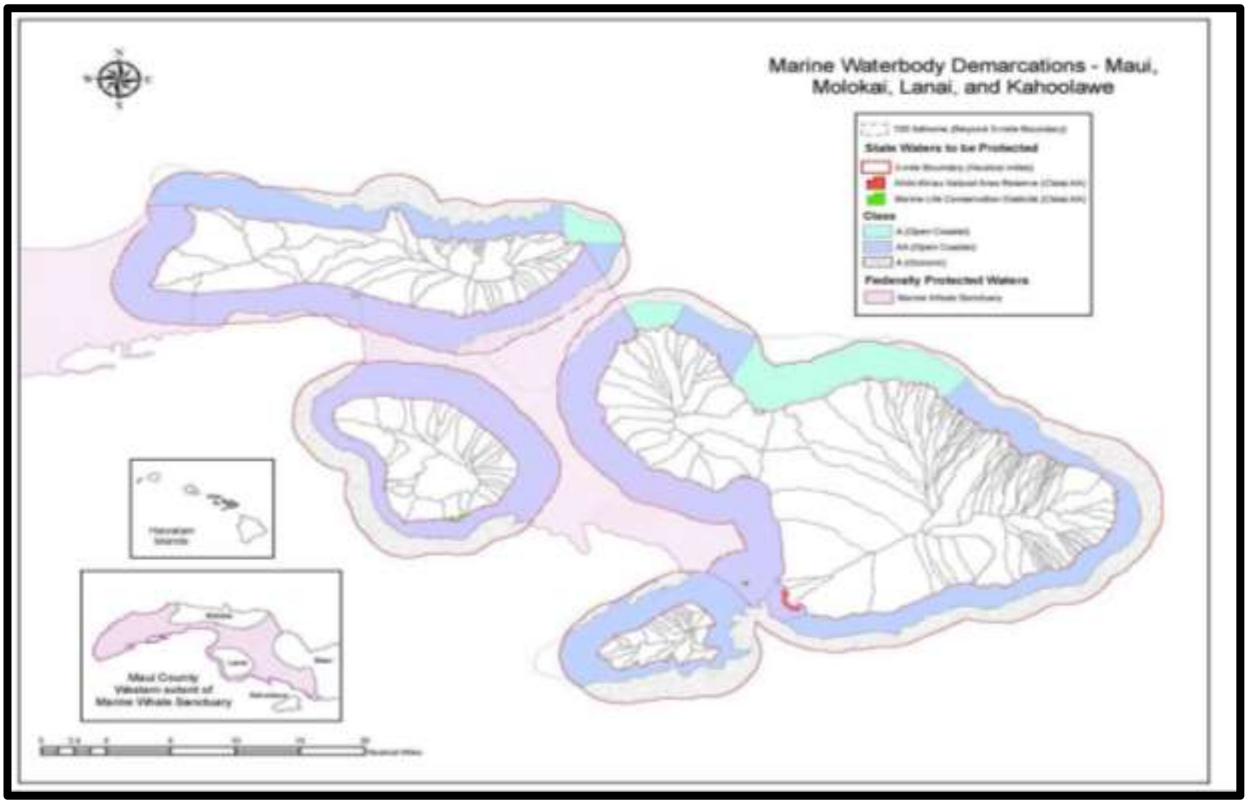
5.1.2.2 <u>Marine Water Classes</u>

The open coastal waters of Māʻalaea Bay area designated 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.

Class A: 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 19. Maui County Marine Water Classes



5.1.2.3 Marine Bottom Ecosystem Classes

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

Class I: 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 7 through 12 provide the applicable numeric criteria for water column chemistry in inland waters (streams and estuaries) and marine waters (open coastal and oceanic) within the PWP area (Source HAR§11-54, 2014).

Table 7. 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 8. 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 9. 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 10. Specific Marine Water Quality Criteria for Open Coastal Waters

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)	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 11. Marine Water Quality Criteria for Oceanic Waters

Parameter	Hawai‘i 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 12. Recreational Criteria for all Sate Waters

Parameter	Hawai‘i 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 Criteria for Marine Bottom Ecosystems

The criteria for Marine Bottom Ecosystems are found at HAR §11-54-7. A major reef tract for Maui begins in Mā‘alaea Bay and extends south through North Kihei. 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."

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 for non-consumptive scientific research (demonstration, observation, or monitoring only), non-consumptive education, aesthetic enjoyment, passive activities, and preservation.

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

In the most recent finalized Integrated Water Quality Report (Hawaiʻi Department of Health, 2022), five water quality monitoring stations are listed by the DOH CWB that fall within the Pōhākea Watershed boundary. They include Kapoli Beach Co. Park, Māʻalaea Beach, Māʻalaea Boat Harbor Station, Māʻalaea Small Boat Harbor, and McGregor Point. Of these five sites, Māʻalaea Beach is the only site to have attainment statuses listed for each parameter. All other locations are lacking in sampling duration or frequency for attainment statuses to be determined for one or more parameters.

5.2.1.1 HI599968 - Kapoli Beach Co. Park

Kapoli Beach Co. Park is listed in both the 2020 Final 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 Enterococcus.

5.2.1.2 HI058731 - Māʻalaea Beach

Māʻalaea Beach is listed in the 2020 Final IR report for enterococcus, Nitrate+Nitrite, turbidity, and chlorophyll-a impairments. In the 2022 Final IR report, Total Nitrogen, and Ammonium were added to the list of impairments. The site has been given low priority status for the development of a Total Maximum Daily Load (TMDL) for these parameters. Assessment of new numerical data collected at this location indicates changes in attainment statuses where water quality standards are not being met.

5.2.1.3 HIW00082 - Māʻalaea Boat Harbor Station

Māʻalaea Boat Harbor Station is listed in both the 2020 Final IR report and the Final 2022 IR for Total Nitrogen, Nitrate+Nitrite, Turbidity and Chlorophyll-a impairments. The site has been assigned low priority status for the development of a Total Maximum Daily Load (TMDL) for these impairments. No attainment status is offered in either report for Enterococcus, Ammonium, or Total Phosphorus.

5.2.1.4 HI00140 - Māʻalaea Small Boat Harbor

Māʻalaea Small Boat Harbor is listed in both the 2020 Final and 2022 Final IR reports for 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. No attainment status is offered in either report for Enterococcus, Total Nitrogen, Nitrate+Nitrite, Ammonium, or Total Phosphorus.

5.2.1.5 HI227321 - McGregor Point

McGregor Point is listed only in 2022 Final IR report, however not enough data has been collected to make evaluations.

Table 13. Pōhākea Watershed Water Quality Stations and Impairments for the 2020 Final and 2022 Final Integrated Water Quality Reports

Final 2020 Integrated Water Quality Report								
Station	Water Body ID	Water Quality Parameters						
		Enterococcus	TN	Nitrate + Nitrite	Ammonium	TP	Turbidity	Chlorophyll-*a*
Kapoli Beach Co. Park	HI599968	-	**N**	**N**	**N**	**A**	**N**	**A**

Mā'alaea Beach	HI058731	N	**A**	**N**	**A**	**A**	N	N
Mā'alaea Boat Harbor Station*	HIW00082	-	N	N	-	-	N	N
Mā'alaea Small Boat Harbor*	HIW00140	-	-	-	-	-	N	N
Final 2022 Integrated Water Quality Report								
Station	Water Body ID	Water Quality Parameters						
		Enterococcus	TN	Nitrate + Nitrite	Ammonium	TP	Turbidity	Chlorophyll-*a*
Kapoli Beach Co. Park	HI599968	-	N	N	N	A	N	A
Mā'alaea Beach	HI058731	N	**N**	N	**N**	A	N	N
Mā'alaea Boat Harbor Station*	HIW00082	-	N	N	-	-	N	N
Mā'alaea Small Boat Harbor*	HIW00140	-	-	-	-	-	N	N
McGregor Point	HI227321	-	-	-	-	-	-	-

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 report are bolded and underlined

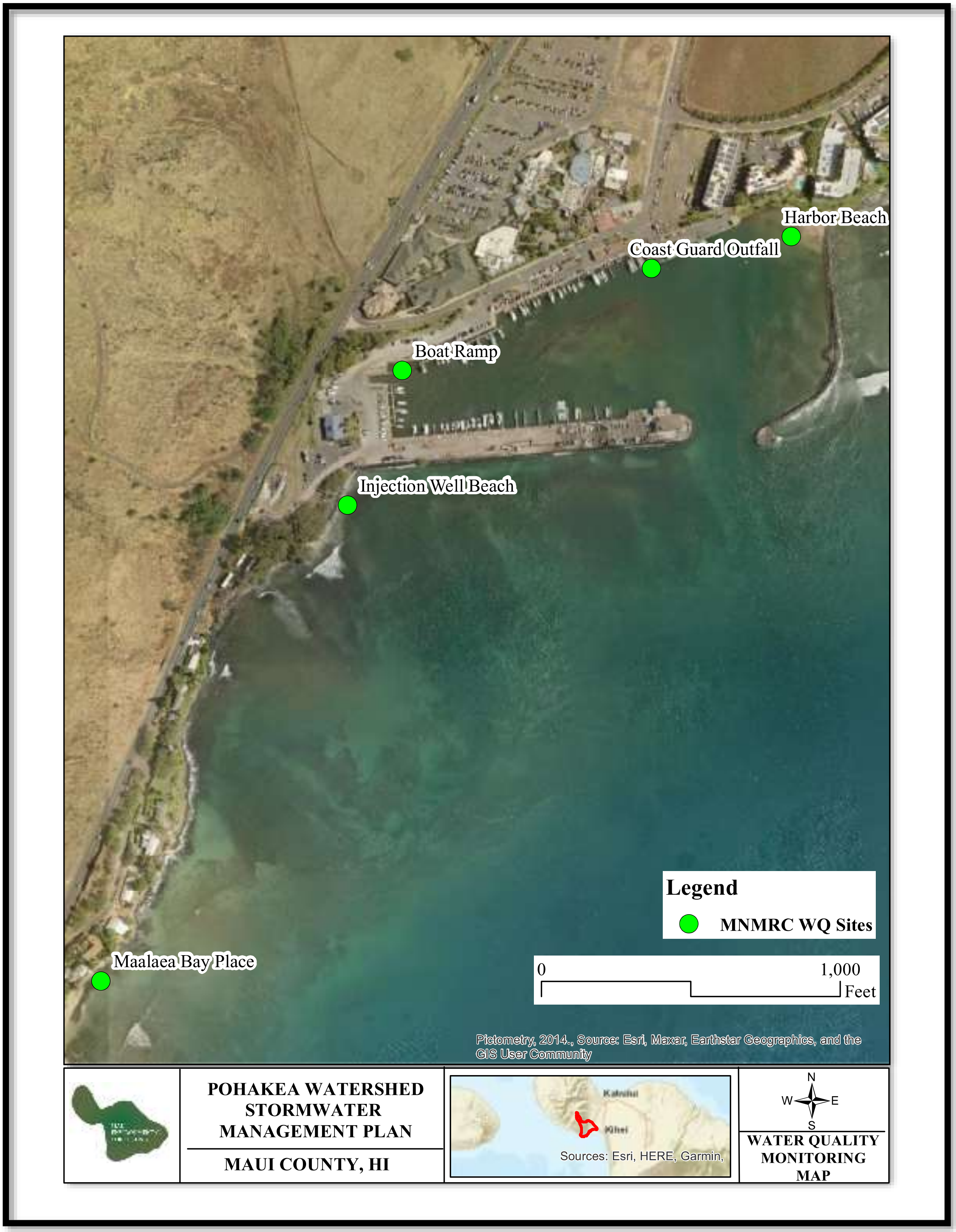
Turbidity measurements in exceedance of water quality standards can be caused by sediment laden water discharging from freshwater streams and/or from the resuspension of sediment caused by tidal or wave action within coastal waters. Increased sedimentation and nutrient loading on the extensive offshore 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.

5.3 Maui Nui Marine Resource Council Water Quality Data

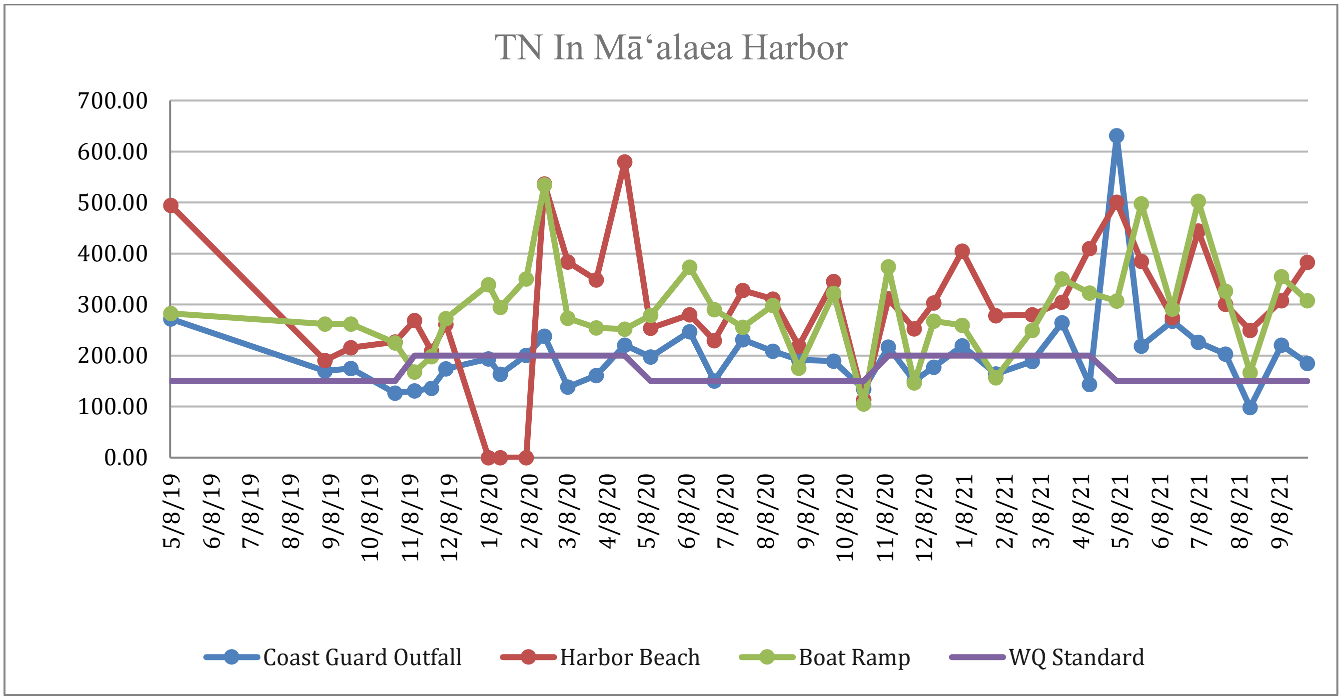
Maui Nui Marine Resource Council (MNMRC) collected water quality data from five sites in and around Māʻalaea Harbor. Three of the sites, Coast Guard Outfall, Harbor Beach, and the Boat Ramp, are located inside of Māʻalaea Harbor and fall under the embayment water type. The other two locations, Māʻalaea Bay Place and Injection Well Beach, are located along the coastline directly southwest of the harbor and are categorized as open water bodies. The parameters assessed by MNMRC include total nitrogen (TN), total phosphorus (TP), phosphate, silicate, nitrate + nitrite (NO_3+NO_2), ammonia, and turbidity. Data was collected from May 2019 to September 2021.

Figure 20. MNMRC Water Quality Sampling Sites



To assess the data collected by MNMRC, MEC compared the total nitrogen, total phosphorus, nitrate + nitrite, and ammonia values to water quality standards designated by the EPA. Water quality standards are requirements set by the DOH to which a water body must meet in order to maintain its function and condition. Because data does not exist for discharge volumes, adjustments for water quality standards during wet and dry seasons were based on seasonal rainfall. November 1st through April 30th was considered the "wet" season, and May 1st through October 31st was considered the "dry" season. The data is plotted on the graphs below.

Figure 21. Total Nitrogen in Māʻalaea Harbor



The water quality standard for total nitrogen in an embayment is 150 ug/L during the wet season and 200 ug/L during the dry season. Total Nitrogen levels exceeded water quality standards approximately 77% of the time inside of Māʻalaea Harbor. All three locations tracked similarly, however, total nitrogen concentrations at the Coast Guard Outfall site were consistently lower than the Harbor Beach and Boat Ramp sites.

In open coastal waters with a total nitrogen standard of 150 ug/L and 110 ug/L during wet and dry seasons respectively, total nitrogen levels exceeded the water quality standard 58% of the time. Total nitrogen concentrations at both sampling locations appear to rise and fall at similar times.

Figure 22. Total Nitrogen Outside Māʻalaea Harbor

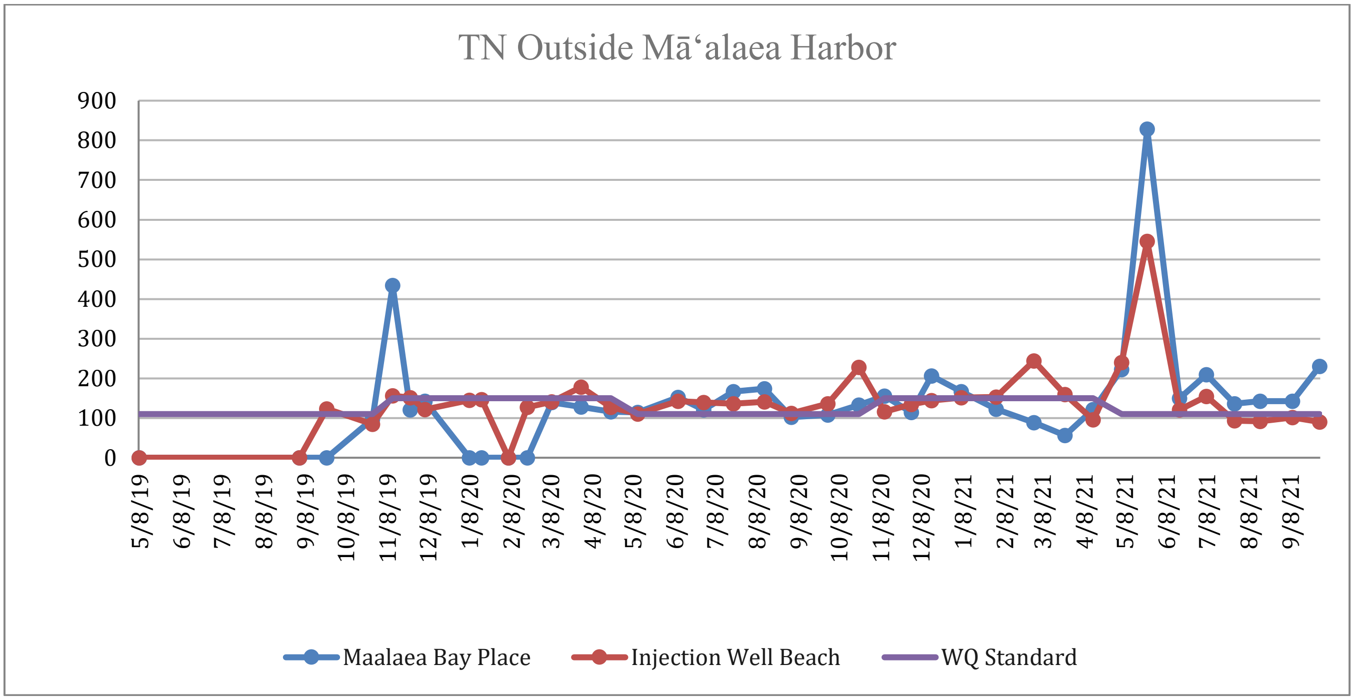
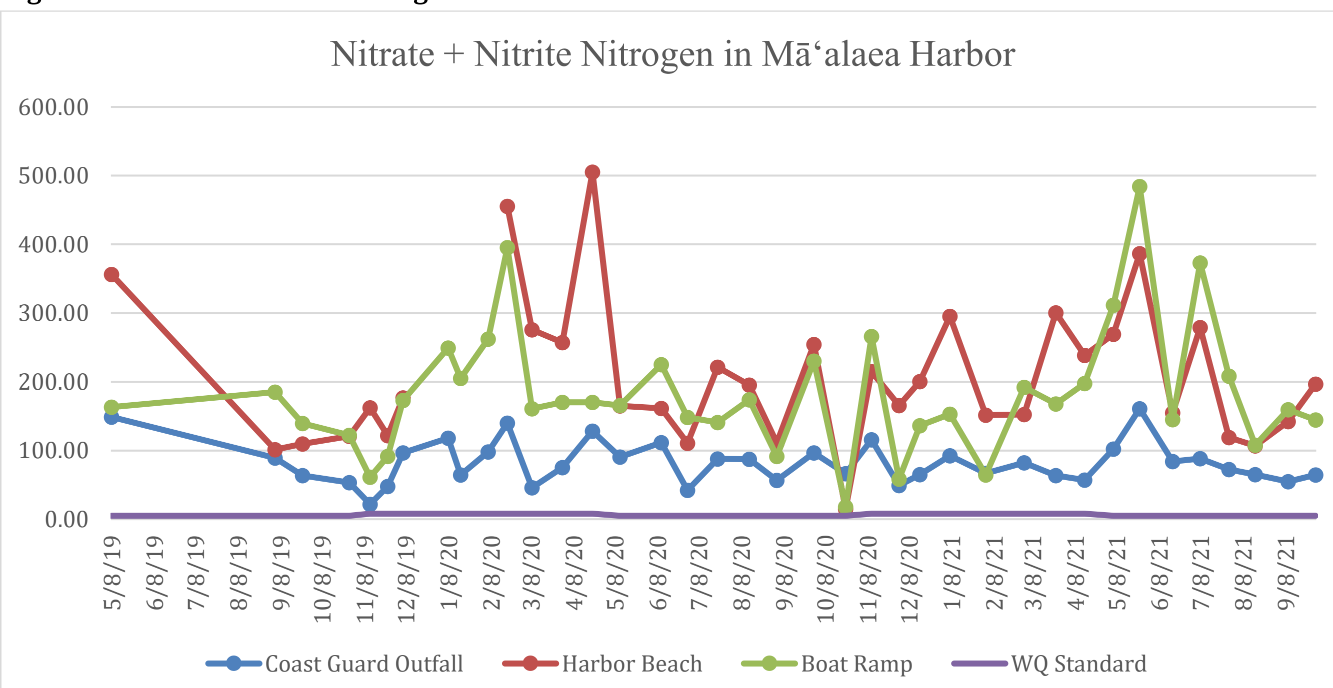


Figure 23. Nitrate + Nitrite Nitrogen in Māʻalaea Harbor



Nitrate + Nitrite levels exceeded water quality standards nearly 100 percent of the time at all sample sites in and around Māʻalaea harbor. Water quality standards for Nitrate + Nitrite Nitrogen are 8.0 ug/L during wet and 5.0 ug/L during dry seasons in an embayment. The concentration of Nitrate + Nitrite Nitrogen was lowest at the Coast Guard Outfall site.

In open coastal waters, water quality standards for Nitrate + Nitrite Nitrogen are 5.0 ug/L and 3.5 ug/L during wet and dry seasons. Māʻalaea Bay Place consistently had higher Nitrate + Nitrite Nitrogen levels.

Figure 24. Nitrate + Nitrite Nitrogen Outside Māʻalaea Harbor

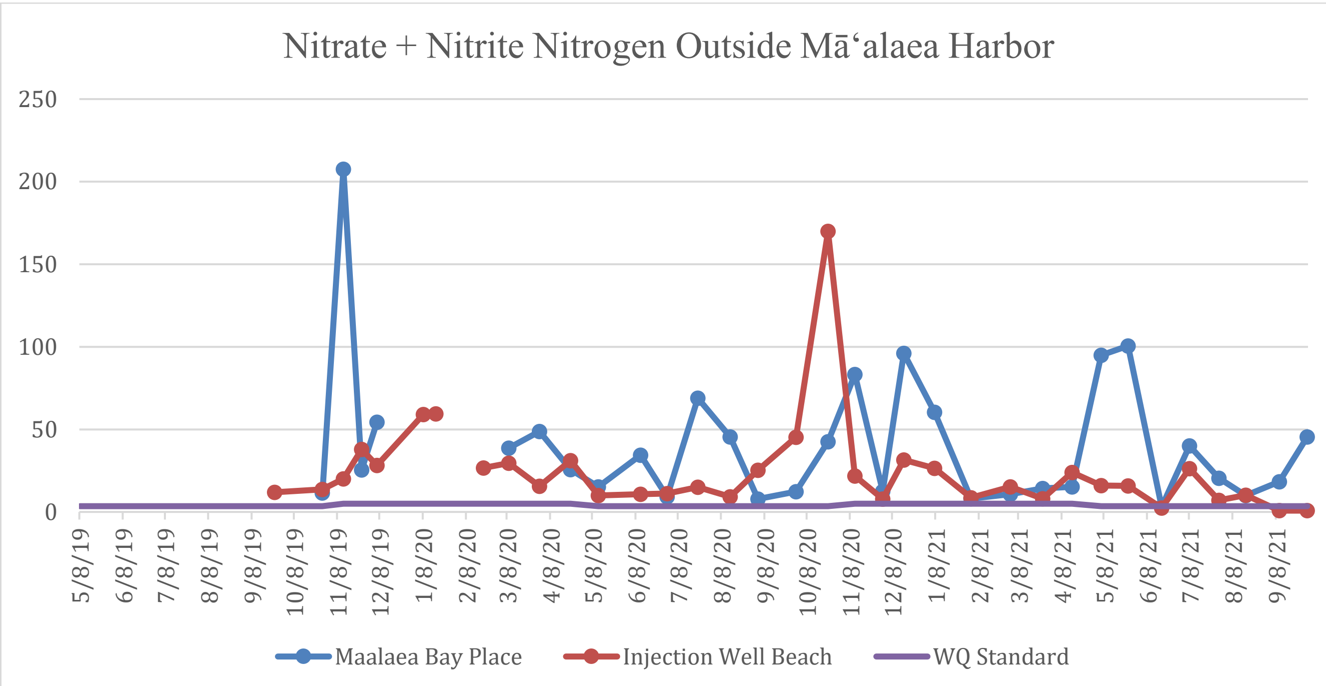
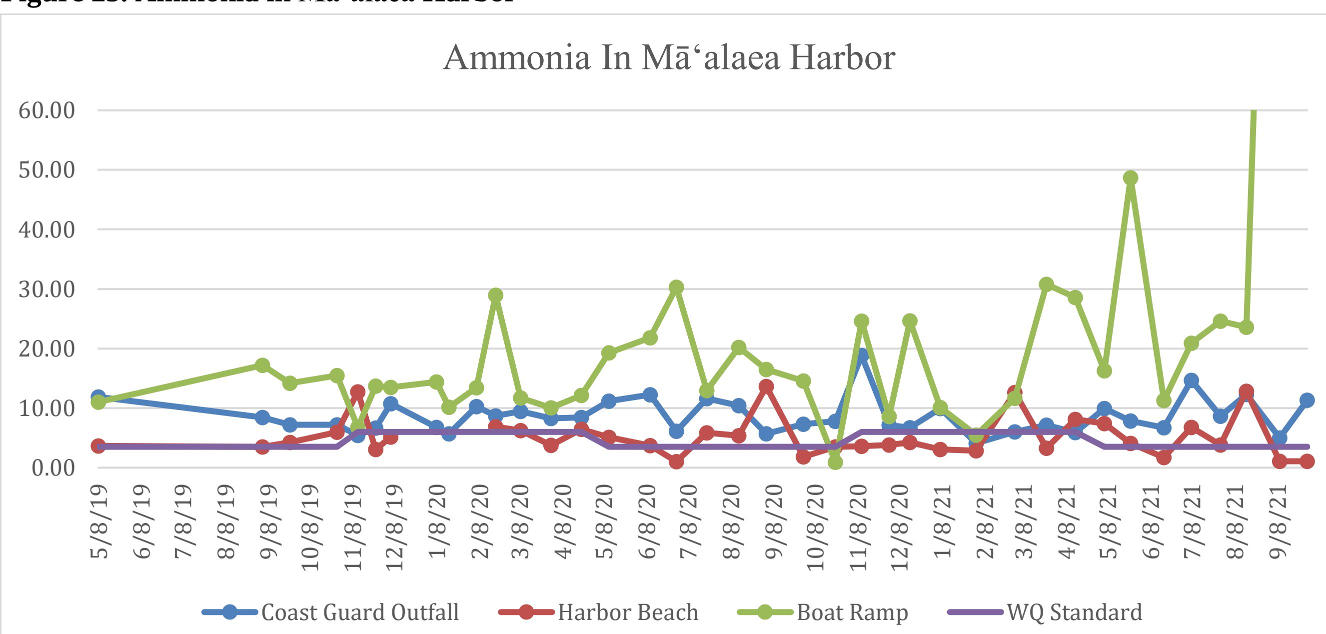


Figure 25. Ammonia in Māʻalaea Harbor



The water quality standard for Ammonia in an embayment is 6.0 ug/L during the wet season and 3.5 ug/L during the dry season. Ammonia levels exceeded the water quality standard approximately 83% of the time inside Māʻalaea Harbor. Of the three sample sites, the Boat Ramp location had the greatest levels of Ammonia.

Outside of Māʻalaea Harbor, water quality standards were exceeded approximately 68% of the time with the standards for open water set at 3.5 ug/L for wet season and 2.0 ug/L for dry season. Steep fluctuations existed at both sample locations.

Figure 26. Ammonia Outside Māʻalaea Harbor

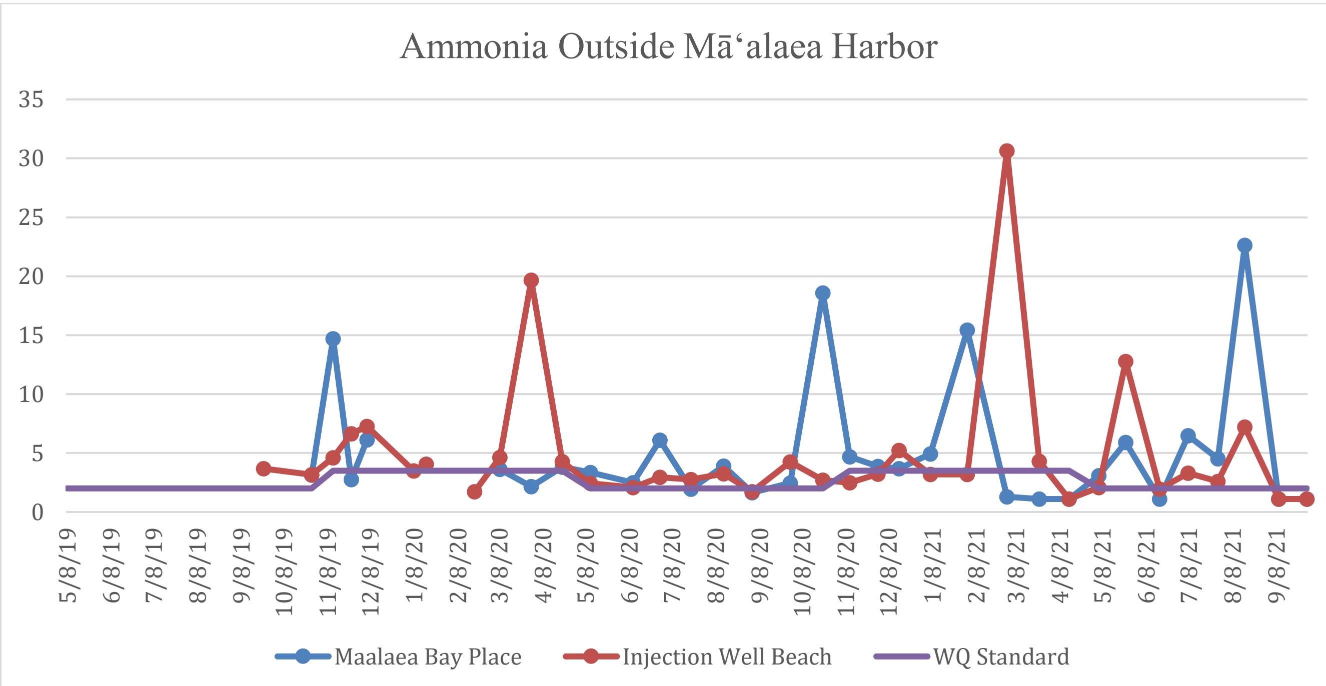
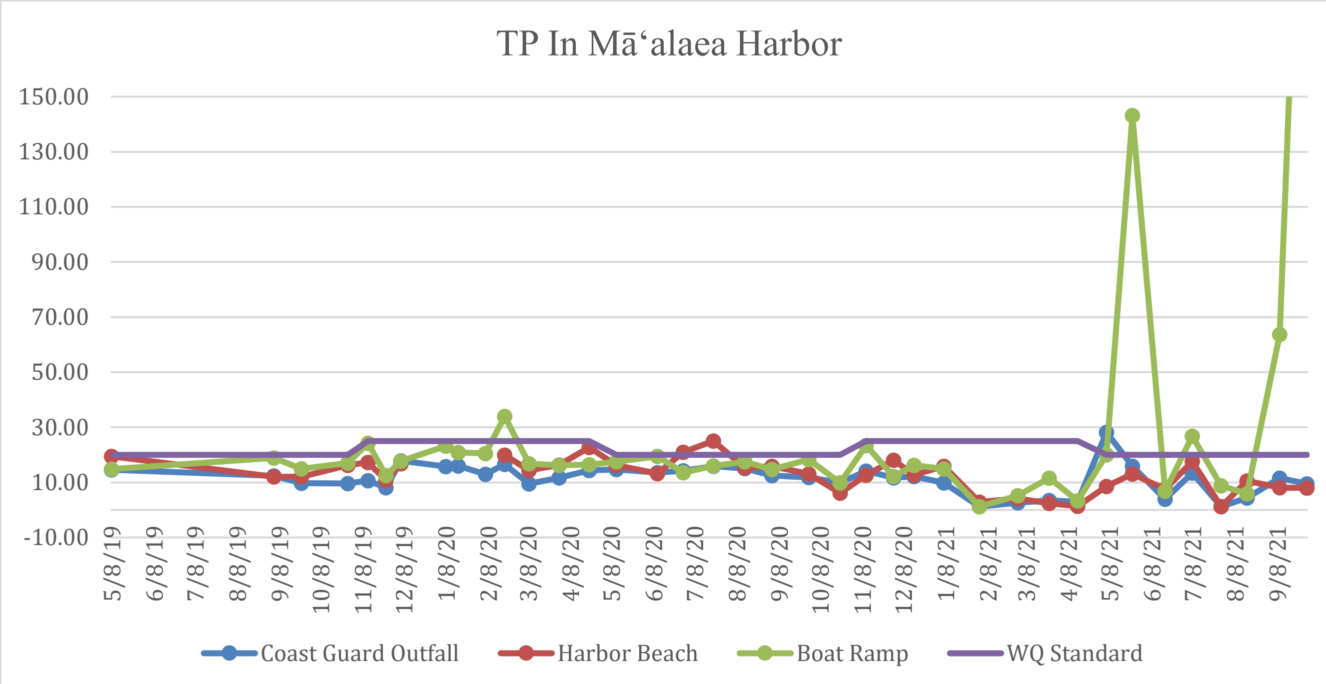


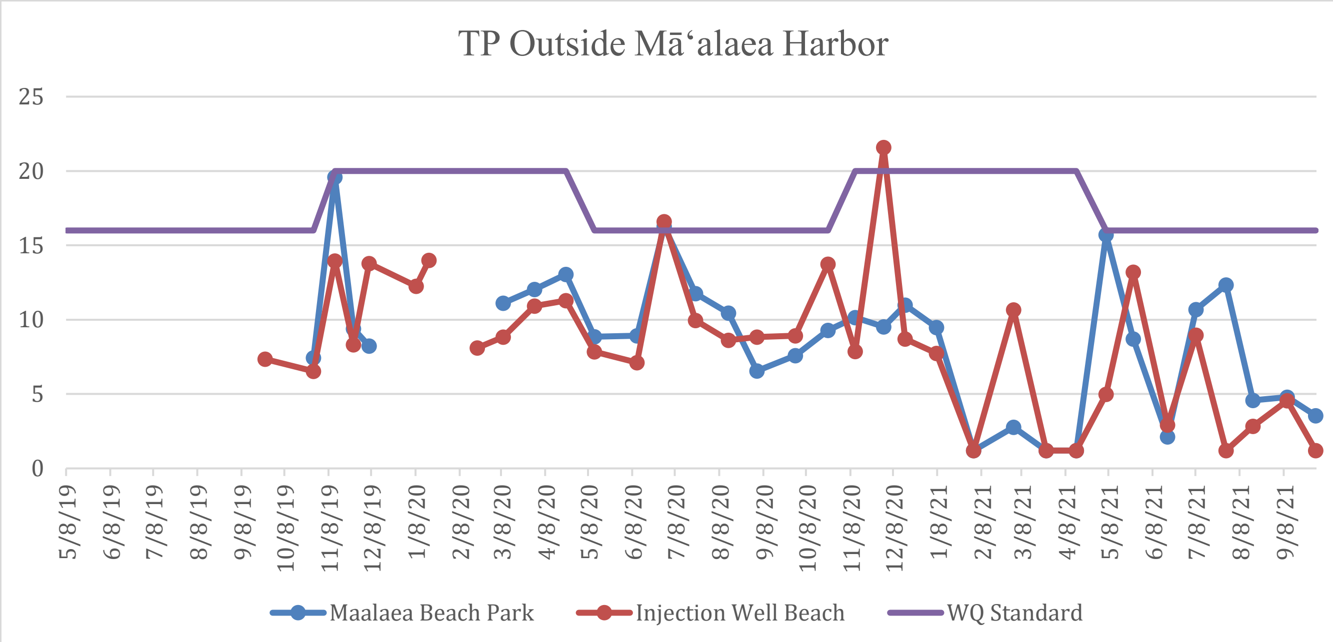
Figure 27. Total Phosphorus in Māʻalaea Harbor



Except for occasional spikes, total phosphorus levels remained at or below the water quality standard of 25.0 ug/L for wet conditions and 20 ug/L for dry conditions inside Māʻalaea Harbor. The Boat Ramp was the only location to experience steep influxes in phosphorus levels in 2021.

Outside of Māʻalaea Harbor the water quality standards for total phosphorus are set at 20 ug/L for wet conditions and 16 ug/L for dry conditions. Both sites tracked similarly with only two exceedances of the water quality standard at Injection Well Beach.

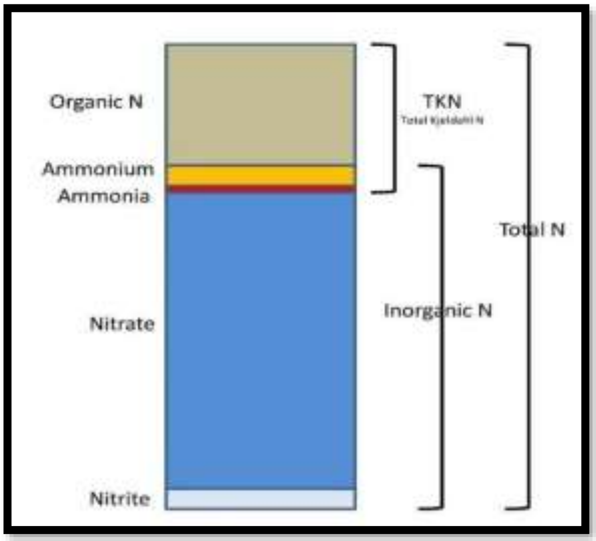
Figure 28. Total Phosphorus Outside Mā'alaea Harbor



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. Some types of algae are toxic and can cause respiratory issues, rashes, neurological impairments, and stomach or liver illness. 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 29. 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).

Several abandoned cesspools are associated with the Māʻalaea Harbor. In addition, several homeless encampments exist in the culvert system below Honoapiʻilani Highway. Feral ungulate feces, human feces, decomposing vegetation, agricultural fertilizer, golf courses, and other sources of nutrients may also be causing or contributing to the high nutrient concentrations observed in and around the harbor. Appendix B Water Quality Monitoring Plan 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 Māʻalaea Bay and Māʻalaea Harbor. 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

The two primary sources of water pollution in the PWP 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.

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 at 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).

Stormwater runoff from construction sites greater than one acre discharging to Class A waters are regulated point sources under the State's General NPDES Permit for stormwater associated with construction activity. Discharges of stormwater associated with industrial activity to Class AA waters require an individual NPDES permit. Table 14 below lists the NPDES permits that exist within the Pōhākea Watershed boundary.

Table 14. NPDES Permits within the Pōhākea Watershed

Name	Permit Number	Address	Permit	Type	Issued:	Expires:
Maui Ocean Center	HI0021504	192 Māʻalaea Road, Wailuku, HI 96793	Individual Permit	Form 2C: Wastewater from existing operations	9/25/2020	10/31/2025
Māʻalaea Generating Station	HIS000004	North Kihei Road Maui, HI 96753	Individual Permit	Form 2F: stormwater associated with industrial activity	12/09/2019	1/31/2024

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.

Sixteen injection well UIC permits exist within the Pōhākea Watershed boundary (NPDES and UIC Map). Of these, 12 are used for sewage, two are used for industrial wastewater, and two are used for stormwater runoff. These wells are relatively shallow in depth and it is widely believed that sewage wastewater effluent from these wells is making its way through the porous substrate and mixing with nearshore coastal waters, promoting algal growth and having deleterious effects on the environment (Dollar 2011). Table 15 below lists these wells and provides information on their permit number, operator and location within the Pōhākea Watershed.

Figure 30. NPDES and UIC Map

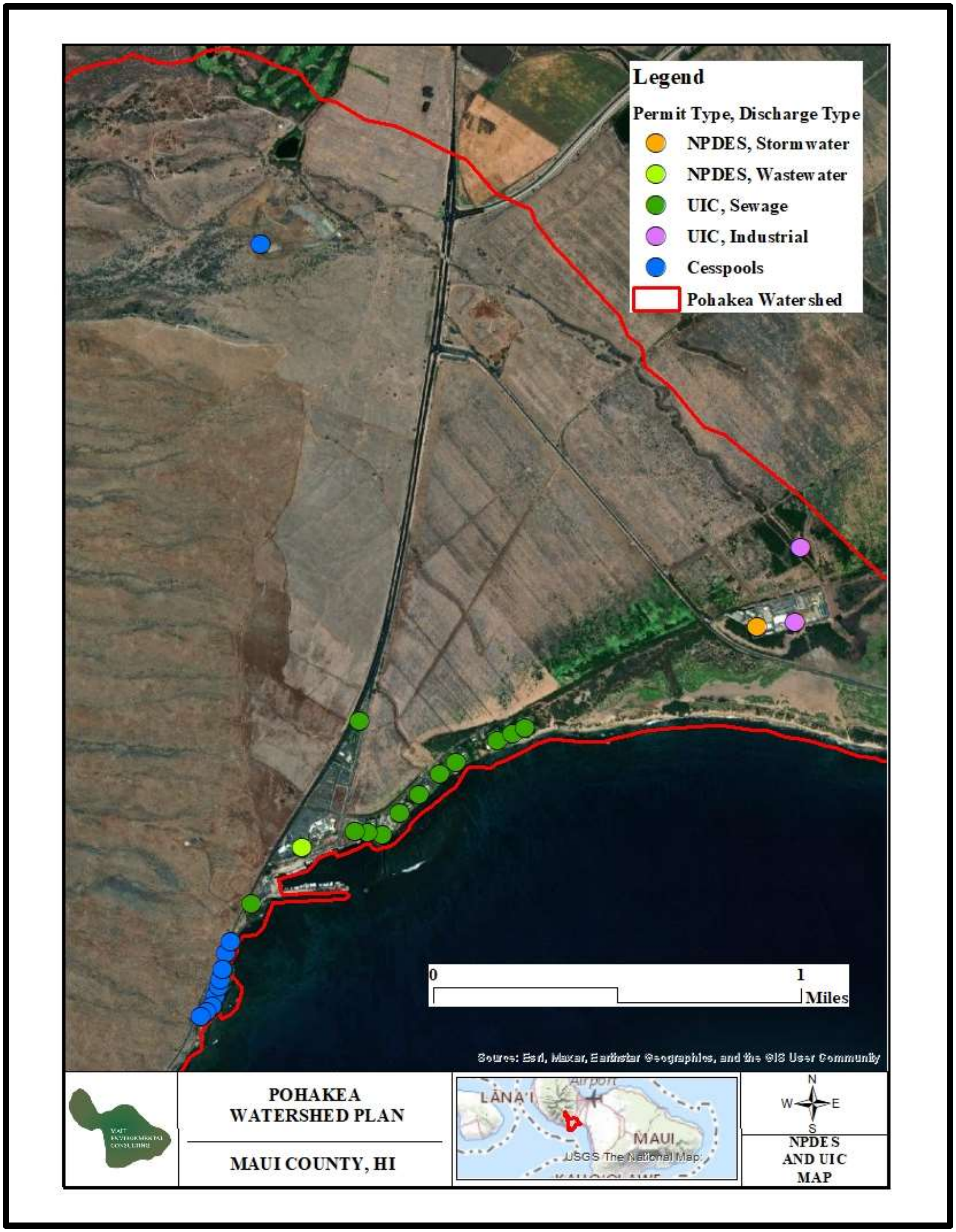


Table 15. UIC Permits within The Pōhākea Watershed

Permit Number	Operator	TMK	Discharge Type	Well Classification	Location
UM-2818	HR Bio Petroleum Māʻalaea Facility	Not Listed	Industrial	Class V, Subclass AB	Not Listed
UM-1592	Māʻalaea Power Plant	2-3-8-005-025	Industrial	Class V, Subclass AB	North Kihei Road, Māʻalaea, Wailuku, Maui
UM-1870	Makani A Kai Condominium	2-3-8-014-001	Sewage	Class V, Subclass AB	300 Hauʻoli St., Māʻalaea, Wailuku, Maui
UM-1871	Hono Kai Resort Condominium	2-3-8-014-002	Sewage	Class V, Subclass AB	280 Hauʻoli St. Māʻalaea, Wailuku, Maui HI 96793
UM-1863	Kanai A Nalu Condominium	2-3-8-014-004,2-3-8-014-005	Sewage	Class V, Subclass AB	250 Hauʻoli St., Māʻalaea,Wailuku,Maui 96793
UM-1272	Māʻalaea Banyans Condominium	2-3-8-014-011	Sewage	Class V, Subclass AB	190 Hauʻoli St. Wailuku, Maui
UM-1345	Island Sands Condominium	2-3-8-014-015	Sewage	Class V, Subclass AB	150 Hauʻoli Street, Wailuku, HI 96793
UM-1327	Lauloa Resort Condominium	2-3-8-014-016	Sewage	Class V, Subclass AB	100 Hauʻoli St., Wailuku, Maui

Permit Number	Operator	TMK	Discharge Type	Well Classification	Location
UM-1273	Māʻalaea Kai Condominium	2-3-8-014-021	Sewage	Class V, Subclass AB	70 Hauʻoli St., Māʻalaea, Wailuku, Maui
UM-1329	Milowai Māʻalaea Condominium	2-3-8-014-022	Sewage	Class V, Subclass AB	50 Hauʻoli St. Wailuku, Maui
UM-1235	Māʻalaea Yacht Marina Condominium	2-3-8-014-024	Sewage	Class V, Subclass AB	30 Hauʻoli St., Wailuku, Maui
UM-1864	Māʻalaea Mermaid Condominium	2-3-8-014-026	Sewage	Class V, Subclass AB	Hauʻoli St., Māʻalaea, Wailuku, Maui
UM-2625	Māʻalaea Small Boat Harbor	2-3-6-001-051	Sewage	Class V, Subclass AB	Not Listed
UM-1954	Māʻalaea Triangle Wastewater Treatment Facility	2-3-6-001-001	Sewage	Class V, Subclass AB	Māʻalaea Rd & Honoapiʻilani Hwy
UM-2681	Honoapiʻilani Highway	2-4-5-006, 2-4-5-009, 2-4-6-004-013, 2-4-5-009-034	Storm Runoff	Class V, Subclass C	Honoapiʻilani Highway, Route 30 Between mile posts 19.90 & 20.97
UM-2767	Honoapiʻilani Highway	2-4-5-031-101	Storm Runoff	Class V, Sublcass C	Honoapiʻilani Highway Realignment, Phase 1

6.2 Nonpoint Source Pollution

6.2.1 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.

Residential areas, including the homes located along Māʻalaea Bay Place 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 30 depicts the locations of cesspools within the Pōhākea Watershed boundary.

Leaching from these cesspools may be contributing to the high levels of enterococcus and nutrients observed within Māʻalaea. Once in the water, nutrients such as nitrogen and phosphorus can cause algae blooms as well. As stated earlier, high Chlorophyll-*a* values act as evidence of these algae blooms. Due to the fact that enterococcus levels are not attaining water quality standards, pathogens from these cesspools may be making their way into coastal waters in appreciable amounts.

6.2.2 Agricultural Lands

Agricultural lands may provide a nonpoint source for sediment, pathogens, and nutrient pollution. Within the Pōhākea Watershed, fallow agricultural plots associated with Mahi Pono are situated on gently sloping fields east of Honoapiʻilani Highway. Pōhākea Gulch and the Waiheʻe Ditches 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.

6.2.3 Landscaped Golf Courses, Resorts and Residential Communities

Several landscapes throughout the Pōhākea Watershed are unnatural, requiring irrigation and fertilizer to exist. The Kahili golf course and the numerous condominiums along Hauʻoli Street have manicured grassed lawns and are examples of these unnatural landscapes. 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.

6.3 Estimating Nonpoint Source Pollutant Loads

6.3.1 NSPECT Modeling

NSPECT is an informative spatial tool developed by the National Oceanic Atmospheric Administration (NOAA) Coastal Services Center (CSC) for watershed managers and planners (Eslinger, 2012). It is a GIS-based application that models potential water-quality impacts from nonpoint source pollution and erosion. The model inputs include soil maps from U.S. Department of Agriculture (USDA), Natural

Resources Conservation Service (NRCS), Soil Survey Geographic Database, 30m Digital Elevation Models (DEMs) from the United States Geological Survey (USGS), annual precipitation from the Parameter- elevation Regressions on Independent **S**lopes Model (PRISM) group, and Coastal Change Analysis Program (CCAP) land cover. Each land cover type has an associated impervious surface co-efficient. Data from each of these sources was downloaded and clipped to the boundary of the Pōhākea Watershed and processed using ArcGIS software.

MEC ran the NSPECT model for sediment, nitrogen, and phosphorus delivery throughout the Pōhākea Watershed. The model provides 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.

It should be noted that NSPECT has known limitations with accuracy and precision when modeling for erosion in wet, steep slopes like those in the upper reaches of the Pōhākea Watershed. This is due, in part, to a lack of available data collection from inaccessible mountainous areas. Inputs to NSPECT, 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, the bulk of this portion of the watershed is not actively being farmed. MEC recognizes that there are other models available, namely InVEST, and that there are trade-offs between cost-efficiency and higher accuracy (more robust modeling methods and procedures can be costly and time-intensive).

Table 15 lists the quantitative data resulting from the NSPECT modeling effort. In addition, the results of the NSPECT modeling exercises for localized sediment, nitrogen and phosphorus are included as figures (Figures 31-33). These figures are offered as qualitative data serving as visual representations of the various sediment and nutrient sources as water flows toward coastal waters.

The Localized Sediment Map (Figure 31) depicts several areas within the watershed where sediment transport is particularly high. The NSPECT model predicts heavy amounts of localized sediment for land uses at higher elevations where mountain slopes are fairly steep. In the lower reaches of the watershed, where the slope changes from being extremely steep into the various gulches and gullies within the coastal floodplain, localized sediment availability is also relatively high. NSPECT depicts the highest localized sediment to be associated with Mahi Pono agricultural lands. As stated previously, NSPECT pollutant models are limited by the datasets that go into the model. We believe the sediment values depicted within the agricultural areas of the watershed are overestimated because they are treated as active farmland. These areas are currently fallow and covered in dense grasses. These areas are not currently being tilled or fertilized and are likely not contributing as much sediment or nutrients as the model predicts. NSPECT values for sediment ranged from a high of 13,120 metric tons in areas such as Pōhākea Stream to virtually no localized sediment throughout the majority of the watershed.

The Localized Nitrogen and Phosphorus Maps (Figures 32 and 33) depict high amounts of these nutrients (highest amount being 2.68mg/l and 0.48mg/l respectively) in agricultural lands associated with the Hope Builders, LLC and Mahi Pono properties. In addition, elevated nutrient concentrations were calculated for the Hawaiian Cement Quarry.

Table 16. NSPECT Localized Pollution Values

NSPECT Localized Pollution			
Non-Point Source Pollution	Nitrogen (mg/l)	Phosphorus (mg/l)	Sediment (Tons)
Minimum Value	0.70	0.05	0
Maximum Value	2.68	0.48	2,330

The Localized Sediment Map depicts several areas within the watershed where sediment transport is particularly high. In the lower reaches of the watershed, where the slope of the West Maui Mountains changes from being extremely steep into the various gulches and gullies ultimately leading to the coastline, localized sediment availability is high. In addition, Pōhākea, Kanaio, and Māʻalaea Streams running through the agricultural lands and the Hawaiian Cement Quarry are listed as elevated areas of localized sediment. The NSPECT model does not consider anthropogenic changes to the watershed and therefore, the hydrologic impacts of the Waiheʻe Mauka and Makai Ditches with regard to these streams are not accounted for in the model.

The Localized Nitrogen and Phosphorus Maps model for nutrient concentrations records high amounts in those land uses associated with agriculture and the highly developed land associated with the Māʻalaea condominiums, business district, and harbor. As stated above, the NSPECT model does not consider anthropogenic changes to the watershed and therefore, the hydrologic impacts of the Waiheʻe Mauka and Makai Ditches with regards to these streams are not accounted for in the model.

Figure 31. Pōhākea NSPECT Sediment Map

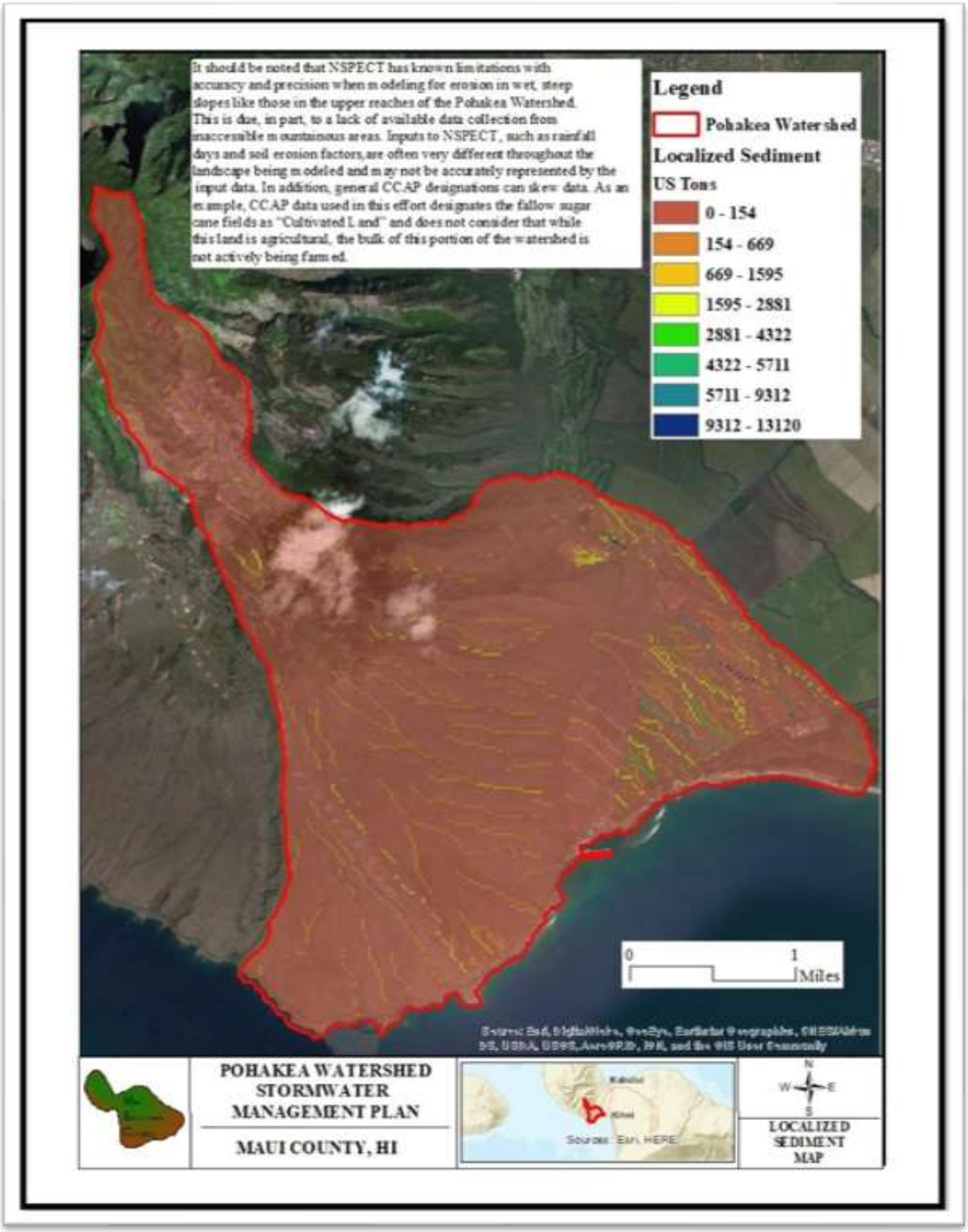


Figure 32. NSPECT Localized Nitrogen Map

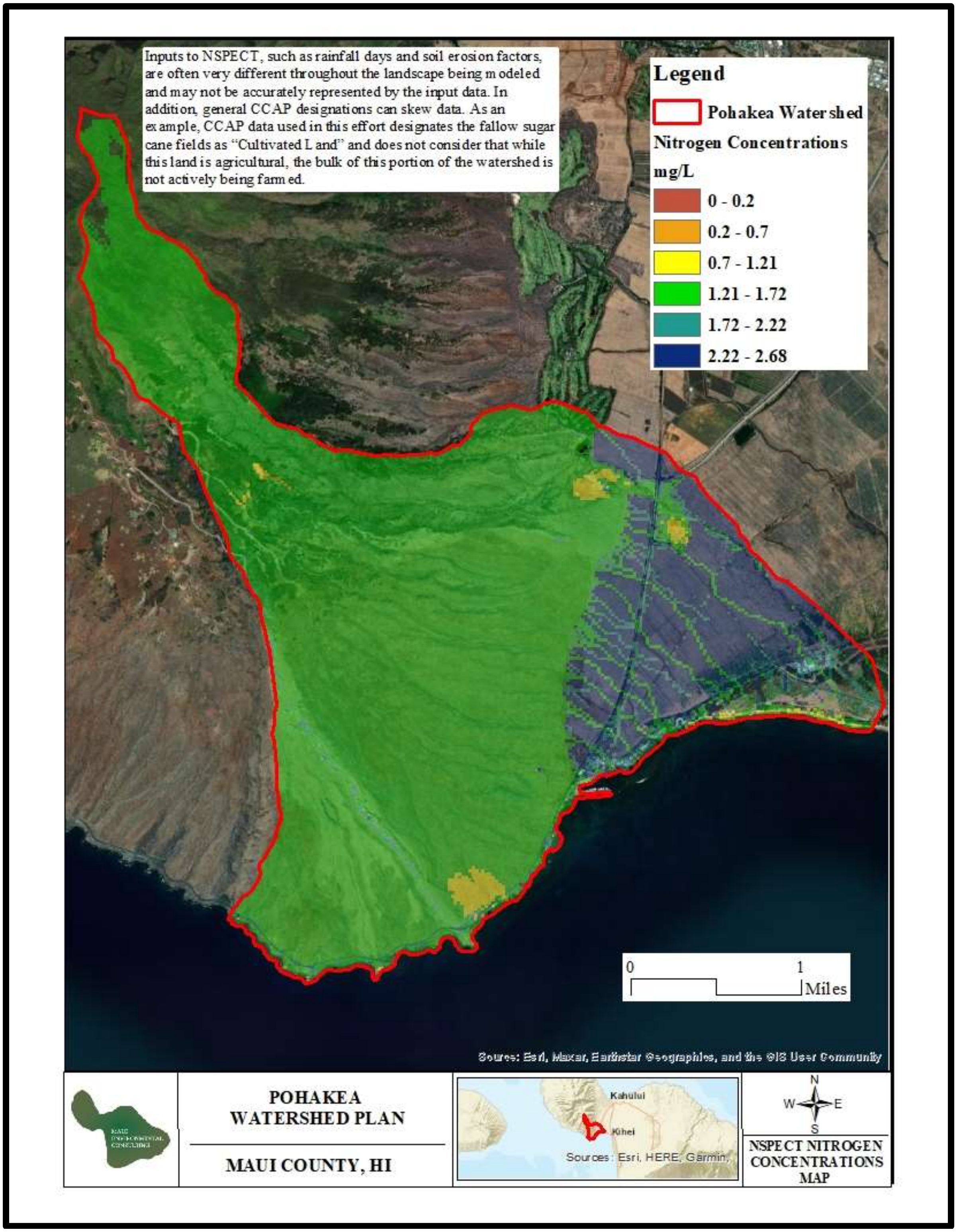
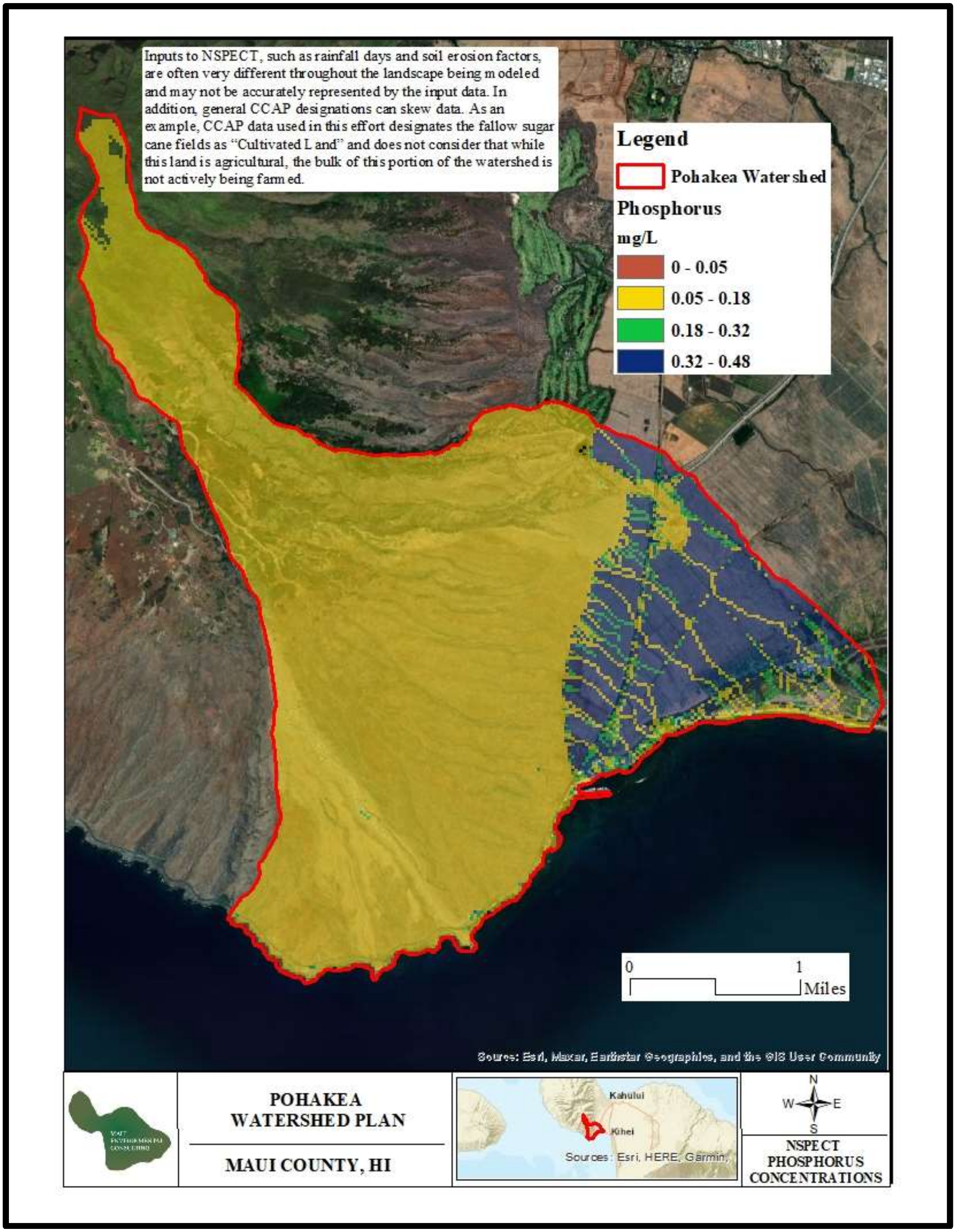


Figure 33. NSPECT Localized Phosphorus Map



6.3.2 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. For Pōhākea Watershed, the 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 Universal Soil Loss Equation (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/).

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 does not estimate pollutant load reductions for dissolved constituents.

Cesspool contributions were also accounted for. There are 10 known cesspools in the Pōhākea boundary. The national average of 2.43 persons per household was used as the number of persons serviced by each cesspool. Table 17 presents the STEPL total load estimates by land use type for Nitrogen, Phosphorus, and Sediment within the Pōhākea Watershed Boundary.

Table 17. STEPL Pollutant Loads by Land Use within Pōhākea

Total Load by Land Use			
Sources	**N Load (lb/yr)**	**P Load (lb/yr)**	**Sediment Load (t/yr)**
Urban	214.35	32.98	4.92
Cropland	17672.48	6470.97	5064.53
Pastureland	1512.33	402.47	291.37
Forest	1290.65	530.62	311.70
Septic	31.09	12.18	0.00
Total	21237.71	7648.19	5834.04

6.4 Field Assessment of Nonpoint Source Pollution

Sediment, nutrient, and other pollutant sources associated with the Pōhākea Watershed were assessed using field observations. In addition, the Nonpoint Source Pollution and Erosion Comparison (NSPECT) model was used to identify pollutant hot spots for the watershed to better understand these sources at a landscape level.

MEC staff canvassed the watershed 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, bare ground, 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. The Pōhākea Watershed was divided into four distinct areas including Mauka/Conservation Lands, Mid-Level Ag Lands, Commercial and Urban Lands, 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 unimproved roadways and powerline corridors) 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 are discussed below.

6.4.1 Mauka/Conservation Lands:

6.4.1.1 Unimproved Roads

Historic land uses in this area (primarily cattle ranching) have left behind an extensive network of unimproved and unmaintained agricultural roadways. Some roadways are deeply incised into the landscape, an indication of long-term sediment loss and erosion. Water bars (berms constructed across roadways designed to channel water off the road) and kickouts (channels which convey water away from the road), have failed in many places. Disused and unmaintained roadways are acting as stormwater conveyances during rain events and are channeling stormwater and sediment into adjacent gulches (Roads and Powerlines Map).

6.4.1.2 Powerline Corridors

There are a number of powerline corridors associated with transmission and distribution power lines. The status of these lines is unknown, but downed lines, and aging poles were observed at several locations. In addition, burned areas were observed directly below transmission corridor power lines. The powerline access roads for these corridors were observed to be in various states of disrepair, and the clearing of vegetation from under and around the power lines has created bare areas which, like agricultural roads act as stormwater and sediment conveyances (Roads and Powerlines Map).

6.4.1.3 Wind Farm Road

While the access road leading up to the windmills is well engineered and well maintained, there were several areas observed where erosion was causing undermining of the road surface, and loss of the gravel overlay.

6.4.1.4 Land Slides

It was observed that native scrub habitat was being lost as topsoil sloughed off and ‘mini’ landslides were occurring. 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*), Buffalo Grass (*Brachiaria mutica*), 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.

6.4.2 Mid-Level Ag Lands

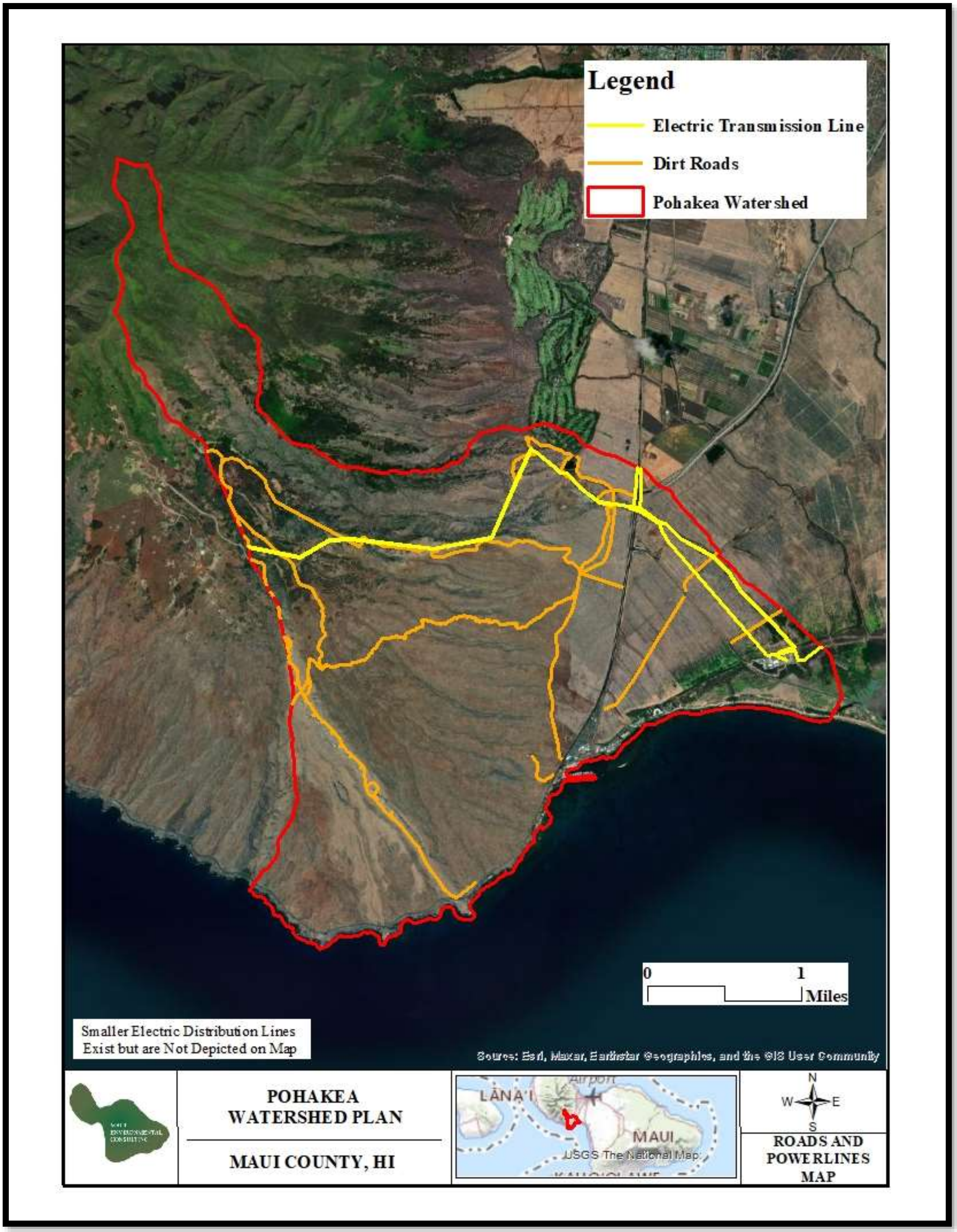
6.4.2.1 Head Cuts Along Highway

Substantial loss of sediment was observed along the upstream side of the highway where stream flow was directed underneath the highway through box drains and culverts. The constriction point created by these culverts, possibly due to their small size, has led to extensive head cutting within the stream channel and loss of many tons of sediment material during times when the streams flow. Head cuts occur when stream force is directed downward due to a constriction of flow (in this case a road culvert), and creates a sheer bluff or cliff known as the knickpoint. The head cutting observed was ‘active’ in that more stream channel incision, loss of floodplain connectivity, and loss of sediment at an exponential rate will continue to worsen as the knickpoint migrates further upstream each time the stream flows.

6.4.2.2 Hawaiian Cement Quarry

Hawaiian Cement Quarry is located at the base of Pōhākea Gulch, just before the land begins to level out and the gulch converges with the Waiheʻe Mauka Ditch. This quarry is mining aggregate materials from what appears to be a large ancient debris flow deposit which came down from Pōhākea Gulch. The Stream now flows around the quarry site, splitting into two rivulets skirting along the north and south sides of the excavation site and rejoining just downslope of the quarry. The Waiheʻe Mauka Ditch skirts along the eastern edge of this excavation.

Figure 34. Pōhākea Roads and Transmission Powerlines



6.4.2.3 __Landfill__

Operations at the Pu’u Hele Cinder Pit Quarry began during WWII. The cinder from this puʻu was used to create military and service roads throughout the island. In 1996 the resulting pit became a privately-owned construction dump named the Maui Demolition and Construction Landfill. In September of 2016, the landfill reached height restrictions and was subsequently closed. Pōhākea Stream Gulch skirts along the edge of the now closed and capped landfill. While a detailed survey of this site was not conducted due to lack of landowner permission, there is presumably a potential for sediment or other materials to leach into the stream and/or groundwater from this site.

6.4.2.4 __Waiheʻe Ditches__

There are two historic irrigation ditches, both named ‘Waiheʻe Ditch’ (for purposed of this report, they are referred to as Waiheʻe Mauka Ditch and Waiheʻe Makai Ditch). These ditches historically brought irrigation water from Waiheʻe Stream to irrigate fields throughout the central isthmus.

The Waiheʻe Mauka ditch is evident in the northern portion of the watershed until it converges with Pōhākea Gulch. The remaining portion of the original Waiheʻe Mauka Ditch runs essentially north/south at the inflection point between the mountains and the relatively flat plain. A reservoir located at the southern end of the Kahili Golf Course appears to be the terminus of the actively used portion of the Waiheʻe Mauka Ditch. While the ditch was observed to be dry within the project area, during high rain events, it could discharge additional sediment laden stormwater into Pōhākea Stream. It is assumed a control structure exists at the reservoir associated with Kahili Golf Course, but due to access restrictions, MEC was not able to confirm this. A well-defined channel does exist coming from the reservoir and leading to a confluence with Pōhākea Stream just east of the Hawaiian Cement Quarry. The original Mauka Ditch pathway continues along the inflection point where the steep West Maui Mountains meet fallow agricultural lands and is no longer an obvious conduit for water except during high flow rain events, or possibly when excess water from the ditch is directed into it. It was being utilized as a powerline corridor that terminates near the intersection of Honoapiʻilani Highway and Māʻalaea Road (By the old Buzz’s Wharf building). This corridor was severely eroded at its southern end where it intersects with the highway and was an active sediment transport pathway. It was likely a major transport mechanism responsible for large amounts of sediment observed washing onto and across the highway, and down into the parking area near the boat ramp at Māʻalaea during large storm events. Maui Nui Marine Resource Council hired Goodfellow Bros. to regrade this road in December of 2020.

The Waiheʻe Makai Ditch has also been altered from its original extent. The ditch is an armored, box-cut channel beginning along Honoapiʻilani Highway flowing south. It severs Kanaio Gulch from its original course and becomes a more natural, unarmored system after receiving water from three additional unnamed gulches that are routed via culvert under the highway. At the confluence of this ditch with the third unnamed gulch on the makai side of the highway, the system turns southeast, losing its concrete lining and continuing through a detention basin mentioned in Section. 2.2.2 above before ultimately discharging into Māʻalaea Bay.

6.4.2.5 Sugar Cane Ag Roads

The legacy of agricultural roads continues downslope into areas of the landscape that were actively cultivated with sugar cane until late 2016. Unimproved agricultural access roads, especially at stream crossings are a potential sediment source whenever the streams flow.

6.4.2.6 Fire Breaks

Mahi Pono has begun to plow firebreaks along the perimeters of the fields wherever they are adjacent to a roadway. These firebreaks leave an area devoid of vegetation approximately 20 yards wide and could be a source of sediment loss during rain events.

6.4.2.7 MECO Powerline Corridors

Powerline corridors were generally placed to traverse sugar cane fields along stream riparian corridors, ditches, and other areas where they wouldn't interfere with cultivation activities. These locations are potential flow paths during storm events, so any activities such as the repair or replacement of lines or poles require access and construction activities within these sensitive areas. MECO staff reported the loss of several utility poles to flood waters associated with high flows in Pōhākea Stream during one storm event. Evidence of heavy equipment use, tree removal, and earthmoving associated with utility pole replacement was observed within these areas.

6.4.2.8 MECO Māʻalaea Powerplant

Pōhākea Stream runs along the eastern edge of the MECO Māʻalaea Powerplant where it discharges into Keālia Pond. The riparian zone of Pōhākea Stream is also utilized as an electricity transmission corridor crossing the surrounding fallow agricultural lands. MECO staff reported power poles being undermined by heavy flows within Pōhākea during recent storm events.

In addition, evidence of surface water discharge was observed as rills and gullying were apparent in the wetland areas adjacent to the facility. Observations during storm events are needed to determine the amount of flow produced during these events at the outfall of Pōhākea Stream into Keālia Pond. MECO also has a NPDES permit for stormwater associated with industrial activity, which likely discharges directly into Keālia Pond during heavy rainfall events.

6.4.2.9 Kahili Golf Course

The Kahili Golf Course is primarily located north of Pōhākea Watershed. However, the Waiheʻe Mauka Ditch runs along the entire eastern boundary of the golf course before discharging into a reservoir located just north of the Hawaiian Cement Quarry within the Pōhākea Watershed. While a control structure was not observed leading from this reservoir, the Waiheʻe Mauka Ditch is well defined below this catchment and discharges into Pōhākea Gulch just east of the Hawaiian Cement Quarry. Pōhākea ultimately discharges into Keālia Pond and Māʻalaea Bay. Golf courses can be a source of nutrient runoff from fertilizers. Kahili Golf Course closed during the pandemic and is currently only open to walking golfers on the weekends. The golf course was not contacted as part of this watershed management plan and course turf management BMPs were not assessed.

6.4.2.10 Fallow Pastures

All the streams within the project area are ephemeral and are considered losing or disappearing streams because water is infiltrated into the aquifer as it flows downstream. This results in generally more water volume upstream than downstream, and is characterized by deep gulches and canyons upstream and relatively small rivulets and stream channels downstream. As the streams discharge out of the West Maui Mountains, they flow onto a broad gently sloping plain between the base of the mountains and the mauka side of the highway. This plain was historically used for sugar cane cultivation, as well as pineapple and asparagus, but this appears to have ceased some time ago, and the area is now used for livestock grazing or remains fallow. There may also be feral ungulate grazing in this area although no evidence was observed. This landscape is significantly degraded with numerous areas devoid of vegetation, and is dominated by invasive grasses and weeds. There is evidence of sheet flow across these barren patches and the entire landscape is a significant contributor of sediment to the streams flowing through it. Streams within this area are highly degraded, with vertical stream banks, little to no vegetative armoring, and evidence of recent and persistent erosion events.

6.4.3 Commercial and Urban Land

6.4.3.1 Stream Diversions

The cut off reach of Kanaio Stream that was diverted into the armored channel (Waiheʻe Makai Ditch) running parallel to the Highway, still exists as a dry gulch that continues through fallow sugar cane fields from the highway until it terminates in the field mauka of Haycraft Beach. It is likely that this stream once flowed into wetlands in the vicinity of Haycraft Beach. Peter Cannon of the Māʻalaea Village Association has referred to the wetlands that Kanaio flowed into the Māʻalaea mudflats. Further investigation of the historic hydrologic conditions in this area are recommended to inform potential restoration activities.

6.4.3.2 Dirt Lots and Parking Lots

Vacant lots and dirt parking lots are found at various locations adjacent to the harbor. While some of these areas have been improved with a gravel overlay, many are simply bare compacted earth which can easily be transported to the nearby ocean by wind and rain. The paid parking located near the north loading dock and the parking areas at the west (towards Lahaina) end of the harbor are prime examples of baren dirt in close proximity to the ocean.

6.4.3.3 Māʻalaea Triangle Parking Lot

The parking lots that service the Māʻalaea Triangle represent approximately 350,000 square feet of impervious surface. This area is a source of considerable urban stormwater runoff and its associated pollutants during rain events. While the drains are stenciled to indicate that they lead to the ocean, the stormwater entering them receives no treatment before being discharged directly into the harbor. Runoff from parking lots contains sediment as well as petrochemicals, heavy metals, trash, and other pollutants associated with urban runoff.

6.4.3.4 Car Washes and Condo Impervious Surfaces

The roads, parking lots and buildings associated with the oceanfront resorts and condominiums along Hauʻoli Street represent a significant area of impervious surface. Runoff from these areas increases the volume of stormwater runoff flowing into the ocean, and is a significant contributor of sediment as well as petrochemicals, heavy metals, trash, and other pollutants associated with urban runoff. Swimming pool backwash and car washing areas were also observed discharging directly into the channelized stream which flows into the ocean. There are likely additional sources of nutrient pollution within the landscaped areas of these condominiums.

6.4.4 Keālia Pond

Keālia Pond and its surrounding wetlands are extremely important for preventing pollution from entering the ocean. The ecological function of Keālia Pond as a wetland provides numerous ecosystem services acting as both a nutrient sink and buffer against stormwater runoff pollution entering the ocean. The pond provides critical habitat for endangered aquatic bird species as well as many other flora and fauna. Pollution from Pōhākea Stream 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 Pōhākea and the adjacent Waikapu 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 are warranted. Sediment laden stormwater captured in Keālia is regularly discharged at the pond's outfall into Māʻalaea Bay and the ocean.

7.0 GOALS AND MANAGEMENT RECOMMENDATIONS

The Pōhākea watershed is characterized by long periods of up to several years with little to no rainfall. Discharge from gulches and gullies into Māʻalaea Harbor and Māʻalaea Bay rarely occur. Unfortunately, when stormwater events do occur, the potential for flash floods, and very large stormwater volumes is possible within this watershed. The occurrence of these extreme flooding events is only likely to increase as weather patterns change due to climate change. Any stormwater mitigation measures and restoration activities must be engineered to handle the high flow events that will eventually occur.

In addition, extremely limited water quality data exists for the watershed. As stated earlier, the DOH CWB currently only monitors at five locations within the entire 5,268-acre area: Māʻalaea Beach, Māʻalaea Boat Harbor Station, and Māʻalaea Small Boat Harbor. Each location is important in providing public access to fishing, swimming, boating, and other recreational activities. No stream outfalls exist at any of the monitoring locations, however, stormwater discharge into Māʻalaea Harbor during heavy rainfall events. For this reason, the Pōhākea Water Quality Monitoring Plan was created for the Pōhākea Watershed and is included as Appendix B to this watershed plan At a minimum, if none of the other management projects and strategies listed below are implemented, the Pōhākea Water Quality Monitoring Plan (or portions of this plan) should be implemented to narrow existing data gaps in water quality issues affecting the watershed, and to better determine where sediment and nutrient pollution is occurring throughout the watershed. The following sections provide projects and strategies designed to address specific land use 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. Load reduction estimates for each of these projects are provided to better inform stakeholders on the potential efficacy of each project.

7.1 Mauka/Conservation Lands

7.1.1 Unimproved Roads

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. 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 Pōhākea Watershed's roads was conducted to determine stakeholder access needs and 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. The roads observed in upland areas are severely compacted, and the soils have lost most, if not all, of their stormwater infiltration capabilities. In coordination with landowners and potential road users, disused, and unnecessary or redundant roadways should be identified for decommissioning, and roads likely to stay in use improved using water bars, sediment traps and BMPs to minimize downslope transport of eroded sediments such as the BMPs found in the document entitled: Unpaved Road Standards for Caribbean and Pacific Islands.
See: https://dcrm.gov.mp/wp-content/uploads/crm/2017IslandUnpavedRoadStandards.pdf

Roads for stabilization and closure should be prioritized based on 1) public use needs, 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.

Mauka roadways in Pōhākea that are contributing to sloughing and landslides should be prioritized as well as those that are directly contributing sediment and stormwater into gulches. 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 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.

7.1.2 Powerline Corridors

Similar to the recommendations for unimproved roadways, the extent to which access is needed and vegetation must be controlled or removed from powerline corridors should be assessed. 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 (see MECO Powerline Corridors section below).

7.1.3 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. During field observations, a burned area associated with a mauka powerline corridor was observed, as well as a number of downed lines, and aging powerline poles. 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 well documented in this area, and every effort should be made to prevent their occurrence in collaboration with Maui Electric Company.

The Hawaiʻi Wildfire Management Organization is a 501(c)(3) non-profit working in Hawaiʻi to protect the environment from wildfire damage. Their goals are to prevent wildfires, mitigate for their impacts, aid in post-fire recovery, and to provide for a collaborative environment. In 2016, they made the following movie discussing the recent Māʻalaea wildfires and their effects on water quality in the watershed: (https://www.youtube.com/watch?time_continue=18&v=ZtsG5fP-Z9Y)

After fires are extinguished, restoration activities should be coordinated and targeted to quickly stabilize newly burned areas with appropriate planting. Techniques such as hydro mulching with native plants, which have been piloted in West Maui by the Puʻu Kukui Watershed Preserve (https://www.puukukui.org/) have potential application in this regard, but further refining of the methods is needed within dry land contexts as well as further study of the overall ecological response of plant communities and vegetation regrowth following fires in this particular area.

7.1.4 Wind Farm Road

While the access road leading to the windmills is in excellent condition, incorporating good use of road management BMPs, overall road performance and erosion prevention could be improved in several places along its stretch. The steep grade of this road makes it an ideal candidate for the strategic planting of vetiver and native plants at kickouts and water bars. This would also prevent imported (expensive) gravel aggregate from washing off the roadway into adjacent gulches. Vetiver, when planted on road kickout contour lines (The line joining equal elevation points along a surface), can trap sediment and prevent it from being conveyed into the stream gulch. It can also effectively filter and sink water flowing off the road, thereby meeting road maintenance goals without compromising sediment mitigation objectives. This technique has been successfully piloted and refined in West Maui where the presence of either of two specific factors was deemed to lead to the most overall success of the method: 1) High maintenance capacity to remove accumulated material in a timely manner, and 2) a steep grade of the road combined with aggressively cut water bars to create ample 'freeboard' or storage space for accumulated material to gather. Both of these conditions are present along the wind farm access road.

7.1.4.1 Detention Structure at the Bottom of the Wind Farm Road

Located at the bottom of the wind farm access road is a parking area that could accommodate a detention structure. This structure would detain stormwater flowing down Malalowaiaole Gulch and allow sediment and any roadway aggregate to settle out of suspension instead of being discharged into the ocean (See Figure 8. Discharge Locations Map). Culverts currently directing this flow under the Honoapiʻilani Highway represent a bottleneck or constriction point in the stormwater flow that could be retrofitted to accommodate a standpipe or other control structure that would increase stormwater retention times before discharge. Runoff management systems for existing roads are supported in Chapter 5 Section 3 of the Hawaiʻi Watershed Guidance.

7.1.5 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. The NRCS Practice 601 for vegetative barriers is offered as an example:
https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs144p2_010398.pdf)

This practice involves planting vetiver or other suitable vegetation on contour to stabilize actively eroding hillslopes, capture sediment, and to promote the infiltration of stormwater sheet flow into the ground so that it does not move laterally across the landscape. This practice consists of planting rows of vegetation along contour lines with vertical distances of six feet between lines. This practice also has the potential to allow for the reintroduction of Hawaiian native plants and trees which can be planted behind the vegetation rows as a suitable soil base accumulates.

Figure 355. Examples of Contoured Vegetative Barriers

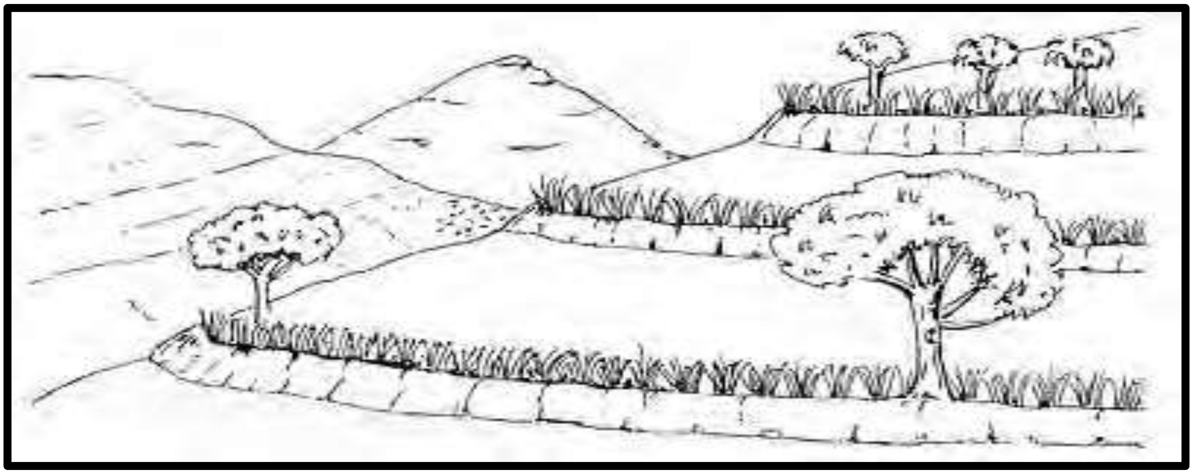


Figure 36. Vegetative Barriers

7.2 Mid-level Ag Lands

7.2.1 <u>Head Cuts Immediately Mauka of Highway</u>

Due to the substantial and ongoing losses of sediment observed at head cuts just mauka of the highway, head cut stabilization is a priority recommendation for preventing sediment loss within the project area. Head cut stabilization is accomplished by either 1) excavating the actively eroding knickpoint (cliff) and incised stream banks to substantially reduce the slope, or 2) by filling in the incised channel below the knickpoint to obtain same result.

Both these methods serve to reduce stream flow velocity which prevents further scouring and erosion, however filling in the channel is not possible in these cases due to the presence of the highway just below the head cuts. Along the newly reshaped stream channel slope, boulders are used to create riffle pools which further reduce stream flow velocity and allow one pool to fill up before spilling into the next. Head cut stabilization and restoration is greatly enhanced by including native plants to further prevent erosion and maintain the new channel shape.

There are at least four sites that are candidates for head cut repair in Pōhākea. They range in height from 1-2 meters, to over 8 meters high. The larger head cuts will require substantially more excavation to be effectively stabilized and restored, and costs will increase concurrently. Due to the flashy nature of the Pōhākea Watershed characterized by long periods with little to no rain punctuated by substantial and damaging stormwater flows, any head cut stabilization or stream channel reshaping must be engineered to handle these high flow events.

It is also important to address the underlying initial causes of the head cuts. In these cases, it appears that the constriction points created by the box drains and culverts where stream flow is directed under the highway are significantly undersized, and cause water to back up, creating head cut conditions.

According to a drainage plan commissioned by MNMRC and produced by CDF Engineering in December of 2021, head cutting should be addressed by a reduction in slope to three to one. Geotextiles should be utilized to armor the stream channel in preparation for large storm events.

Figure 37. Proposed Head Cut Repair

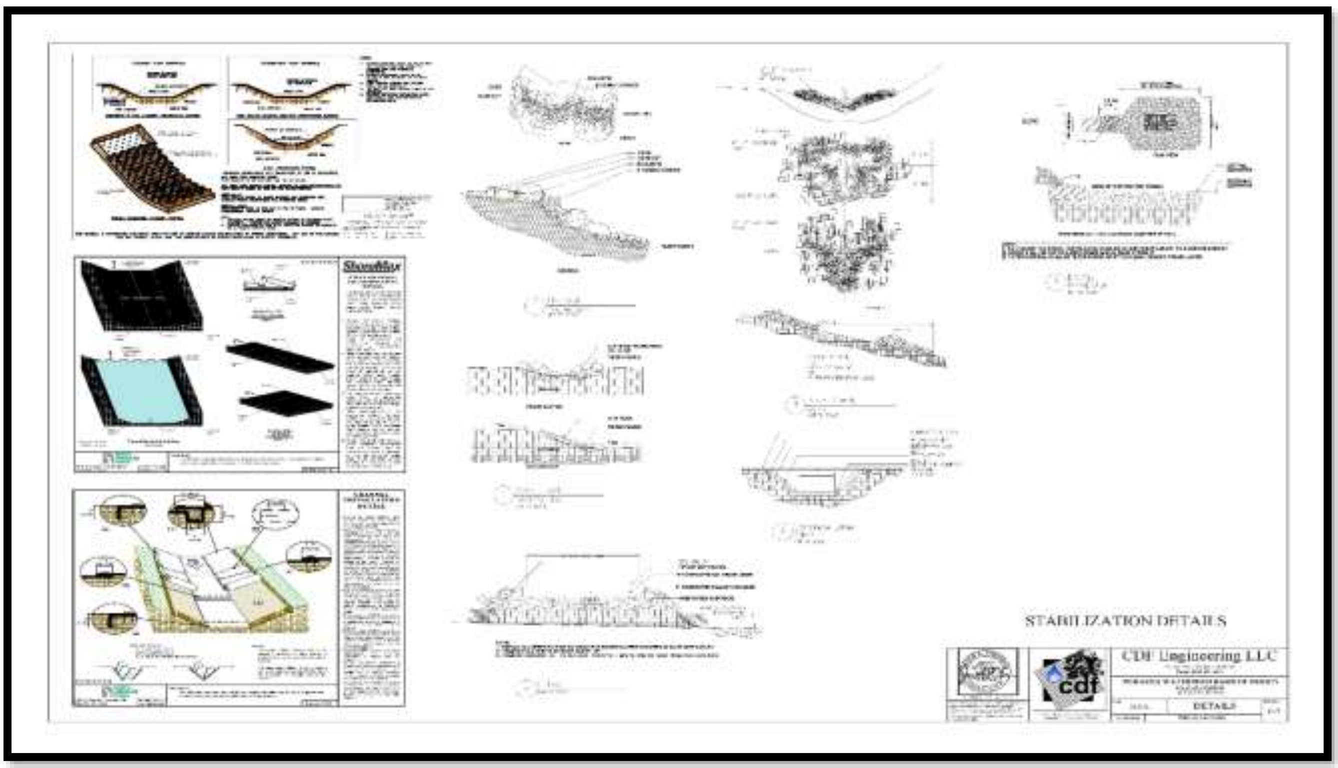


Figure 38. Proposed Head Cut Stabilization Drawings

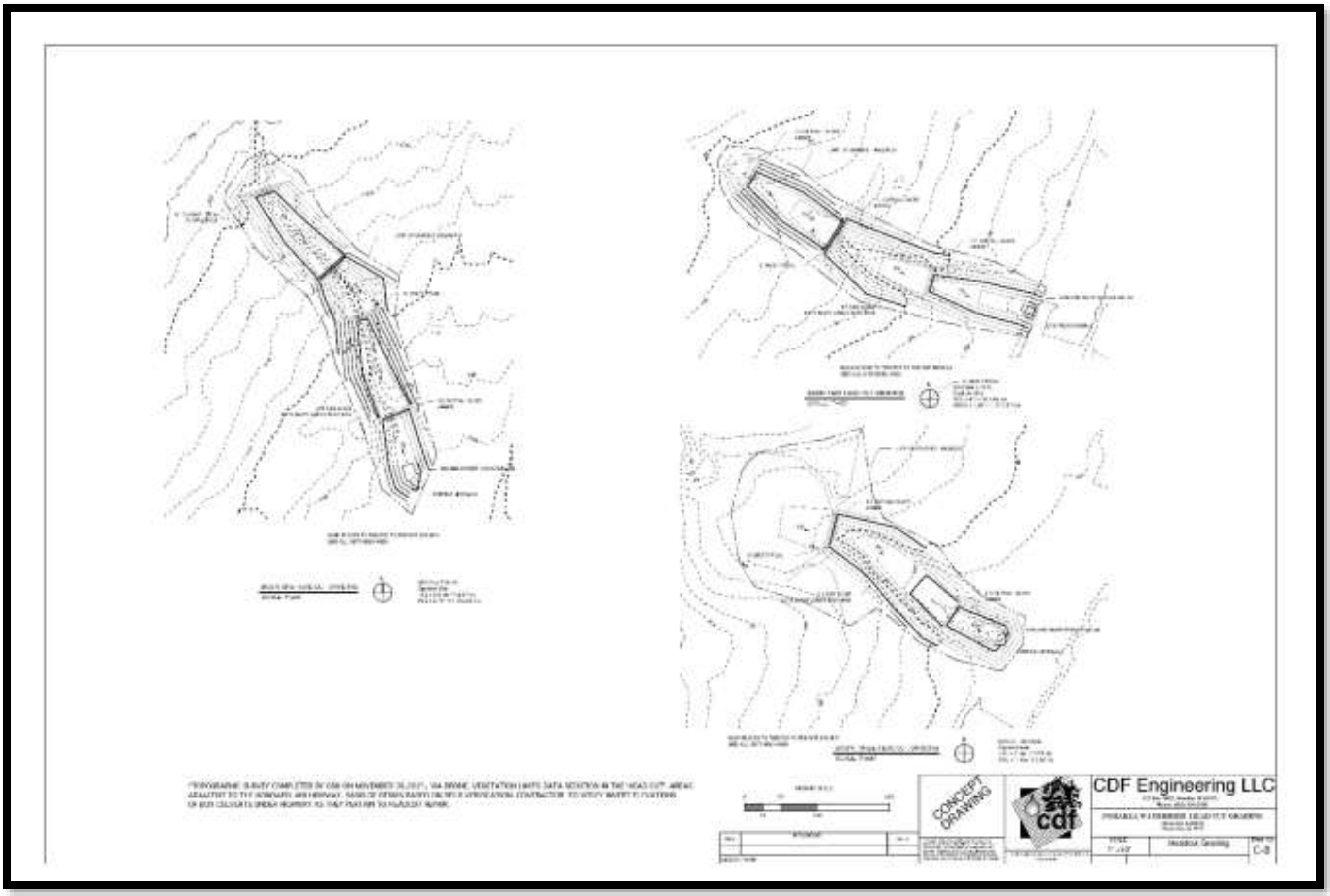


Figure 39. Examples of Head Cutting

7.2.2 Quarry

The Hawaiian Cement Quarry is positioned at a vulnerable location on an existing debris flow. While an extensive survey of the site is not included within this report, it is essential that best management practices are implemented in and around the quarry to prevent loss of alluvium deposits to the surrounding streams and gulches. One area in particular observed was the entry and exit point to the quarry, where heavy trucks have to cross a portion of the Waiheʻe Mauka Ditch. This area should be managed to prevent sediment loss from the road surface and from trucks entering and exiting the facility.

Quarrying activities in this area could have synergies with stormwater mitigation goals. For example, quarries and mines are required to have a 'closure plan' in place that details the effective lifespan of the operation, and includes the details of closure and landscape reclamation requirements. This quarry is well positioned to receive flows from Pōhākea Stream and could be redesigned as a stormwater detention/infiltration facility once the quarrying activities reach the end of their effective lifespan.

Earthmoving, excavation, and hauling of excavated material represents a significant portion of the total cost associated with construction of a stormwater detention or infiltration facility. It could be possible to coordinate excavation and earthmoving needs with stormwater detention needs such that today's borrow pits and fill excavation sites could be tomorrow's stormwater detention basins.

7.2.3 Landfill

Verification of the use of landfill capping best management practices is recommended as well as further study of the portion of Pōhākea Stream that runs along the edge of the landfill to ensure this area will not be undermined during a sizeable storm event when the stream flows.

7.2.4 Waiheʻe Ditch System

The hardened channel of the Waiheʻe Makai Ditch that runs adjacent to the highway collects substantial roadside rubbish and should be more effectively maintained as the bulk of this material is likely to end up in the ocean during a high flow event. It is unclear if the ditch itself is part of any existing roadside cleanup efforts, but it could be incorporated into 'Adopt a Highway' programs, volunteer efforts from organizations like Malama Maui Nui, Maui County and/or Department of Transportation litter control efforts. Organizations that regularly do 'Beach Cleanups' could be encouraged to clean up this channel as an alternative, and keeping this channel free of rubbish will likely have a far greater impact than waiting until this garbage makes its way downstream to the ocean and onto beaches in Māʻalaea.

The Waiheʻe Mauka Ditch pathway that is now being utilized as a powerline corridor was severely eroded and was an active sediment transport pathway during high flow events. In December of 2019, MNMRC hired Goodfellow Bros. to regrade the road and place BMPs in areas where it intersects gullies. Continued maintenance of this road should continue as necessary.

The ditch pathway is approximately 9,000 feet long from its last assumed functioning reservoir to the terminus at the highway near Māʻalaea Harbor. To maintain the entire length of this road, depending on the severity of future damage, could cost as much as $50,000.00

7.2.5 Sugar Cane Ag Roads

Now that sugar cane is not actively being cultivated in the area, Mahi Pono should conduct an assessment of the current necessity and future needs of dirt agriculture roads (see ag roads section above). 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.

7.2.6 Fire Breaks

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 firebreak by not creating excessive biomass, be dense growing to prevent sugar cane regrowth, and ideally be a nitrogen fixing legume that could nourish degraded soils. 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.
https://cms.ctahr.Hawaiʻi.edu/soap/Resources/Sustainable-and-Organic-Topics/cc-gm

7.2.7 MECO Powerline Corridors

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. Stream beds should not be overly disturbed and soil piles or other loose material should be relocated well out of reach the stream flood plain. 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. As stated earlier, this was recently the case along Pōhākea Stream when several utility poles had to be replaced after being undermined by heavy flows within the riparian corridor.

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 a 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.

7.2.8 MECO Facility

While this site does have a NPDES stormwater permit, a detailed survey of the MECO Power generation facility is recommended because there are most likely opportunities to mitigate the site's potentially large stormwater footprint through bioretention or other Low Impact Design (LID) techniques. An assessment could also ensure that any other surface discharges are properly treated through appropriate management practices before being released into Pōhākea Stream and/or Keālia Pond. The area where Pōhākea Stream discharges into the pond should be assessed for sediment transport. MECO constructed an earthen berm around the southern end of the facility in 2019 to contain stormwater runoff.
http://gokihei.org/environment/meco-meeting-regarding-proposed-detention-basin-at-Māʻalaea

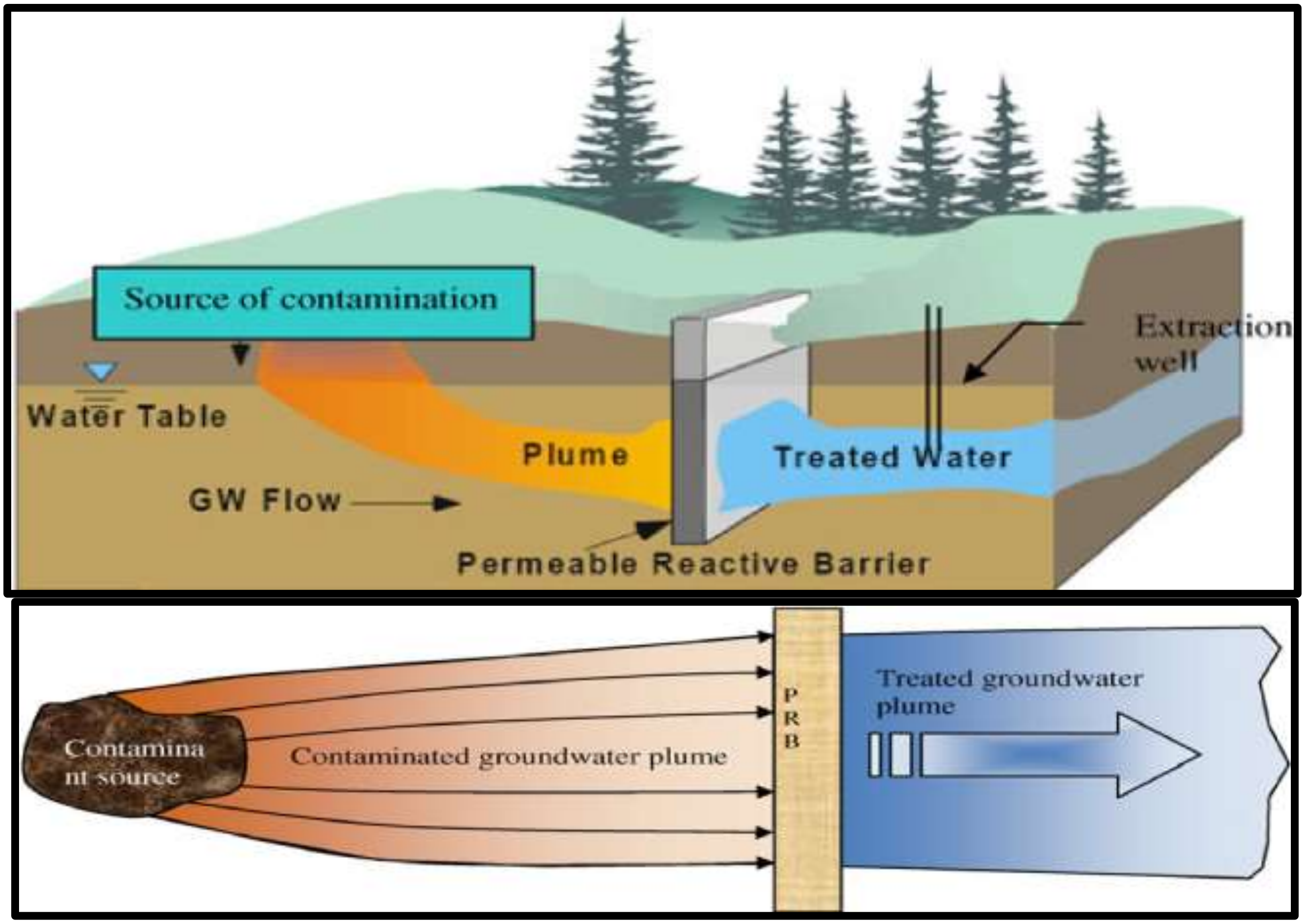
7.2.9 Kahili Golf Course

While a relatively small portion of the golf course falls within the project area, there are numerous turf management BMPs that can effectively reduce nutrient stormwater runoff and groundwater pollution on golf courses. 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 in West Maui include:

7.2.9.1 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 40. Nutrient Curtain (Permeable Reactive Barrier)



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 18. 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**

7.2.9.2 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 41. 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. 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

7.2.10 Fallow Pastures and Hope Builders, LLC and West Maui Construction, Inc.

The part of the Pōhākea Watershed landscape containing fallow pastures located between the base of the West Maui Mountains and the highway form a relatively gently sloped plain. The County and State had partnered to purchase this land for approximately seven million dollars and dedicate it to DOFAW for conservation. However, Hope Builders, LLC and West Maui Construction, Inc. was able to acquire the land for approximately six million dollars in 2022. It is unclear at this time what Hope Builders, LLC and West Maui Construction, Inc. intends to do with the property. This land has significant potential to mitigate sediment transport to the ocean through several restoration activities.

During high flow events millions of gallons of stormwater pour down out of the West Maui Mountains and onto this plain. Restoration measures would have the collective goal to slow, detain, filter, and permeate into the ground as much of this stormwater as possible. There may be existing structures in this area, such as old reservoirs associated with irrigation infrastructure and the Waiheʻe Mauka Ditch running along the base of the mountains, that could be repurposed or renovated to serve as detention infrastructure. Detention basins are typical structural systems for runoff control mentioned in Chapter 5 Section 1 of the Hawaiʻi Watershed Guidance report. Ideally, detention infrastructure would be decentralized with multiple practices installed using a 'treatment train' approach whereby the collective impact of the overall stormwater treatment system is greater than the sum of its individual components.

7.2.10.1 Large Detention Basins

In December of 2021, MNMRC paid Goodfellow Bros and CDF Engineering to prepare a drainage report for the Hope Builders, LLC and West Maui Construction, Inc. parcel. At that time, this property was still owned by the Spencer family, and is often still referred to as the Spencer Property. The purpose of this report was to evaluate the existing and proposed drainage conditions for the subject project as well as discuss the effectiveness of installing retention basins near the outlet of the watershed (directly above the Honoapiʻilani Highway). The proposed improvements for the subject project include constructing retention basins to allow sediment from stormwater to settle out during storm events. Ultimately, the intent is to allow only treated stormwater to enter Māʻalaea Bay from this watershed. The focus area was in five different gulches as they cross the Hope Builders, LLC and West Maui Construction, Inc. property.

Figure 42. Retention Basins Proposed for Hope Builders, LLC

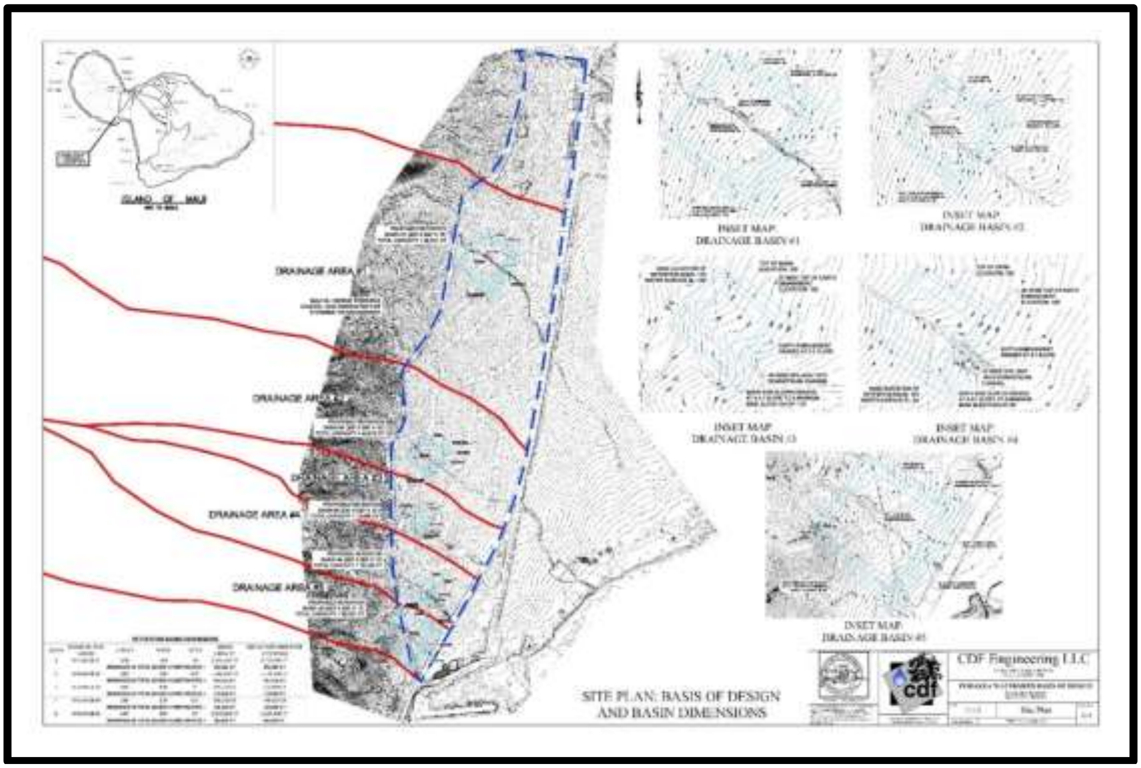


Table 19. Existing Runoff Volumes

Drainage Area #	Existing Runoff Volume in Cubic Feet	Existing Runoff Volume in Cubic Feet per Second
1	2,570,400	714.00
2	1,115,388	309.83
3	353,448	98.18
4	449,820	124.95
5	2,225,000	625.00

The post-development drainage pattern includes directing all surface runoff towards newly constructed retention basins. Additionally, the post-development drainage pattern includes the modifications of gulches with the installation of a series of retention basins designed to slow the discharge of stormwater into Māʻalaea Bay. The overflow from the proposed retention basin system is directed towards the Māʻalaea Harbor (Māʻalaea Triangle) commercial development to the east of the subject parcels. The proposed drainage system will prevent the runoff from adversely affecting the adjacent and downstream properties.

7.2.10.2 Stormwater Wells

The underlying geology in Pōhākea Watershed consists of layers of volcanic deposits; some containing rapidly cooled lava that is brittle and highly porous, while other deposits are denser as a result of having cooled more slowly. Dense layers do not allow water to rapidly percolate, while the less dense, porous layers promote surface water infiltration into the aquifer. This latter geology 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.

7.2.10.3 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 43. Stormwater Infiltration Well

7.2.10.4 Infiltration Trench or French Drain

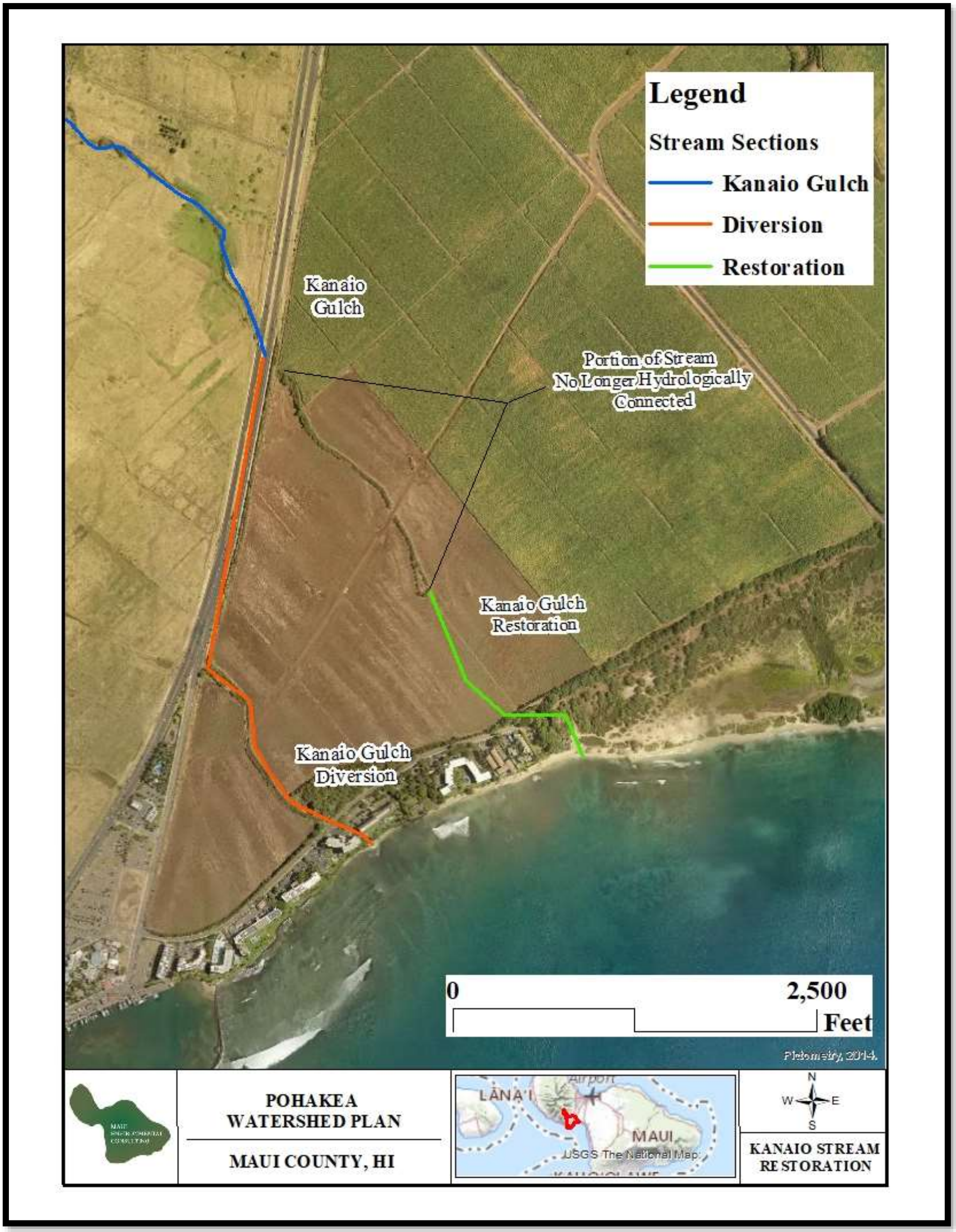
This structure is similar to a well except that it is configured as a long trench filled with gravel or a perforated pipe which spreads water over a larger area. Excess stream water could be directed into a trench, provided the water did not contain significant fine sediment particles which might eventually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

7.3 Commercial and Urban land

7.3.1 Stream Diversions

Kanaio Stream is currently diverted into the Waihe‘e Makai Ditch that runs parallel to the highway. Downstream from the highway, about 2,000 feet of the Kanaio Stream pathway is still visible winding its way through the fallow sugar cane field. Before it was diverted, this stream likely discharged into a wetland area in the vicinity of Haycraft Beach. This disconnected portion of Kanaio Stream would be a good candidate for stream channel restoration, and reestablishment of pre-alteration flow regimes. Hydromodifications are discussed in Chapter 5 Section 5 of the Hawai‘i 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 this essentially ‘dead reach’ would have the added benefit of reducing flow volumes currently directed into the previously mentioned detention basin that has failed in the past due to being overrun by stormwater.

Figure 44. Kanaio Stream Restoration



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 Kanaio Stream, the stream is already diverted, essentially eliminating this expense. This also could allow a longer-term phased approach to restoration activities conducted in the disconnected stream channel. The existing stream channel (makai of the highway) is approximately 2,000 feet in length, and from its terminus in the fallow sugar cane field, it is approximately another 1,500 feet to the wetlands associated with Keālia Pond (near to Haycraft Beach Park at the end of Hauʻoli Street.) Presumably, Kanaio Stream historically flowed into these wetlands, which likely extended beyond their present-day boundaries. Using the costs cited above, an estimate to restore the entire 3,500 feet would be $847,420. Costs have the potential to be substantially lower than this figure due to the fact that the Kanaio Stream channel still exists makai of the highway, the stream is ephemeral and rarely flows, and because there is one property owner throughout the restoration footprint.

7.3.2 Dirt Lots and Parking Lots

Dirt parking lots in the vicinity of the harbor should be targeted for improvement. At the very least, they should be improved with gravel, pervious pavers, or another suitable substrate. Ideally, they should be curbed, and all runoff directed into low impact design elements such as bioretention to capture and infiltrate stormwater. The paid parking across from Buzz's Wharf is too close to the ocean, and should be eliminated, and the compacted soil revegetated and restored.

7.3.3 Māʻalaea Triangle Parking Lot

Within the urban corridor of the Pōhākea Watershed, the parking lots that service the Māʻalaea Triangle represent approximately 276,000 square feet of impervious surface. This area is a potential source of stormwater runoff. Currently, stormwater entering storm drains receives no treatment before discharging directly into the harbour. Runoff from parking lots has the potential to contain sediment as well as petrochemicals, heavy metals, trash, and other pollutants associated with urban runoff. According to Chapter 5 Sections 3 and 4 of the Hawaiʻi Watershed Guidance report, parking lots are to include stormwater runoff management and pollution control measures and designs.

7.3.4 Cesspools at Māʻalaea Harbor and Residences along Māʻalaea Bay Place

Both within the harbor at Buzz's Wharf and at the small neighborhood of homes found at the southern end of the Harbor, individual on-site disposal systems such as cesspools or septic tanks are being used for wastewater. These systems are a known source of nutrient contamination to groundwater and the ocean. There is currently a small scale 'package plant' wastewater treatment system located at the corner of the Honoapiʻilani Highway and the southern harbor entrance/exit road. While the capacity of this treatment plant is unknown, its close proximity to these homes makes it ideal infrastructure to receive the waste streams from these homes. All the homes in this neighborhood fall within 1000 feet of the treatment plant. While a gravity fed wastewater collection system is likely not feasible in this site due to rocky terrain and the presence of a large gulch which would need to be crossed, a smaller scale E-1 or other low-pressure system could be utilized. The advantage of this system is that smaller diameter piping can be installed just 1 foot below the ground, and can be routed to follow the landscape's natural topography. In this case the highway right of way would be the logical path for the collection system. For information about the E-1 system, see; https://eone.com/sewer-systems/products/grinder-pumps

7.3.5 Condominium Injection Wells

Private injection wells associated with condominiums along Hauʻoli Street are a source of nutrient transport to the nearshore areas of Māʻalaea Bay. As in the case above, the presence of an existing treatment plant built to process the Māʻalaea Village's wastewater (Māʻalaea Triangle Wastewater Treatment Facility) (see Injection Wells section above) begs the question of the feasibility of connecting these condos to a central treatment system. Any updates or upgrades to existing infrastructure to reduce runoff pollutant loads in waters near urban or developed areas are supported in Chapter 5 Section 3 of the Hawaiʻi Watershed Guidance report.

In April 2022, the Maui County Council included $9.5 million in the Fiscal Year 2023 budget to construct a wastewater treatment facility for the Māʻalaea community. This money would come from the federal government and be funneled into the state revolving loan fund to pay for the project.

7.3.6 Car Washes and Condo Impervious Surfaces

The condominiums along Hauʻoli Street 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 Māʻalaea Condos is recommended to determine those sites best suited for LID retrofits. These projects could be developed and installed in collaboration with condo residents and Māʻalaea community groups.

7.3.7 Māʻalaea Harbor Boat Maintenance Facility

The small boat yard operation located near the boat ramp at Māʻalaea is a potential source for chemical pollutants. Marinas and boat yards are known sources for potentially harmful pollutants including heavy metals such as coper based ablative paints, solvents, and fiberglass residues associated with sanding and scraping of boat hulls. Proper design of hull maintenance areas is supported in Chapter 5 Section 4 of the Hawaiʻi Watershed Guidance report. Appropriate BMPs are essential at this facility due to its close proximity to the harbor.

7.3.8 Māʻalaea Harbor Oyster Colonies

As filter feeders, oysters are capable of pumping large volumes of water through their gills every day. This process removes nutrients like nitrogen and phosphorus from the water while improving water clarity, removing algae, and promoting other life in the harbor. MNMRC is currently conducting an oyster bioremediation project in the harbor.

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

The implementation projects proposed in this Plan are outlined below. They include excavated detention basins, stream rehabilitations, head cut stabilization with vegetation and/or geotextiles, unpaved road stabilization, LID infrastructure within the urban corridor, and Mā'alaea Village Association injection well closures. Below we discuss practices that are currently being implemented or 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.

In addition to modeling for current pollutant loads within the PWP, 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.

8.1 Excavated Basins

As mentioned in Section 7.2.10.1, the CDF Drainage Report contracted by MNMRC reviewed five drainageways within the Spencer Property portion of the Pōhākea Watershed. These drainages are associated with four named streams including Pōhākea, Kanaio, Mā'alaea, and Malalowaiaole, as well as several unnamed gulches and gullies. As part of this report, CDF proposed five detention basins with varying dimensions and capacities for capturing stormwater. Table 20 below depicts each of the five proposed detention basins and its relative capacity for capturing stormwater.

Table 20. Proposed Excavated Basin Dimensions and Capacities

Proposed Basin Capacities in Cubic Yards	Proposed Basin Capacities in Cubic Feet	Potential Stormwater able to be Captured in Liters
96,531.00	2,606,337.00	73,803,123.56
43,012.00	1,161,324.00	32,884,979.44
13,568.00	366,336.00	10,373,463.24
18,123.00	489,321.00	13,856,004.89
85,531.00	2,309,337.00	65,393,033.96

Using this information along with Total Suspended Solid (TSS) water quality data collected by the Maui Ocean Center (MOC) in October and December of 2017 and again during a third storm in February 2018, we were able to approximate and average TSS to be 0.005137 pounds per liter of stormwater. Given the above volumes of stormwater able to be captured by each of the five proposed detention basins and the average TSS concentration observed over three storm events, we were able to approximate the sediment pollution reduction that would occur from the installation of the proposed basins.

Table 21. Sediment Pollution Reduction Estimates based on CDF Proposed Basin Volumes and MOC Stormwater Sampling Data Collected in 2017 and 2018

Basin Number	Proposed Basin Capacities in Cubic Yards	Proposed Basin Capacities in Cubic Feet	Potential Stormwater able to be Captured in Liters	Pounds of Sediment able to be captured by each basin
1	96,531.00	2,606,337.00	73,803,123.56	379,109.76
2	43,012.00	1,161,324.00	32,884,979.44	168,922.61
3	13,568.00	366,336.00	10,373,463.24	53,286.11
4	18,123.00	489,321.00	13,856,004.89	71,175.13
5	85,531.00	2,309,337.00	65,393,033.96	335,909.05
Total Sediment in Pounds				1,008,402.66
Total Sediment in Tons				504.2

8.2 Head Cut Stabilization

In 2018, while canvassing the Pōhākea Watershed for sources of land-based pollution, MEC observed four locations exhibiting substantial loss of sediment along the upstream side of Honoapiʻilani Highway. At these locations stream flow is directed underneath the highway through box drains and culverts. The constriction point created by these culverts has led to extensive head cutting within the stream channel and loss of many tons of sediment material during times when the streams flow. Head cuts occur when stream force is directed downward due to a constriction of flow (in this case a road culvert), and creates a sheer bluff or cliff known as the knickpoint. The head cutting observed was 'active' in that more stream channel incision, loss of floodplain connectivity, and loss of sediment will continue at exponential rates as the knickpoints migrate further upstream each time the stream flows.

At the request of MNMRC, MEC installed simple erosion monitoring infrastructure at four previously identified stream locations where severe head cutting had been observed. The head cut monitoring infrastructure consisted of soil pin arrays made up of three 10-inch galvanized nails placed around the perimeter of each head cut. This monitoring infrastructure was intended to offer general approximations of soil loss at each monitoring station. At set time intervals and after heavy rainfall events from July 2020 to March 2021, soil loss was monitored and recorded to quantify the amount of sediment and other pollutants entering Māʻalaea Bay during stormwater events. The four monitoring stations were titled:

1. Historic Māʻalaea Gulch Head Cut Monitoring Station
2. Current Māʻalaea Gulch Head Cut Monitoring Station
3. Spencer Lands Head Cut Monitoring Station

4. State Lands Head Cut Monitoring Station

Two stormwater events in early 2021 contributed to significant erosion that washed away the monitoring pins at the knickpoints of the Historic Māʻalaea Gulch and Current Māʻalaea Gulch Head Cut Monitoring Stations. In total, an estimated 70,737.39 pounds of soil was lost. Some evidence of soil loss was documented at the other two sites, however, no further head cutting or sheet flow erosion was observed. Another cause for concern was rubbish associated with ongoing homeless encampments clogging the stormwater infrastructure that runs under Honoapiʻilani Highway.

Due to the substantial and ongoing losses of sediment observed at head cuts just mauka of the highway, head cut stabilization is a priority recommendation for preventing sediment loss within the Pōhākea Watershed. Head cut stabilization is accomplished by either 1) excavating the actively eroding knickpoint (cliff) and incised stream banks to substantially reduce the slope, or 2) by filling in the incised channel below the knickpoint, yielding the same result. Stabilization or stream reshaping must be engineered to accommodate long periods of no rain punctuated by heavy rainfall events. The photos below illustrate the head cut conditions at each of the four monitoring stations.

Assuming head cut stabilization methods proposed by CDF Engineering in Section 7.2.1 can be implemented to eliminate erosion during storm events, we can assume approximately 70,000 pounds of sediment would be eliminated from entering Māʻalaea Harbor and Māʻalaea Bay each year. These estimates are based on the head cut monitoring that occurred in 2021, when rainfall was just slightly above the five-year average.

Figure 45. Historic Māʻalaea Gulch Head Cut Monitoring Station – March 2021

Figure 46. Current Māʻalaea Gulch Head Cut Monitoring Station – March 2021

Figure 47. Spencer Lands Head Cut Monitoring Station – March 2021

Figure 48. State Lands Head Cut Monitoring Station – March 2021

8.3 Stream Rehabilitation – Kanaio Stream

Kanaio Gulch, which has been altered and no longer discharges into Keālia Pond or Māʻalaea Bay, is a good candidate for stream channel restoration. Peter Cannon of the Māʻalaea Village Association has been campaigning for this stream to be reconnected to what he calls the Māʻalaea mudflats. The portion of this stream mauka of the highway is now diverted into a concrete lined ditch that consolidates stormwater from four different gullies and gulches before passing through a detention basin and into Māʻalaea Bay.

To restore proper function to the coastal flood plain, Kanaio Gulch should be reconnected to its stream bed makai of the highway, and this portion of the stream should be reconnected to Keālia Pond and the ocean. Coupled with appropriate infiltration and detention BMPs, restoration of this stream would have the added benefit of reducing flow volumes and retain water instead of having it discharge into a basin that has historically become overwhelmed with stormwater.

If stream rehabilitation is to occur, it should be coupled with the creation of a detention basin. The location of this basin may be dependent on whether a detention basin is placed on the Spencer/Hope Builders, LLC and West Maui Construction, Inc. parcel mauka of Honoapiʻilani Highway. If that basin has not been implemented at the time of the Kanaio Gulch rehabilitation, it should be relocated to occur on Mahi Pono property makai of the highway.

Kanaio Gulch is within Drainage Basin 1 and according to the CDF drainage report, this basin has an existing runoff volume of 2,570,400 cubic feet. To offset this volume, the drainage report suggests the construction of a 550’x550’x10’ detention basin. With these dimensions, the basin will be able to capture approximately 2,606,337.00, which exceeds the runoff volume for the drainage basin. Using the stormwater sampling data collected by MOC in 2017 and 2018, we estimate a detention basin of these dimensions associated with Kanaio Gulch could capture approximately 379,109.76 pounds of sediment.

8.4 Unpaved Roads

The unpaved roads associated with the Pōhākea Watershed are often situated on extremely steep ridgelines. These include the MECO Road and the windfarm road. The Spencer Road (now Hope Builders, LLC and West Maui Construction, Inc.) lays at the inflection point between the steep ridges and valleys of Mauna Kahālāwai and the gently sloping agricultural lands associated with the coastal plains. These roads and others higher up in the watershed were mainly constructed to serve agricultural purposes. The MECO Road serves as a maintenance road as well as an escape route for windfarm personnel in the event of catastrophic fire.

Due to the steepness of these roads and the fact that they are not regularly maintained, they had become highly eroded, with deeply incised channels and rills throughout their lengths. Many of the kickout and water bars that were installed with the road were no longer functioning when the Pōhākea Stormwater Management Plan was written. With funding from the National Fish and Wildlife Fund, The Hawaiʻi Tourism Authority, and the Maui County Office of Economic Development, MNMRC worked Maui Environmental Consulting, LLC to record the baseline condition of the roads. Then, Goodfellows Bros. and Land Prep LLC were contracted to regrade the roads, making sure to reconnect kickouts and reshape water bars. MEC recorded baseline and post-grading conditions. Results of these efforts can be found in two reports: Pre and Post GI Mapping Reports.

To approximate the sediment reduction accomplished by the grading of these roads, MEC worked with Jason Hew at NRCS employing the RUSLE2 program. Several data points were entered into the program, including rainfall of 15-16 inches, a soil type of rRK Rock Land/Rock Land Silty Clay Loam 55%, and a slope length of 500 feet. We assumed an average slope steepness of 18% based on contours and map measurements. Without any BMPs, soil loss was estimated to be 31.6 tons per acre of road. Approximately 11.37-acres of road were regraded during these efforts, resulting in approximately 359.3 tons of potential sediment loss prior to the grading effort. After BMPs were entered into the program to account for the grading work that MNMRC contracted, RUSLE2 estimated soil loss to be lowered to 12.6 tons per acre, resulting in approximately 143.3 tons of potential sediment loss – a reduction of 216 tons of sediment.

8.5 Low Impact Design (LID)

MEC reviewed water quality parameters of concern and water quality impairments associated with the urban corridor of the Pōhākea watershed. In addition to this desktop exercise, MEC staff utilized professional surveying equipment to record the locations of landscaping planters, curbs, storm drains, and impermeable surfaces.

To better understand the pollutants of concern, MEC held an initial stakeholder meeting on October 29th, 2021 with Amy Hodges from MNMRC, Tapani Vuori from the Maui Ocean Center, Robin Knox from Save the Wetlands Hui, Travis Liggett of Reef Power, Shelby Serra of the Pacific Whale Foundation, and Robert Vafaie of the Māʻalaea Harbor Shops. The group identified pollutants associated with cars, namely oil and grease and toxic metals such as cadmium, as being major pollutants of concern. Solid waste was also discussed with an emphasis placed on vegetative debris contributing to nutrient loading within the harbor. Additional topics related to solid waste included wind pickup and dispersion, the prevalence of COVID-19 masks and other loose items in vehicles as additional sources or rubbish. Lastly, stormwater was discussed as a general pollutant of concern in that it currently leaves the parking lot through storm drains and enters Māʻalaea Harbor, potentially transferring sediment, rubbish, and other pollutants from the parking lot.

To determine the volume of stormwater generated at the Māʻalaea Triangle, MEC used one inch of rain as a baseline in calculations. Using ArcGIS, impermeable surface withing the parking lot was determined to be approximately 276,211 square feet. One inch of rain was converted to feet and multiplied by the impermeable surface area to generate the volume of this area in cubic feet. There are 7.48 gallons of water contained in one cubic foot, resulting in a total of 171,482.74 gallons of stormwater being generated from one inch of rain within the parking lot.

Table 22. Approximate Stormwater Generated from 1" of Rainfall

Stormwater Generated from One Inch of Rainfall	
Impermeable Surface in Square Feet	276,211.00
One Inch of Rain Converted to Feet	0.08
Volume in Cubic Feet	22,925.50
7.48 Gallons of Water per Cubic Foot	7.48
Total Gallons of Stormwater from 1 Inch of Rainfall	171,482.74

Knowing the current conditions within the Project, as well as the approximate amount of stormwater generated from one inch of rain, the stakeholder group was able to identify performance standards for the Māʻalaea Triangle parking lot. The main performance standard was to capture all stormwater onsite before it discharges into storm drains leading to the harbor. Other performance standards included capturing oil, grease, and metals that may be generated by the parking lot, minimizing use of irrigation water, utilizing native plants in landscaping, reducing solid waste pollution, and educating the public on the importance of stormwater, and pollution reduction measures.

Specific BMPs of interest to achieve these performance standards included permeable pavement, curb cuts, bioswales, landscaping with drought tolerant native plants, and speed bumps doubling as water bars to slow and redirect stormwater. Because of the existing landscaping planters already distributed throughout the parking lot, it was determined that converting these areas to bioswales was a high value candidate project. Bioswales are a constructed depression planted with native vegetation that allows stormwater from impermeable surfaces such as roofs, driveways, and parking lots to collect, briefly store and then infiltrate into the groundwater.

Using ArcGIS, it was determined that approximately 1.62 acres of permeable surface exists within the Project. Unfortunately, due to topography, much of this area is located on the uphill portion of the parking lot and will not perform well as a bioswale location. Removing any permeable surfaces where stormwater cannot easily be diverted using gravity or speed bumps repurposed as water bars, approximately 40,715 square feet of permeable surface remains for potential conversion to bioswales.

For bioretention, storage is allocated to ponded water on the surface, water stored within the pores of soil/compost media, and water stored within the voids of coral stone and/or gravel layers. The following formula was used to determine the approximate volume of stormwater captured by 40,715 square feet of bioretention (Horsley Witten, 2014).

Pv = Vsp + Vs + Vg

Where;

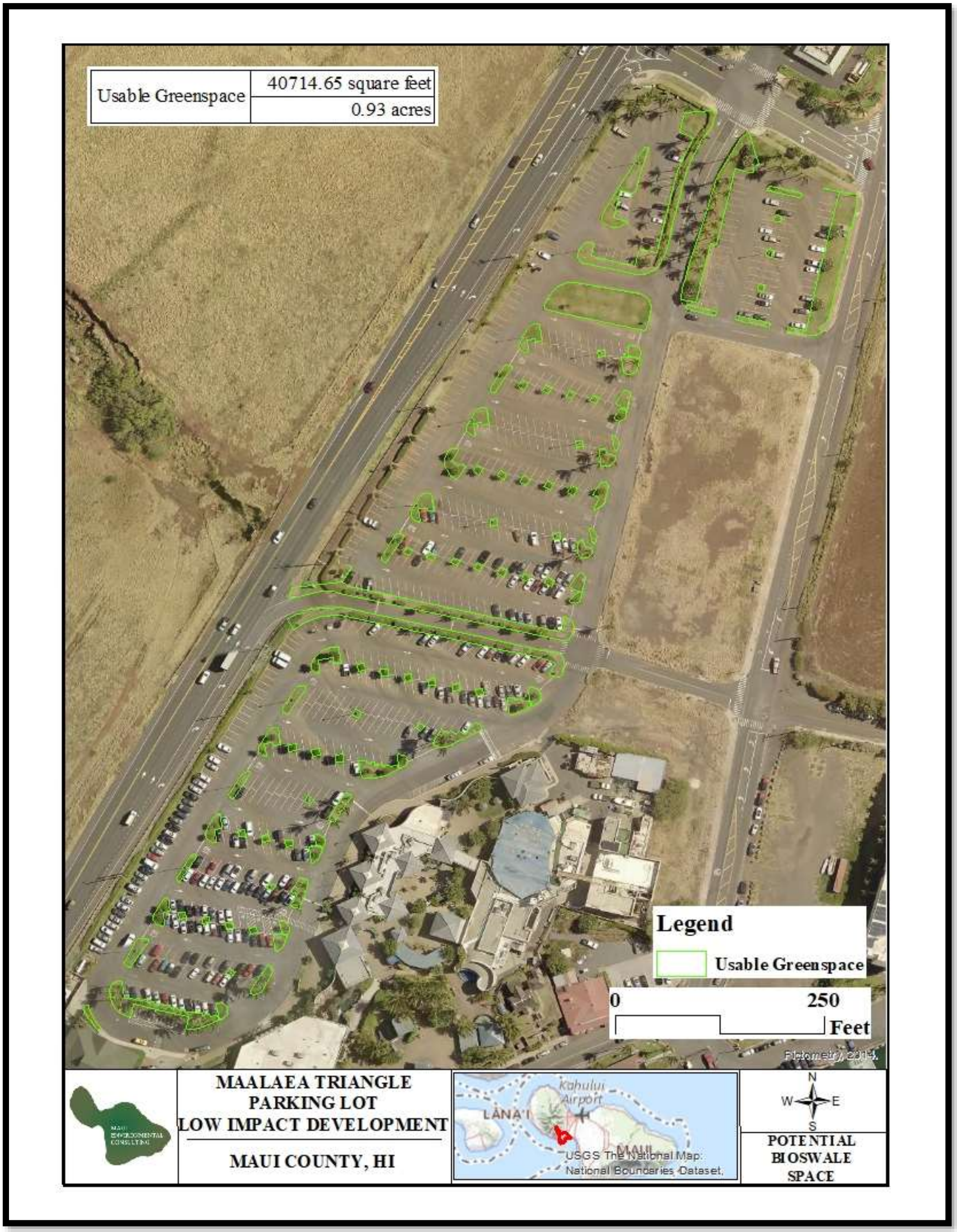
Pv = Volume of stormwater captured
Vsp = Surface ponding volume (we assumed one foot) x 1.0
Vs = Storage volume of soil/compost x 0.25
Vg = Storage volume of gravel and/or stone/coral layer x 0.40

Using this formula, approximately 354,668 gallons of stormwater can be captured if the available planters and greenways associated with the Māʻalaea Triangle parking lot are converted to bioswales.

Table 23. Total Stormwater Volume Captured by Conversion of Planters to Bioswales

Vsp	
Bioswale Surface in Square Feet	40,714.65
One foot of surface ponding	1.00
Volume in Cubic Feet	40,714.65
Vs	
1.5 Inches of soil/compost	0.125
Volume in Cubic Feet	5,089.33
Multiply by 0.25	1,272.33
Vg	
4 inches of soil media barrier (sand and stone)	0.33
Volume in Cubic Feet	13,571.55
Multiply by 0.4	5,428.62
Pv	47,415.60
7.48 gallons per cubic foot	
Stormwater captured in gallons	354,668.71

Figure 49. Potential Bioswale Locations



Comparing this volume with the stormwater generated from the February 2017 event, it becomes clear that this LID infrastructure alone would be able to completely capture approximately two inches of rainfall occurring during a storm event without any of this water leaving the parking lot and being discharged through storm drains into Māʻalaea Harbor. To put this in perspective, a review of the period-of-record data (1916-Present) reveals that of the 21,145 days where rainfall data was recorded, only 123 days had rainfall amounts above two inches. This equates to rainfall at the Waikapu 390 rainfall gauge being under two inches 99.42 percent of the time since August of 1916. Essentially, transitioning the available planters to bioswales would capture and retain stormwater onsite for all but the largest storm events (all but 0.58 percent of all recorded storm events) occurring at the Māʻalaea Triangle parking lot.

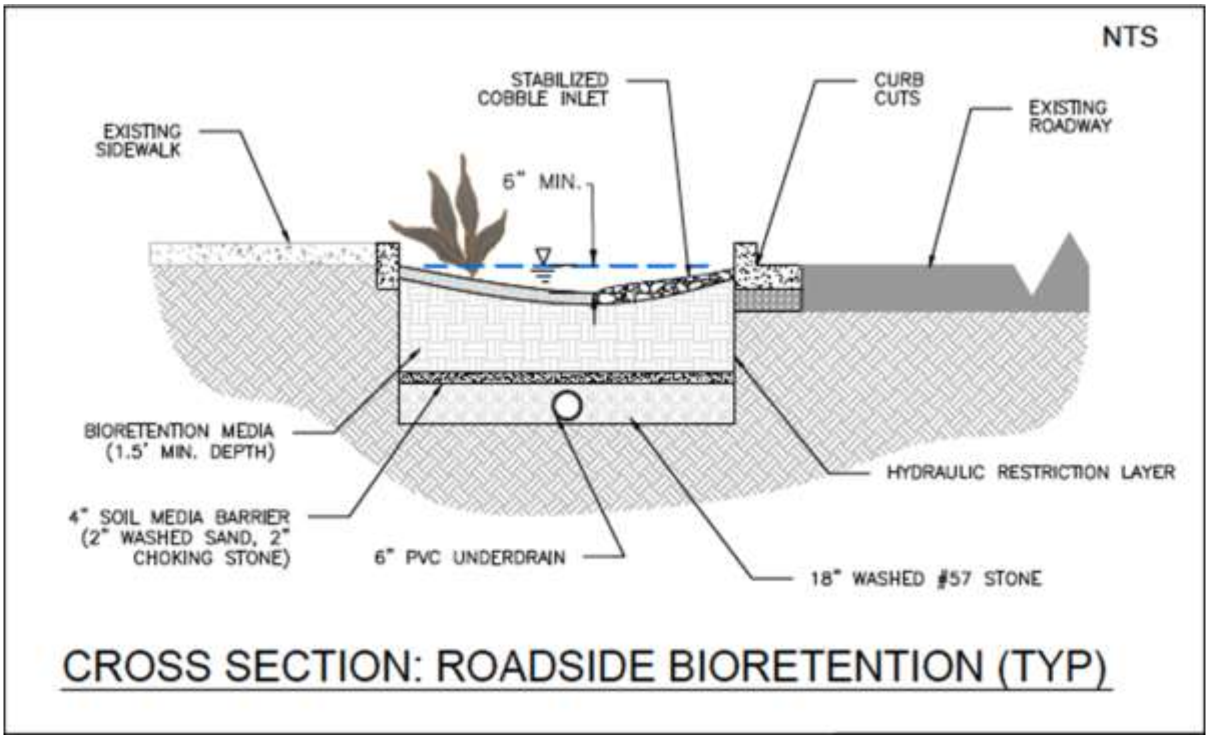
These bioswales would also provide an opportunity to plant drought tolerant dryland native forest plants. These plants, coupled with the LID green infrastructure, would provide an educational experience for visitors to the Māʻalaea Triangle. Additionally, these plants require less irrigation than traditional landscaping and may provide a cost savings opportunity. Currently, irrigation costs are low although there have been documented leaks that caused irrigation costs to rise significantly. From November of 2020 to October of 2021, the total water bill for the Project was $556.80. Unfortunately, $227 of this cost came from the month of August 2021, when damage to the irrigation system occurred. Typically, monthly water bills would be approximately $30. With native draught tolerant plant species placed in bioswales, irrigation costs could potentially be eliminated entirely.

Table 24 List of Drought Tolerant Plants with Costs

Hawaiian Name	Scientific Name	Cost
ʻAʻaliʻi	*Dodonaea viscosa*	$ 2.75
ʻIlima	*Sida fallax*	$ 3.00
Wiliwili	*Erythrina sandwicensis*	$ 4.00
ʻOhe makai	*Polyscias sandwicensis*	$ 3.25
Naio	*Myoporum sandwicense*	$ 3.50
Alaheʻe	*Psydrax odorata*	$ 4.00
Koaiʻa	*Acacia koaia*	$ 3.25
Chaff flower	*achyranthes splendes var. splendens*	$ 2.25
ʻĀweoweo	*Chenopodium oahuensis*	$ 2.85
Āwikiwiki	*Canavalia pubescens*	$ 3.50
Maʻo hau hele	*Hibiscus brackenridgei*	$ 3.25

Bioswales also offer the opportunity to utilize biochar. Biochar is black carbon produced from organic biomass by way of pyrolysis. This process involves the devolatilization of organic material, leaving the carbon char behind. This char can capture pollutants such as heavy metals and can provide a substrate for nitrogen fixing bacteria and other beneficial microbes. Biochar also plays an important role in carbon sequestration. In the following diagram, biochar could be used as an amendment to the bioretention media displayed.

Figure 50. Cross Section of a Bioswale



8.6 Injection Well Upgrade or Closure

As mentioned earlier, In April 2022, the Maui County Council included $9.5 million in the Fiscal Year 2023 budget to construct a wastewater treatment facility for the Māʻalaea community. While it is difficult to model individual pollutant load reductions from connecting the ten condominiums to a treatment facility, we did obtain approximate discharge volumes for the injection wells in operation from a 2018 Kihei Community Association presentation.

Table 25. Māʻalaea Condos Wastewater Effluent Volumes in Gallons per Day

Condominium Name	Wastewater Effluent in Gallons per Day
Milowai Condominium Resort	8,500
Māʻalaea Kai Condominiums	7,000
Lauloa Condominium Resort	5,791
Māʻalaea Banyans Condominiums	7,369
Kanai A Nalu Condominium	18,190
Makani A Kai Condominiums	7,457
Hono Kai Resort	7,500
Maui Island Sands Resort	13,000
Māʻalaea Mermaid Condominiums	3,239
Māʻalaea Yacht Marina Condominiums	7,882

The poor water quality and resulting coral reef degradation within Mā'alaea Bay has been well documented. By eliminating approximately 86,000 gallons of wastewater effluent from entering the bay every day, this project may provide the largest nonpoint-source improvement to the health of these coastal waters of any project listed in this report.

8.7 Existing Management Practices

8.7.1 Oyster Bioremediation

As part of its "Vision for Pōhākea", which includes many ongoing water quality projects, MNMRC has been deploying cages of sterile oysters to help clean Mā'alaea Harbor. They have placed as many as ten thousand oysters in the harbor and continue to replace them as they complete their life cycle. Currently, there are approximately five thousand oysters in the harbor, with three thousand added at the end of September 2022.

According to their website (www.mauireefs.org), these oysters can filter up to 50 gallons of water per day. By doing so, the collect suspended solids and nutrients. These pollutants are either metabolized and help the oyster to grow or they are encapsulated and drop to the sea floor where they can no longer cause harm.

To estimate pollutant load reductions from the oyster filtering pilot project, we first approximated the volume of the harbor and compared it to the filtering capabilities of five thousand oysters. The average depth of the harbor fluctuates as sand and silt build up. We estimate the average depth of the harbor to be approximately 10 feet deep. Using ArcGIS, we measured the area of the harbor to be 667,437 square feet. Multiplying these two numbers, we came up with an approximate harbor volume of 6,674,370 cubic feet. There are 7.48 gallons in a cubic foot, meaning Mā'alaea Harbor has a volume of approximately 49,924,287 gallons. Assuming each of the 5,000 oysters is filtering 50 gallons per day, they are capable of filtering the entire harbor in roughly 200 days.

8.7.2 Water Quality

MNMRC has been collecting water quality data at three sites within the harbor and two sites outside the break wall in Mā'alaea Bay (See map on page 57). These sites aid in assessing the efficacy of projects being implemented throughout the Pōhākea Watershed.

8.7.3 Vetiver Planting

MNMRC in collaboration with Sunshine Vetiver has planted approximately 2,000 vetiver slips at seven sites that exhibit erosion rills and gullies after small storm events. These plants are watered regularly in the hopes that they will anchor soils in place and prevent erosion during storm events.

8.7.4 Feral Ungulate Control

The Department of Land and Natural Resources Division of Forestry and Wildlife has been culling hundreds of deer in the upper portions of the watershed. By controlling deer populations, DOFAW is ensuring these animals do not continue to denude the landscape and exacerbate erosion. Six hundred deer were culled in 2022 via aerial shooting from helicopters.

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), which is makai of Pi‘ilani Highway within the urban corridor, 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.

Table 26. Potential Permits needed for Excavated Basins and Head Cut Repair

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	Required for any work being conducted in the Special Management Area	Application will require plots/drawings of work being conducted	Any use, activity, or operation qualifying as "development", and has a total cost fair market value of $500,000 or more; or has significant adverse environmental or ecological effect within the Special Management Area.

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 Hawai‘i 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 Hawai‘i Department of Health	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, Hawai‘i 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 Hawai‘i Water Quality Standards compliance plan	Applies to locations requiring Department of Army Permit
Conservation District Use Application (CDUA)	State of Hawai‘i, Department of Land and Natural Resources	Any development actions in Conservation Districts as designated by the State Land Use Commission	Application will require a Hawai‘i Chapter 343 EA/EIS	Pipeline or reservoir installation in the Conservation District
National Pollution Discharge Elimination System (NPDES) Permit	Clean Water Branch, Hawai‘i 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

Permit Name	Issuer	Trigger	Application Requirements	Project Improvements
Use and Occupancy Permit/Construction within a State Highway Permit	Division of Highways, State of Hawai‘i, 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

9.2 Implementation Project Cost Estimates

In addition to modeling pollutant load reductions from the various implementation projects outlined in this watershed plan, we have prepared project cost estimates to facilitate stakeholders in obtaining financial assistance and in the decision-making process. These 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, their location in the watershed, community support, etc. While we attempted to formulate these costs using the best information available, many of these cost estimates may not be accurate and are meant as estimates and stakeholders should always budget for projects using quotes and information obtained at the time of implementation.

9.2.1 Excavated Detention Basins:

Maui Nui Marine Resource Council received a quote for 4.28 million from Goodfellow Bros. to install the five detention basins discussed in Section 8.1. This quote was provided in December 2021.

9.2.2 Head Cut Repair

For illustrative purposes, the budget for a head cut repair project is outlined below.

Table 27. Approximate Budget for Head Cut Stabilization

Head Cut Stabilization Budget	
Task Description	Cost ($)
Site Topographic Survey and Preliminary Design	12,700
75% Engineering Design Plans	13,500
Permitting	25,000
Construction Plans	13,800
Construction Administration	13,650
Construction Oversite	42,350
Construction:	
Mobilization	13,700
Site Clearing and Grubbing	15,000
Excavation and Hauling	38,000
Fine Grading and Compaction	20,200
3/4-inch Stone	4,000
12-inch Stone	5,500
Boulders	28,850
Fencing and Gate	6,750
Erosion Control	5,000
Landscaping	12,000
Watering and Plant Replacement	3,000
Total Implementation Cost	$260,300

Head Cut Stabilization Budget	
Task Description	Cost ($)
Total Project Cost	$273,000

Due to the relatively high expense associated with head cut stabilization, and therefore the unlikelihood that these problems will be addressed in a short time frame, MEC recommends continued monitoring at known head cut locations so that soil loss can be quantified and documented. Monitoring of continued head cutting can be accomplished by inserting rebar vertically into the soil at the current extent (bank width and reach) of the head cutting and then in standardized increments moving up the stream channel. In this manner, after stormwater events, soil loss could be quantified based on how much soil has been lost in between rebar posts.

9.2.3 Unpaved Roads

Goodfellow Bros. and Land Prep LLC repaired unpaved roads for approximately $225,000. This included approximately 4.6 miles of roadway, 60 feet wide. This amount to just under $50,000 per mile of road repair.

Table 28 below provides a sample budget for decommissioning roads based on similar projects in West Maui. Note that this sample budget is for the decommission of 1,000 feet of roadway with the use of vetiver and native plants and assumes an average of one vetiver row per 100 feet. In addition, it assumes volunteers will be used for digging and planting, that no ungulate fencing will be installed and that site access via 4x4 truck is available.

Table 28. Sample Budget for Decommissioning Dirt Roads Using Vegetation

Item	**Cost $**
Installation Supplies:	
Plants, equipment, and irrigation supplies	7,500
Surveying and site prep	2,000
Transportation and fuel	1,200
Total:	10,700
Maintenance:	
Initial watering and establishment (first 2 months)	3,200
Adaptive management/maintenance	800
Total:	4,000
Monitoring:	
Supplies (tape measures, erosion posts)	500
Soil lab tests	500

Monitoring transportation and fuel	2400
Total:	3,400
Staff:	
Project management; volunteer coordination, and outreach	8,000
Technical/design consulting	4,000
Monitoring overall effectiveness	2,400
Total:	14,400
Contingency costs (15%)	4,875
Project TOTAL	**$37,375**

9.2.4 Low Impact Design

Costs vary widely for the various Low Impact Design BMPs. For new construction, many of these costs can be included in the overall design and buildout of the project. We have provided costs for retrofitting the existing landscaping greenspace within the parking lot at Māʻalaea Triangle to bioswales.

Table 29. Māʻalaea Triangle Parking Lot Low Impact Design Implementation Cost Estimates

Task	Cost
Surveying	$10,100.00
Construction Documents	$23,800.00
Bidding	$1,500.00
Construction Administration	$3,000.00
Construction	$50,000.00
Total Cost	$88,400.00

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 Pōhākea Watershed Plan, Hawai'i 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 make their way into our streams and coastal waters and harm our 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 SWCD intends to establish and maintain a Watershed Coordinator position to direct, organize, and coordinate efforts related to the Pōhākea Watershed Plan. This individual will be the primary contact between the conservation district, the community, government entities, and other organizations involved in improving water quality within the watershed. They will be responsible for spearheading all 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. All the implementation projects outlined in the PWP 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 organization's data portals will be made available on the www.mauiwatershed.org website.

Stakeholders who implement projects proposed in this watershed Plan will want their efforts to address pollution known to the public. In addition, many individuals will seek out volunteer opportunities to participate in efforts that benefit the community. Public awareness can be expected to improve and/or support water quality and coral reef health.

Informing the public will also assist in enforcement of laws and reporting of activities that cause pollution. The community can also provide technical assistance to solve pollution problems within the watershed.

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:

- SWCD 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 advertised on the www.mauiwatershed.org website operated by the SWCD, as well as on social media. Individual stakeholders are encouraged to promote their contributions to watershed management measures on platforms that best serve them. MNMRC currently has many projects within the PWP and these are advertised on their website. 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. Such marketing events will 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.

The 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 30 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 30. Pōhākea Education and Outreach with Costs

Pōhākea Watershed 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
Maintain Central Maui Soil and Water Conservation District administrative staff (Millie Wagner) 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 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							$70,000

11.0 ELEMENT F - IMPLEMENTATION SCHEDULE

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 schedule for the Pōhākea Watershed Plan, This comparison assisted in identifying which projects should be given priority status. Project costs and complexity were also considered when assigning priority status.

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.

Table 31. Implementation Project Priority Status and Approximate Timeline

Implementation Project	Location (Gulch)	Description	Approximate Timeline to Completion	Organization(s) Responsible for Implementation	Priority
Excavated Basins	Pōhākea, Kanaio, Māʻalaea, Malalowaiaole, and other unnamed gulches	Install detention basins to capture stormwater.	6 months – 2 years	Hope Builders, LLC, West Maui Construction, Maui County	High
Head Cut Stabilization	Historic Māʻalaea Gulch, Current Māʻalaea Gulch, Spencer Lands, State Lands	Excavate knickpoints and incised banks to decrease slope and reduce stream flow	2 years	Hope Builders, LLC and West Maui Construction, Inc., State of Hawaiʻi,	High

Implementation Project	Location (Gulch)	Description	Approximate Timeline to Completion	Organization(s) Responsible for Implementation	Priority
Stream Rehabilitation	Kanaio Gulch	Connect Kanaio Gulch to its original streambed makai of P‘ilani highway to reduce flow volumes and retain water	2 years	Mahi Pono, Mā‘alaea Village Association, State of Hawaii	Medium
Unpaved Roads	Throughout watershed	Decomission, repair, and stabilize roads to prevent erosion	1-4 Years (Ongoing)	Maui Nui Marine Resource Council, MECO, Hope Builders, LLC/West Maui Construction, State of Hawaii	Medium (Ongoing)
Low Impact Design	Mā‘alaea Triangle Parking Lot	Bioswales, permeable pavement, and other BMP's to reduce stormwater runoff from impermeable parking lot surfaces	6 months per project	Maui Ocean Center, stakeholders within Mā‘alaea Triangle	Low
Injection Well Upgrades	Mā‘alaea condominiums, homeowners, and businesses	Connect condomium injection wells and cesspools to wastewater treatment facility	2-10 years	Mā‘alaea Village Association, Maui County	High
Education and Outreach	Throughout Watershed	Conducted by Watershed Coordinator, ensures informed community participation	Ongoing	Central Maui Soil and Water Conservation District, Maui Nui Marine Resource Council, Maui Ocean Center	Medium

12.0 ELEMENT G – INTERIM MILESTONES

The following section provides interim milestones for the various implementation projects proposed in the watershed 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 32 summarizes the information presented in this section.

12.1 Excavated Basins

The basins described in this Plan have been given high 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.

Five basins have been proposed in a drainage report prepeared by CDF Engineering. The total estimated cost for retenetion basin installation is $4.28 million. 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.

12.2 Head Cut Stabilization

Due to the substantial and ongoing loss of sediment mauka of Honoapiʻilani highway, head cut stabilization has been given high priority status. Each storm event that occurs within Pōhākea watershed will likely contribute to further retreat of knickpoints and sediment-laden stormwater runoff. Slope stabilazation repairs are recommended to occur as soon as possible within the next five years. Continued monitoring and mainteance should span the duration of this Plan.

12.3 Stream Rehabilitation

The re-connection of Kanaio Gulch to its orignal, natural streambed makai of Honoapiʻilani Highway has been given a medium priority status. The ephemeral nature and easy access of the stream, and single land-owner through which it passes, streamlines the feasibility of rehabilitation. For that reason, thes project could be designed and executed in the first five years of this Plan.

12.4 Unpaved Roads

Decomissioning, repair, and stabilization of unpaved roads are of medium priority in this Plan. A comprehensive assessment and inventory has been mapped, and work could begin immediately. To decomission and repair one road annually would mean that all roads within the Project area would be completed by 2035.

12.5 Low Impact Design

Low impact design of the Māʻalaea Triangle Parking lot has been given low priorty status. Several BMPs have been proposed in the LID report described above in section 8.5 above. To span the twenty-year timeline of this Plan, projects are divided up to be implemented in five-year increments beginning with the greatest impact to water quality.

12.6 Injection Well Upgrades

Connection of injection wells to a water treatment facility has been given high priority status. $9.5 million have been included in the Fiscal Year 2023 budget for the construction of a waste water treatment facility for the Māʻalaea community. Education regarding the logistics and responsibility for owners of injection wells to decommission, clean up, and connect to the new facility should be made available.

12.7 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, grazing managemnt, and the various implementation projects either ongoing or proposed for the watershed.

Table 32. Interim Milestones

Implementation Project	Location (Gulch)	Description	Priority	Twenty Year Timeline			
				2027	2032	2037	2042
Excavated Basins	Pōhākea, Kanaio, Mā'alaea, Malalowaiaole, and other unnamed gulches	Install detention basins to capture stormwater.	High	1st basin completed	2nd basin completed	3rd basin completed	4th basin completed
Head Cut Stabilization	Historic Mā'alaea Gulch, Current Mā'alaea Gulch, Spencer Lands, State Lands	Excavate knickpoints and incised banks to decrease slope and reduce stream flow	High	Repair all head cuts	Continued monitoring and maintenance	Continued monitoring and maintenance	Continued monitoring and maintenance
Stream Rehabilitation	Kanaio Gulch	Re-connect Kanaio gulch to its streambed makai of Honoapi'ilani highway	Medium	Connect streambeds	Place detention basin in line with stream to catch stormwater sediment	Rehabilitate Kanaio riparian corridor	Reestablish "Mā'alaea Mud Flats" and connect to Kealia Pond
Unpaved Roads	Throughout watershed	Decomission, repair, and stabilize roads to prevent erosion	Medium	Continued maintenance	Continued maintenance	Continued maintenance	Continued maintenance
Low Impact Design	Mā'alaea Triangle Parking Lot	Bioswales, permeable pavement, and other BMP's to reduce stormwater runoff from impermeable parking lot surfaces	Low	Retrofit existing planters with biswales and green infrastructure	Install permeable pavers and water bars	Install storm drain filters and plant vegetative windbreaks	Install inofrmative signs

Implementation Project	Location (Gulch)	Description	Priority	Twenty Year Timeline			
				2027	2032	2037	2042
Injection Well Upgrades	Mā'alaea condominiums, homeowners, and businesses	Connect condomium injection wells and cesspools to wastewater treatment facility	High	Ideally a fully functioning package plant at Mā'alaea	If not, then connect to the Central Maui Wastewater Treatment Facility	Maintenance	Maintenance
Education and Outreach	Throughout watershed	Watershed coordinator to	Medium	Quarterly events per year = 20 events by 2027	40 events by 2032	60 events by 2037	80 events by 2042

12.8 Existing Management Practices

Since the production of the Pōhākea Stormwater Management plan in 2018, several management practices have been employed and are ongoing. Maui Nui Marine Resource Council has played an integral role in many of these efforts as they work to improve the water quality of Pōhākea watershed. Those practices are described below.

12.8.1 Māʻalaea Harbor Oyster Bioremediation

Oysters feed by pumping and filtering large volumes of sea water through their bodies. In doing so sediment and pollutants are removed from the water column. They have the capacity to filter approximately 50 gallons of water each day. In an effort to improve the water quality with in Māʻalaea Harbor, MNMRC began an oyster bioremediation pilot project in 2020. Several thousand Pacific oysers (*Crassostrea* gigas) were initally deployed in cages throughout the harbor. Several months into the project, native Hawaiian oysters (*Dendostrea sandvicensis*) have since voluntarily appeared and have been incorporated into the project. Cages are cleaned and monitored every two weeks. Continued success and expansion of this project is supported.

12.8.2 Water Quality Monitoring

Increased water quality monitoring was recommended as a high priority in the Pōhākea Stormwater Management Plan. In the 2020 and 2022 Integrated Water Quality Reports the DOH CWB included sampling from two additional locations than in previous years. Maui Nui Marine Resource Council also provided water quality data from five additional sites beginning in 2019. A Water Quality Monitoring Plan has since been proposed and is described in Section 14.1. Marine surface waters, stormwater, and subsurface groundwater should all be monitored to better assess pollutant sources and the success of management measures as they are employed.

12.8.3 Vetiver Planting

The steep slopes, miles of unmaintained roadways, and flash flood nature of Pōhākea watershed create many areas with high erosion potential. Planting vegetative barriers of vetiver or other suitable plants to lock in soils were recommended in the Pōhākea Stormwater Management Plan. In an effort to prevent erosion, Maui Nui Marine Resource Council has planted veitver grass at strategically selected sites within the watershed. Vetiver is a deep rooted, non-invasive clump grass, and its purpose is to stabilize hillsides, catpure sediment, and promote infiltration of stormwater sheet flow into the ground. Further vegetative restoration with vetiver or native plants, and the associated watering, monitoring and maintenance is supported.

12.8.4 Feral Ungulate Control

The infiltration of feral ungulates pose a great threat Pōhākea watershed. Problems associated with these animals, in particular axis deer, include depletion of native forests, land and habitat degredation, topsoil exposure and loss, and the spread of invasive species. DOFAW has aerially removed several thousand axis deer from upper elevations of the watershed. Six hundred were removed in 2022. Feral ungulate management remains a priority BMP in protecting native forests and improving water quality within the watershed.

12.8.5 Fire Breaks

Unused and unmaintained roads that were once used for agricultural purposes were graded to provide fire breaks throughout Pōhākea watershed. Maui Nui Marine Resource Council, with funding from the National Fish and Wildlife Foundation, contracted Goodfellow Bros. to grade and clear vegetation along roadways throughout the watershed to supress wildfires within the project area. Fire-resistant vegetation was also planted along the newly graded corridors to reinforce these fuel breaks and to prevent sediment-laden runoff into the ocean. Continued maintenance of firebreaks is recommended to reduce impacts of wildfires.

13.0 ELEMENT H - INTERIM NUMERIC CRITERIA

13.1 Interim Numeric Criteria

The lack of surface water in Pōhākea watershed 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 33). To develop these criteria, Hui O Ka Wai Ola's entire period of record data from three sites within Pōhākea watershed were analyzed. The geometric mean was calculated for measurements of turbidity, total nitrogen, total phosphorus, nitrate + nitrite, and ammonia. Geometric means were compared with the listed 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 standard were divided into thirds to create interim numeric criteria to be attained over the next 18 years. In other words, 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.

As an example, the period of record geometric mean for total nitrogen at Māʻalaea Condos is 251.04 µg/L. The Dry criteria for total nitrogen in an embayment is 150.00 µg/L. This means that currently, Māʻalaea Condos is 101.04 µg/L above the standard. To generate interim numeric criteria, we divided 101.04 µg/L by three to generate a six-year target reduction value of 33.68 µg/L. Therefore, beginning in 2022 and running through 2028, the geometric mean for this period needs to decrease by 33.68 µg/L to a value of 67.36

13.3 Review Process

Data will be reviewed annually by the watershed coordinator, the Hui O Ka Wai Ola staff, and by DOH CWB staff. 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. In addition, the DOH CWB will play an active role in determining the overall success of the watershed plan by their preparation of biannual IR Reports, water quality data provided to them by the Hui O Ka Wai Ola, and from input from the community.

Table 33. Interim Numeric Criteria for Pōhākea 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:				
				0.40	150.00	20.00	5.00	3.50
Māʻalaea Harbor	8/15/2019 to 2/17/2022	41	2022	0.93	21.83	Meeting Standard	55.78	6.12
			2028 IR Report	0.62	14.55	NA	37.19	4.08
			2034 IR Report	0.31	7.27	NA	18.60	2.04
			2040 IR Report	0.00	0.00	NA	0.00	0.00
Māʻalaea Condos	8/15/2019 to 2/17/2022	41	2022	2.52	101.04	Meeting Standard	149.47	2.24
			2028 IR Report	1.68	67.36	NA	99.65	1.50
			2034 IR Report	0.84	33.68	NA	48.83	0.76
			2040 IR Report	0.00	0.00	NA	0.00	0.00
Haycraft Park	8/15/2019 to 2/17/2022	41	2022	3.92	4.13	Meeting Standard	55.56	Meeting Standard
			2028 IR Report	2.61	2.75	NA	37.04	NA
			2034 IR Report	1.30	1.37	NA	18.52	NA
			2040 IR Report	0.00	0.00	NA	0.00	NA

14.0 ELEMENT I – MONITORING PROGRAM FOR EVALUATING IMPLEMENTATION PROJECT SUCCESS

The current water quality monitoring program within the Pōhākea watershed presents numerous data gaps. Currently, the DOH CWB lists five water quality monitoring sites. Of these five sites, Māʻalaea Beach is the only site to have attainment statuses listed for each parameter. All other locations are lacking in sampling duration or frequency for attainment statuses to be determined for one or more parameters. Due to the small datasets from those sites, evaluations have not been made regarding attainment statuses for each parameter in the 2020 and 2022 State of Hawaiʻi Integrated Water Quality Reports. Another flaw 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 method 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. A Water Quality Monitoring Plan has been developed and is described below.

14.1 Pōhākea Water Quality Monitoring Plan Methodology

To fully capture pollution loads and stormwater runoff within Pōhākea watershed, marine surface waters, stormwater, and subsurface groundwater within Pōhākea Watershed should be monitored at various locations listed in the map below (Pōhākea Proposed Water Quality Monitoring Map). Each site was selected specifically to represent samples from locations within the watershed that likely influence nearshore coastal water quality. Surface samples and groundwater samples should be collected from various locations monthly, and again from 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 in the watershed.

14.1.1 Surface Water Sampling Locations

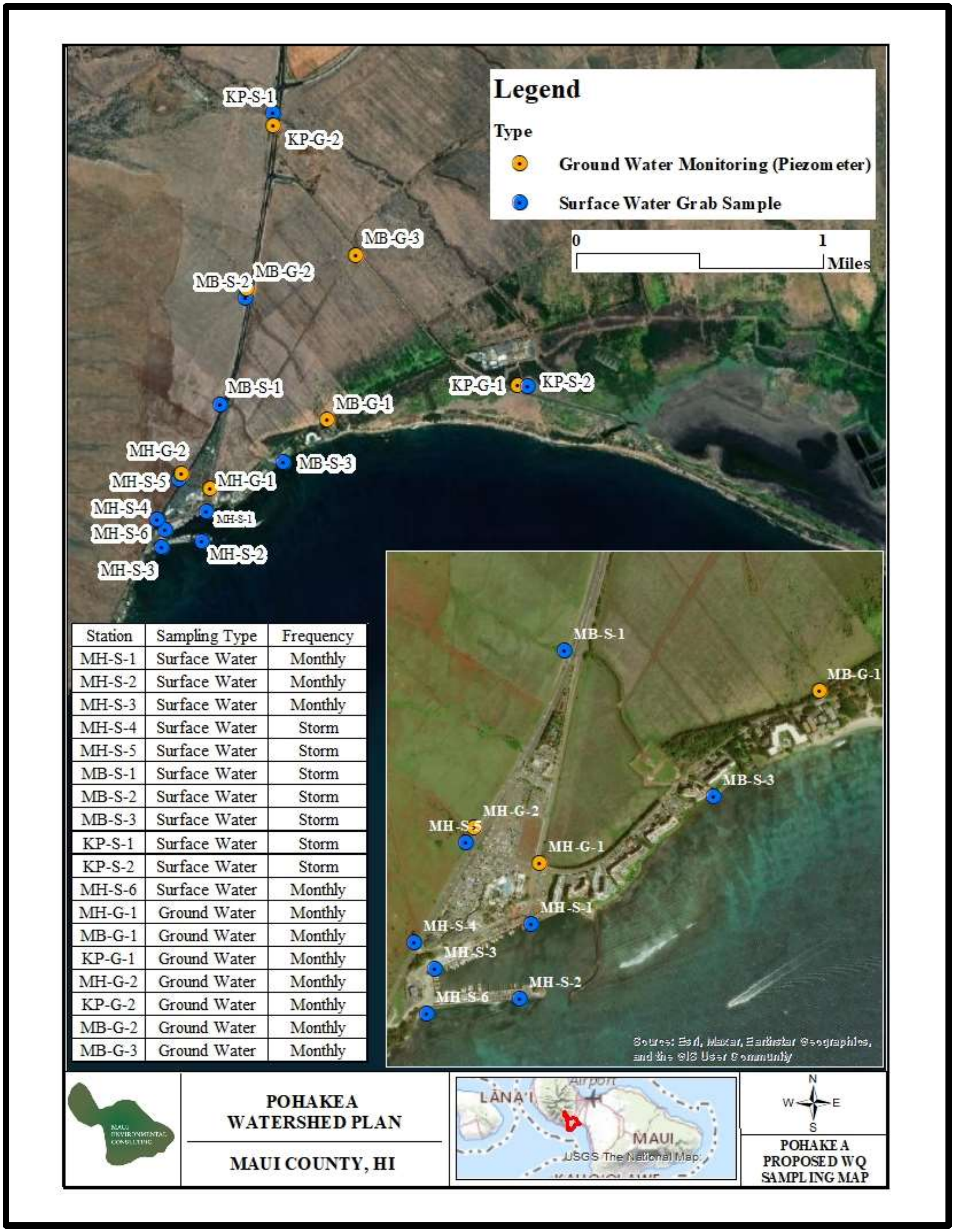
A total of 11 surface water monitoring stations were chosen to characterize water quality within the Pōhākea Watershed discharging into Keālia Pond, directly into Mā'alaea Bay, and stormwater entering Māʻalaea Harbor. Four occur within and around Māʻalaea Harbor and should be sampled monthly, and the remaining seven should be sampled during stormwater discharge events.

To capture stormwater entering Keālia Pond, sampling locations were proposed at the Pōhākea Stream culvert crossing under Honoapiʻilani Highway and at the Pōhākea Stream outfall into the Pond just makai of the MECO power generating facility.

To capture data on water discharging from Kanaio Stream and the numerous unnamed gulches and gullies crossing under Honoapiʻilani Highway and flowing directly into Māʻalaea Bay, three stormwater surface water sampling locations were proposed. One mauka of the highway at the large unnamed gulch that flows under the highway to converge with the Waiheʻe Makai Ditch and the rerouted pathway for Kanaio Stream, one on the mauka side of Honoapiʻilani Highway where Kanaio is rerouted via culvert to the Waiheʻe Makai Ditch, and one sampling location at the concrete lined drainageway in between Maui Island Sands Resort and the Māʻalaea Banyans makai of Hauʻoli Street.

To capture data on water discharging into Māʻalaea Harbor, six stormwater surface water sampling locations have been proposed. Two are mauka of Honoapiʻilani Highway where the Māʻalaea Stream and a major unnamed gulch cross under the highway and discharge directly into the harbor. Two marine surface water stations have been proposed within the harbor. One at the outfall for the stormwater drains servicing the impervious surfaces associated with the Māʻalaea Triangle commercial district and Māʻalaea Road at the east end of the harbor and one near the small boat launch at the western end of the harbor. A sampling location has been proposed directly beyond the entrance to the harbor. A final sampling location is proposed outside the harbor near the Māʻalaea Bay Place residences west of the harbor. As stated earlier, the four sampling locations occurring in and around the harbor should be sampled monthly while the remaining two locations associated with the culverts discharging into the harbor should be sampled when stormwater flow occurs.

Figure 51. Pōhākea Watershed Proposed Water Quality Monitoring Stations



Station	Sampling Type	Frequency
MH-S-1	Surface Water	Monthly
MH-S-2	Surface Water	Monthly
MH-S-3	Surface Water	Monthly
MH-S-4	Surface Water	Storm
MH-S-5	Surface Water	Storm
MB-S-1	Surface Water	Storm
MB-S-2	Surface Water	Storm
MB-S-3	Surface Water	Storm
KP-S-1	Surface Water	Storm
KP-S-2	Surface Water	Storm
MH-S-6	Surface Water	Monthly
MH-G-1	Ground Water	Monthly
MB-G-1	Ground Water	Monthly
KP-G-1	Ground Water	Monthly
MH-G-2	Ground Water	Monthly
KP-G-2	Ground Water	Monthly
MB-G-2	Ground Water	Monthly
MB-G-3	Ground Water	Monthly

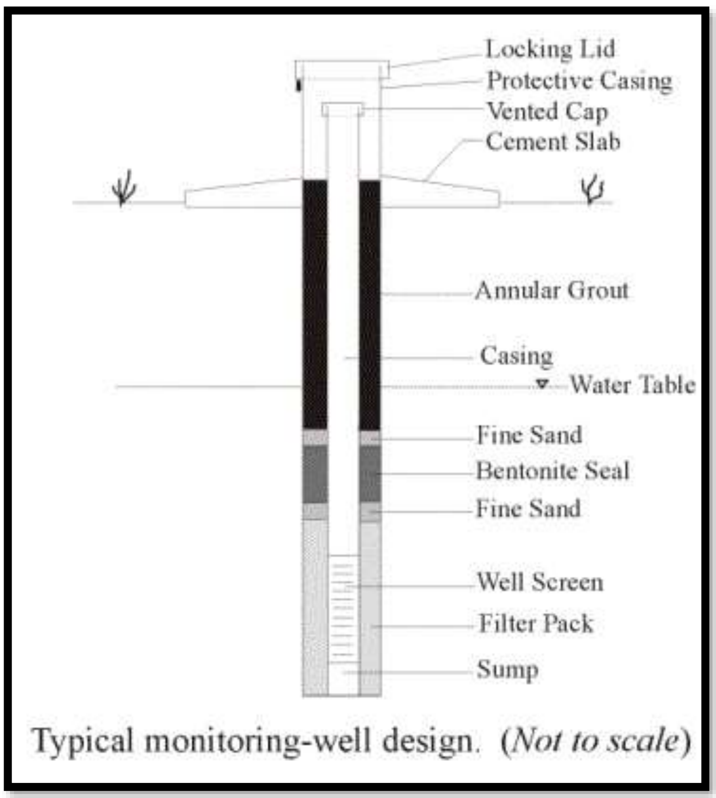
14.1.2 Groundwater Sampling Locations

A total of seven groundwater monitoring stations have been proposed in order to collect water quality samples of groundwater throughout the Pōhākea Watershed. Groundwater samples will be collected via installed piezometers. These devices allow for sample collection and groundwater level monitoring. A depiction of a typical piezometer installation is included as Figure 52 below. Placement of these piezometers was designed to collect representative samples from locations in the Pōhākea watershed potentially affecting nearshore coastal water quality associated with Keālia Pond, Māʻalaea Bay, and within Māʻalaea Harbor.

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

Figure 52. Depiction of a typical Piezometer Installation



Due to the ephemeral nature of the streams and gulches that exist within the Pōhākea Watershed, many of the sampling locations proposed in this water quality monitoring plan will require sampling during storm events when stormwater discharge is occurring. Table 34 below details the sampling type and frequency at each of the locations proposed.

Table 34. Proposed Water Quality Monitoring Sites and Sampling Frequency

Station	Sampling Type	Frequency	Station	Sampling Type	Frequency
MH-S-1	Surface Water	Monthly	MH-G-1	Groundwater	Monthly
MH-S-2	Surface Water	Monthly	MB-G-1	Groundwater	Monthly
MH-S-3	Surface Water	Monthly	KP-G-1	Groundwater	Monthly
MH-S-6	Surface Water	Monthly	MH-G-2	Groundwater	Monthly
MH-S-4	Surface Water	Storm	KP-G-2	Groundwater	Monthly
MH-S-5	Surface Water	Storm	MB-G-2	Groundwater	Monthly
MB-S-1	Surface Water	Storm	MB-G-3	Groundwater	Monthly
MB-S-2	Surface Water	Storm			
MB-S-3	Surface Water	Storm			
KP-S-1	Surface Water	Storm			
KP-S-2	Surface Water	Storm			

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 (at the harbor and coastal sites at a minimum). 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.

14.2 Consistency in Monitoring

Discrepancies currently exist regarding site names and locations recorded in the State of Hawaiʻi Integrated Water Quality Reports. 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

30m Digital Elevation Maps (DEMs) from the United States Geological Survey

A Handbook for Stormwater Reclamation and Reuse Best Management Practices in Hawaiʻi, December 2008, Commission on Water Reclamation Management

CE Ramos-Scharron (2010). *A Review of Surface Erosion and Sediment Delivery Models for Unsealed Roads*, Environmental Modelling and Software

Coastal Change Analysis Program (CCAP) land cover

Commission on Water Resource Management. (2008). *A Handbook for Stormwater Reclamation and Reuse Best Management Practices in Hawaiʻi, December 2008, CWRM*

Coral Reef Alliance, 2017. *Stream Restoration Technical Solutions: Wahikuli and Honokōwai Watersheds*, West Maui.

Dollar, Steven, et al (2011). *An Evaluation of Causal Factors Affecting Coral Reef Community Structure in Māʻalaea Bay, Maui, Hawaiʻi*. Submitted to Maui County Department of Finance, Purchasing Division

Environmental Protection Agency Spreadsheet Tool for Estimating Pollutant Loads (STEPL). https://www.epa.gov/nps/spreadsheet-tool-estimating-pollutant-loads-stepl

Erickson-Kelly, Terrell. (2011). *Learning from Kihei, Maui. Cumulative Impacts and Mitigation of Wetlands.* Natural Resource Conservation Service, United States Department of Agriculture.

Eslinger, David L., H. Jamieson Carter, Matt Pendleton, Shan Burkhalter, Margaret Allen. 2012. "OpenNSPECT: The Open-source Nonpoint Source Pollution and Erosion Comparison Tool." NOAA Office for Coastal Management, Charleston, South Carolina. Accessed June 2018 at coast.noaa.gov/digitalcoast/tools/opennspect.

FWS Classification of Wetlands and Deepwater Habitats of the United States

FWS National Wetland Inventory (NWI)

Giambelluca, T. W., & Nullet, D. (1991). Influence of the trade-wind inversion on the climate of a leeward mountain slope in Hawaiʻi. *Climate Research*, *1*(3), 207–216. http://www.jstor.org/stable/24863349

Gray, Ted, 2014. *Converting a Degraded Quarry Into a Community Asset*. Civil & Structural Engineer. January 29, 2014 White Paper.

Hawaiʻi Department of Health Clean Water Branch, 2022. 2022 State of Hawaiʻi Water Quality Monitoring and Assessment Final Report.

Hawaiʻi Department of Health Clean Water Branch, 2020. 2020 State of Hawaiʻi Water Quality Monitoring and Assessment Final Report.

Horsley Whitten Group Inc. and St. Croix Environmental Association, 2017. *Green Cay Gut Headcut Stabilization Project Final Report*. NOAA Coral Reef Conservation Program.

Horsley Whitten Group Inc. (2014) *Stormwater Management in Pacific and Caribbean Islands: A Practitioner's Guide to Implementing LID*. https://www.coris.noaa.gov/activities/stormwater_lid/

Horsley Whitten Group Inc. and Protectores de Cuencas (2017) *Unpaved Road Standards for Caribbean and Pacific Islands*. NOAA Coral Reef Conservation Program Order No. DG-133C-12- BA-0056/C-0014 under Contract No. GS10F0304T http://www.horsleywitten.com/wp-content/uploads/2017/03/2017IslandUnpavedRoadStandards.pdf

Kohala Watershed Partnership's Pelekane Bay Watershed Restoration Project-Final Report, May 31, 2011

Mayer, D. P. (2010). US Census Data for Maui.

Macdonald, G.A., Abbott, A.T., Peterson, F.L. (1983). *Volcanoes in the Sea: The Geology of Hawaiʻi*, Second Edition. University of Hawaiʻi Press

Mink and Yuen. (2002). *Draft Supplemental Environmental Impact Statement for the East Maui Water Development Plan.*

Mink, J. F., & Lau, L. S. (2006). *Hydrology of the Hawaiian Islands.* University of Hawaiʻi Press.

National Oceanic and Atmospheric Administration (NOAA), National Ocean Service (NOS), National Centers for Coastal Ocean Science (NCCOS), Center for Coastal Monitoring and Assessment (CCMA), Biogeography Program, 2007. Benthic Habitats of the Main Hawaiian Islands prepared form IKONOS and Quick Bird Satellite Imagery, BAE Systems Spectral Solutions Version 1.1

N. Beaudet, et al., (2014) *Nitrates, Blue Baby Syndrome, And Drinking Water: A Factsheet for Families*. Pediatric Environmental Health Specialty Unit, Last updated July 2014.

Oram, Brian (2014). *Phosphate in Surface Water Streams Lakes*. The Water Research Center. Pgs. 1-4

PBR & Associates, Inc. Hawaiʻi. (March 2010). *Honua'ula Draft Environmental Impact Statement*. County of Maui, Maui Planning Department.

PRISM Climate Group, Oregon State University, http://prism.oregonstate.edu, 2019.

Ramos-Scharron, Carlos Baihua & T.H. Newham, Lachlan (2010). *A Review of Surface Erosion and Sediment Delivery Models for Unsealed Roads*. Environmental Modelling & Software. 25. 1-14. 10.1016/j.envsoft.2009.07.013.

Richmond, R. H., Rongo, T., Golbuu, Y., Victor, S., Idechong, N., Davis, G., et al. (2007). *Watersheds and Coral Reefs: Conservation Science, Policy, and Implementation*. *Bioscience* , Vol. 57, no. 7. pp 598-607.

Riparian Buffer Width, Vegetative Cover, and Nitrogen Removal Effectiveness, EPA/600/R-05/118, October 2005

Sawdey. (2009). *Rapid Watershed Assessment: Kama`ole Watershed, Maui Island, Hawai'i*. Internal Draft (unpublished). USDA Natural Resources Conservation Service. Honolulu, Hawai'i.: USDA Natural Resources Conservation Service.

Scott, Robert (2012). *Understanding the Basic Principles of Nitrogen*. Connecticut Water Pollution Abatement Association pgs. 1-3.

State of Hawai'i, Office of Planning, Land Use and Landcover of Main Hawaiian Islands, 1976

State of Hawai'i, Office of Planning Geographic Information System Data Portal

State of Hawai'i, Department of Land and Natural Resources Division of Aquatic Resources, 2017. Marine Life Conservation Districts, Maui – Honolua – Mokule'ia. Online at http://dlnr.Hawai'i.gov/dar/marine-managed-areas/Hawai'i-marine-life-conservation-districts/mauihonolua-mokuleia/

Stearns and McDonald, (1942). *Geology of Groundwater Resources of the Island of Maui, Hawai'i.* United States Geological Survey.

Templeton, Scott (2008). *Estimation and Analysis of Expenses of Design-Bid-Build Projects for Stream Mitigation in North Carolina Department of Applied Economics and Statistics Clemson University.* Clemson University Research Report RR 08-01.

Tetra Tech EM, Inc. (2010). Hawai'i Watershed Guidance. Honolulu, Hawai'i. Hawai'i Office of Planning, Coastal Zone Management Program

U. S. Census Bureau. (2020) Population. https://www.census.gov/quickfacts/mauicountyhawaii

U.S. Geological Survey (USGS) Topographic Quadrangle maps

United States Department of Agriculture, Natural Resource Conservation Service (2001). *Soil Survey of Maui.* US Department of Agriculture.

United States Department of Agriculture RUSLE2 User's Reference Guide (in publication).

United States Environmental Protection Agency (2005). *Guidance for 2006 Assessment, Listing and Reporting Requirements Pursuant to Sections 303(d), 305(b) and 314 of the Clean Water Act.* USEPA U.S. Environmental Protection Agency, Office of wetlands, oceans, and watersheds. USEPA.

United States Environmental Protection Agency (2009). *Handbook for Developing Watershed Plans to Restore and Protect our Waters.*

U.S. Fish and Wildlife Service, Interior. (30 March 2016) Endangered and Threatened Wildlife and Plants; Designation and Nondesignation of Critical Habitat on Molokai, Lanai, Maui, and Kahoolawe for 135 Species. 81 FR 17789 / 50 CFR 17

Wall, Chris (2013). *Nitrogen in Minnesota Surface Waters: Conditions, trends, sources, and reductions report; Chapter 2 Nitrogen in Waters: Forms and Concerns.* Minnesota Pollution Control Agency pg. A2-2.

Zeedyk, Bill, (2006). *Water Harvesting from Low Standard Rural Roads*, Quivira Coalition.

Appendix A. CDF Preliminary Drainage
Report for the Pohakea Watershed

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PRELIMINARY

DRAINAGE REPORT FOR POHAKEA WATERSHED

MA'ALAEA, MAUI, HAWAI'I

Prepared By:

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January 28, 2022

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INTRODUCTION:

The purpose of this report is to evaluate the existing and proposed drainage conditions for the subject project as well as discuss the effectiveness of installing retention basins near the outlet of the watershed (directly above the Honoapi'ilani Highway).

PROPOSED PROJECT:

LOCATION:
The subject lots are located in Pohakea, Ma'alaea, Wailuku mauka of the Honoapi'ilani Highway. The parcels are designated by Tax Map Key Numbers (2) 3-6-001:014 & 018. The main subject lot (parcel 014) is approximately 3,400-acres in size and is owned by the State of Hawaii. Only a portion of the parcel (approximately 1,000-acres) is being examined for drainage purposes. The second lot (parcel 018) is 257.78-acres and is currently owned by MVI LLC and Wailuku Agribusiness Co. Inc. The disturbed area will be concentrated along known drainageways on parcel 018.

PROJECT DESCRIPTION:
The proposed improvements for the subject project include constructing retention basins to allow sediment from stormwater to settle out during storm events. Ultimately, the intent is to allow only treated stormwater to enter Ma'alaea Bay from this watershed. There is no current development plan associated with this project.

EXISTING CONDITIONS:

ADJACENT LAND USE:
The project is located adjacent (mauka) to the Honoapi'ilani Highway in Pohakea, Ma'alaea, Wailuku, Maui, Hawaii. Properties adjacent to the subject property are largely undeveloped. To the North, there is a small quarry, a golf course and other preserve properties. To the West, the original Kaheawa Wind Farm exists with access roads, windmill pads, utility buildings, and substations. To the East, the properties border the Honoapi'ilani Highway. Beyond the highway is the Ma'alaea Triangle commercial center. To the South, the parcel is also bordered by the Honoapi'ilani Highway which skirts the coast.

ONSITE CONDITIONS:
The majority of the main existing project area is open, poorly grassed land. On Parcel 018, agricultural grazing does periodically occur. There is a second phase of the Kaheawa Wind Farm that runs onto parcel 014, although it is outside of our project focus area.

TOPOGRAPHY AND SOIL CONDITIONS:
The lots slope at an approximate average slope of 10%, and elevations on the site range from approximately 3,100 feet to 45 feet

According to the "Soil Survey of Islands of Kauai, Oahu, Maui, Molokai, and Lanai, State of Hawaii (August, 1972)," prepared by the United States Department of Agriculture Soil Conservation Service, the soils within the project site are mostly classified as rRK (Rock land), rRO (Rock outcrop), rRS (Rough broken and stony land), rRT (Rough mountainous land), rSM (Stony alluvial land), and OMB (Oli medial silt loam) with slopes 1–45% slopes. These soil types are characterized as being well drained, having very high runoff, low to moderately low permeability, and a slight erosion hazard. The available water capacity is very low ranging from 0 inches to about 3.9 inches per 5 feet of soil.

HYDROLOGY:

For drainage areas of 100 acres of less, the Rational Method, as described in the "Title MC-15, Department of Public Works and Waste Management, County of Maui, Chapter 4, rules for the design of Storm drainage Facilities in the County of Maui" are used in calculating rainfall runoff. Calculations are based on a 50-year storm event. As we are reviewing this larger watershed (and sub areas within the larger watershed), the drainage areas exceed 100 acres. Therefore, the Natural Resources Conservation Service (NRCS) hydrograph method is used with the 100-year, 24-hour storm. An average estimated Time of Concentration (T_c) of 40 minutes has been used for purposes of this project.

Existing runoff for the main parcel (parcel 014) sheet flows and has flow concentrate into a series of gulches, flowing in an easterly direction towards the Ma'alaea Harbor and parcel 018. Our focus area contains five (5) different gulches.

Gulch #1 has an existing runoff volume of 2,570,400 CF (714 cfs).

Gulch #2 has an existing runoff volume of 1,115,388 CF (309.83 cfs).

Gulch #3 has an existing runoff volume of 353,448 CF (98.18 cfs).

Gulch #4 has an existing runoff volume of 449,820 CF (124.95 cfs).

Gulch #5 has an existing runoff volume of 2,225,000 CF (625 cfs).

*these are for the 50-year, 1-hour storm, 40 min Tc.

The post-development drainage pattern includes directing all surface runoff towards newly constructed retention basins. Additionally, the post-development drainage pattern includes the modifications of gulches with the installation of a series of retention basins designed to slow the discharge of stormwater into Ma'alaea Bay. The overflow from the proposed retention basin system is directed towards the Ma'alaea Harbor (Ma'alaea Triangle) commercial development to the east of the subject parcels.

Since we are not designing for an increase in the existing conditions, the runoff calculated above is the storage volume required. It may be prudent to add freeboard or anticipated development runoff. However, since we are solely reviewing the existing conditions to hold back sediment from a relatively dry slope reach, basin sizing could be decreased to a reasonable percentage of flow for sedimentation mitigation purposes.

PROPOSED DRAINAGE MITIGATION:

The proposed basin system will store calculated runoff volume in the five (5) subject gulches**.** The runoff will be conveyed via the gulches into the new retention basins with the calculated capacity. The basins will be located along each of the gulch lines and will be designed for ease of maintenance and sediment removal. The new on-site aboveground retention basins will overflow off-site to the existing Ma'alaea Harbor (Ma'alaea Triangle) commercial development.

CONCLUSION:

The existing runoff volume is calculated to be as follows:

Gulch #1:	2,570,400 CF
Gulch #2:	1,115,388 CF
Gulch #3:	353,448 CF
Gulch #4:	449,820 CF
Gulch #5:	2,225,000 CF

The proposed drainage system will prevent the runoff from adversely affecting the adjacent and downstream properties. The proposed drainage system will allow settlement of sediment from the stormwater and increasing the water quality within Ma'alaea Bay after storm events.

APPENDIX:

A. SOIL EROSION CONTROL PLAN

B. SWALE AND RETENTION AREA OPERATIONS AND MAINTANCE PLAN

C. CONSTRUCTION DRAWINGS AND MODEL OUTPUTS

APPENDIX A: SOIL EROSION CONTROL PLAN

GENERAL:
The following measure will be taken to control erosion during the construction period.

1. Minimize construction time.
2. Retain existing ground cover as long as possible.
3. Early installation of erosion control measures.
4. Use temporary area sprinklers in non-active areas when ground cover is removed.
5. Provide water for immediate sprinkling, as needed, in active areas.
6. Use temporary erosion control measures where needed.
7. Thoroughly water graded areas at the end of each work day and weekends.
8. Provide temporary irrigation system, and grass all cut and fill slopes within 30 days after grading work is completed.

MINIMUM BMP CHECKLIST FOR SMALL PROJECTS:

1 STABILIZED CONSTRUCTION ENTRANCE
All points of egress and ingress to a site shall be protected with a stabilized construction entrance. 20’ x 20’ min.

2 STOCKPILES
Stockpiles shall not be located in drainage ways or other areas of concentrated flows. During periods of wet weather, such as the rainy season, stockpiles shall be stabilized. Stockpiles covered in plastic when not in use.

3 DUST CONTROL
Dust control should be applied to reduce dust emissions. Contractor to spray water as necessary.

4 SEDIMENT BARRIERS OR TRAPS
Sediment trapping devices such as fences, trap basins or barriers shall be used down slope of all disturbed areas and around the base of all material stockpiles. Stockpiles to be covered with plastic.

5 INLET PROTECTION
All storm drain inlets on site, and those offsite that may receive runoff from the site shall used an inlet protection device.

6 PERMANENT STABILIZATION
All disturbed areas shall be permanently stabilized prior to removing Erosion and sediment measures. All temporary erosion and sediment Control measures shall be removed within 30 days after final site stabilization or after the temporary measures are no longer needed. Trapped sediment and areas of disturbed soil which result from the removal of the temporary measures shall be immediately permanently stabilized. Area to be permanently seeded/mulched within 14 days of final grade except house area which will be formed and slabbed within 14 days.

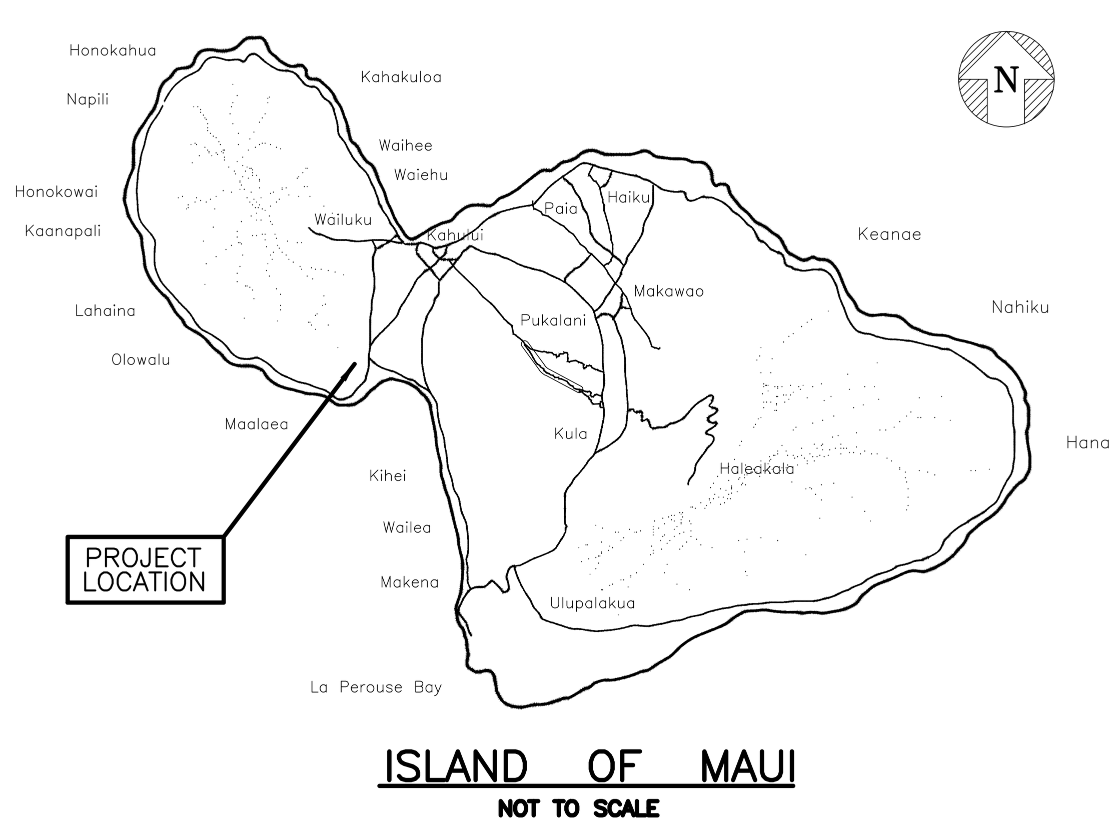
APPENDIX B: SWALE & RETENTION AREA OPERATIONS AND MAINTENANCE PLAN

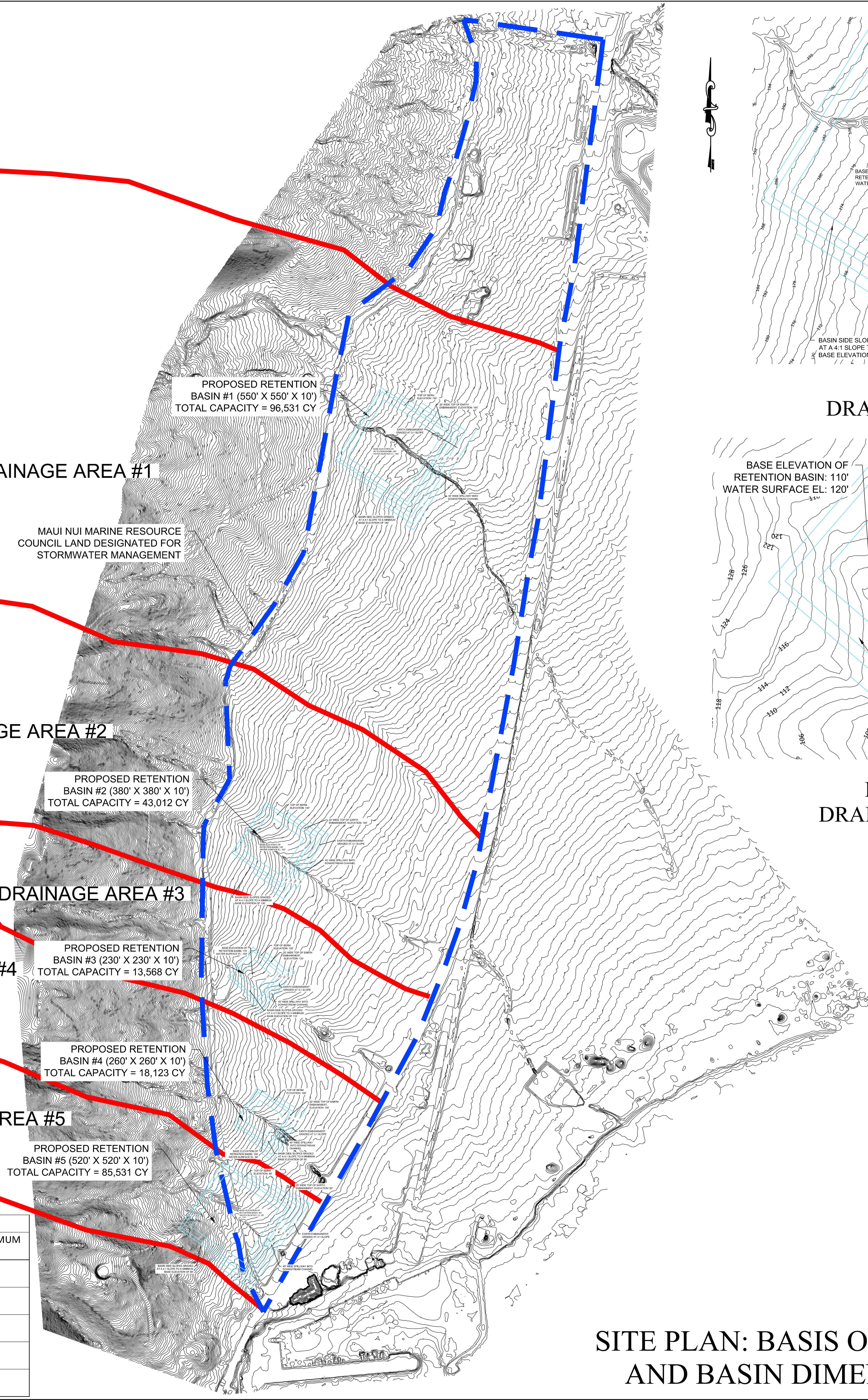
Regular maintenance designed to ensure the long-term efficiency of these systems shall include:

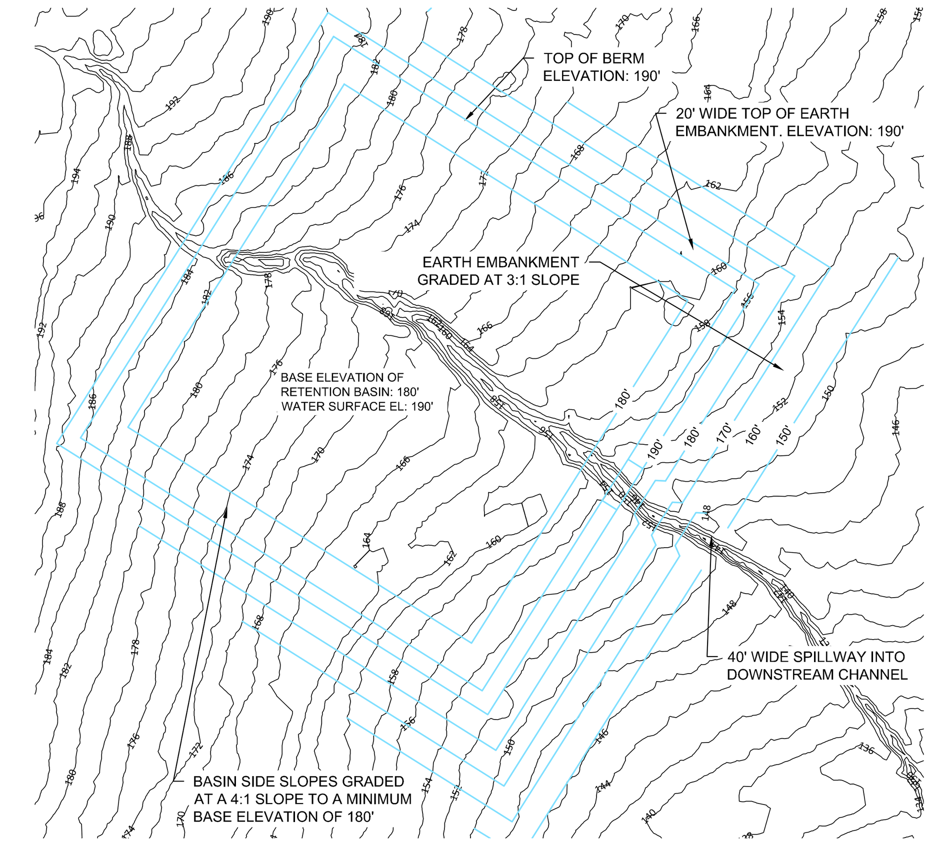
1. Periodic removal of the sediment/soil that is deposited in the vegetated swales and/or retention areas and restore to the original dimensions.
2. Overgrown vegetation on the bottom, sides, and benches of the retention areas shall be removed by means of mowing and/or herbicide spraying.
3. Maintain a vigorous growth of vegetation on all swales and bare soil which includes re-seeding, mulching/matting to protect the disturbed area while vegetation becomes established. Overgrown vegetation along swales shall be removed by means of mowing. If possible avoid herbicides in these areas.
4. Do not pave over, drive over or trample grassed swale and retention area.
5. Keep all culverts free flowing and maintain the original construction ridge height and capacity of vegetated berms and swales. The surface of the berms should be compacted to avoid a blow out if a very large storm occurs. Vegetative growth and accumulated silt deposits at all drainage outlets and at all overflow wiers shall be removed and kept clear at all times.
6. Mosquito infestation shall be controlled by removing stagnant water at bottom of retention areas.
7. After the occurrence of a major storm even, visually inspect the retention basins and swales for accumulation of sediment and debris. Immediately remove any obstruction or blockage in culverts and retention areas. Removal of sediment and debris shall be done after it is deemed safe to accomplish remedial work.
8. All access paths to the retention basin shall be maintained and clear of obstructions. Vegetative growth and accumulated silt shall be removed. Loose gravel/dirt within access path shall be compacted to maintain a safe route for vehicles used for the maintenance of the retention basins.
9. Roof drains, swimming pool or spa back flush, foundation drains and drainage from other sources producing intermittent or constant volumes of water should not be piped directly into swale or retention area.
10. In the event that the property is sold, the current owner shall pass this operations and maintenance plan to the new owner.

APPENDIX C:

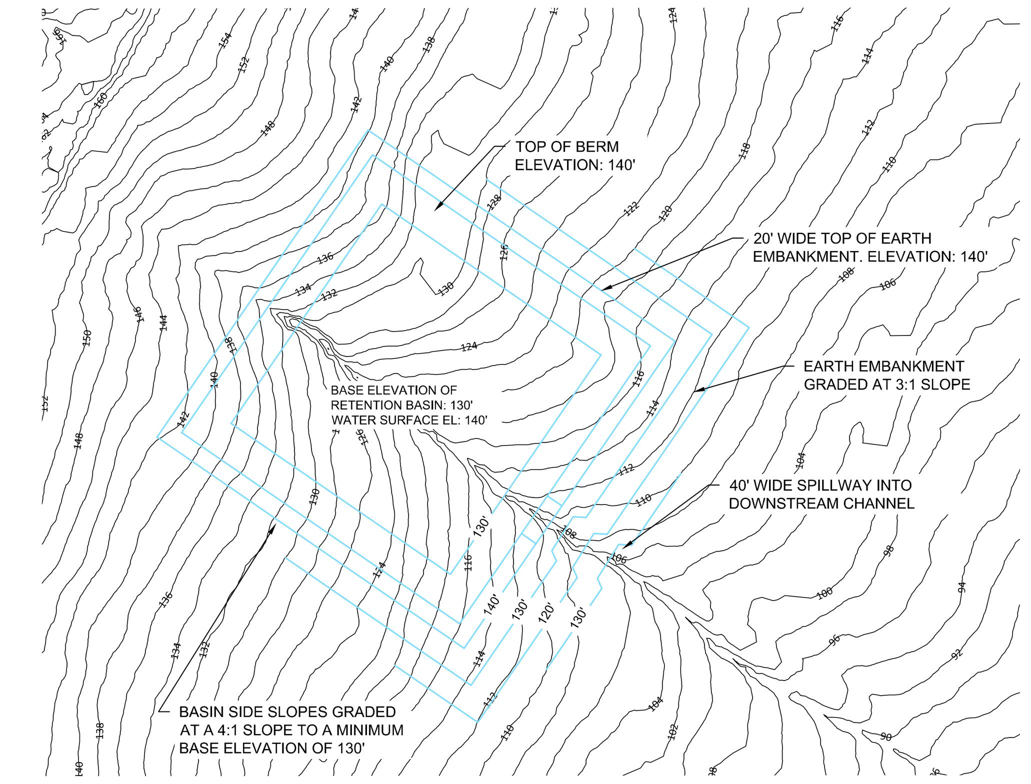
CONSTRUCTION DRAWINGS AND MODEL OUTPUTS



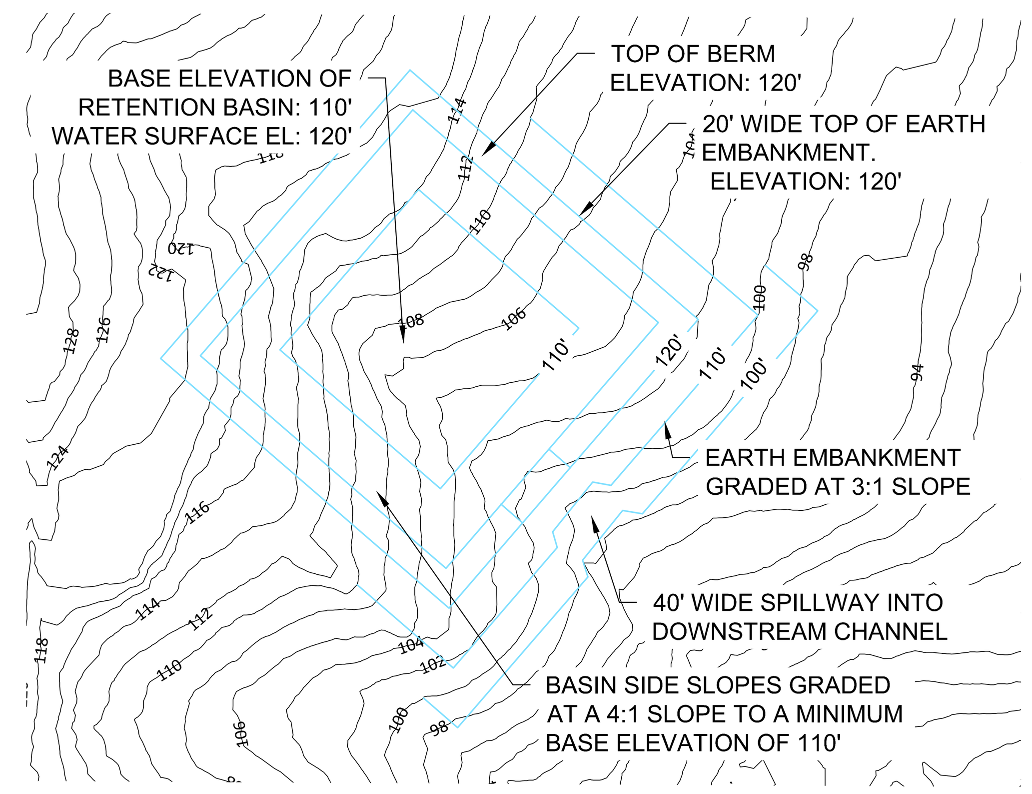




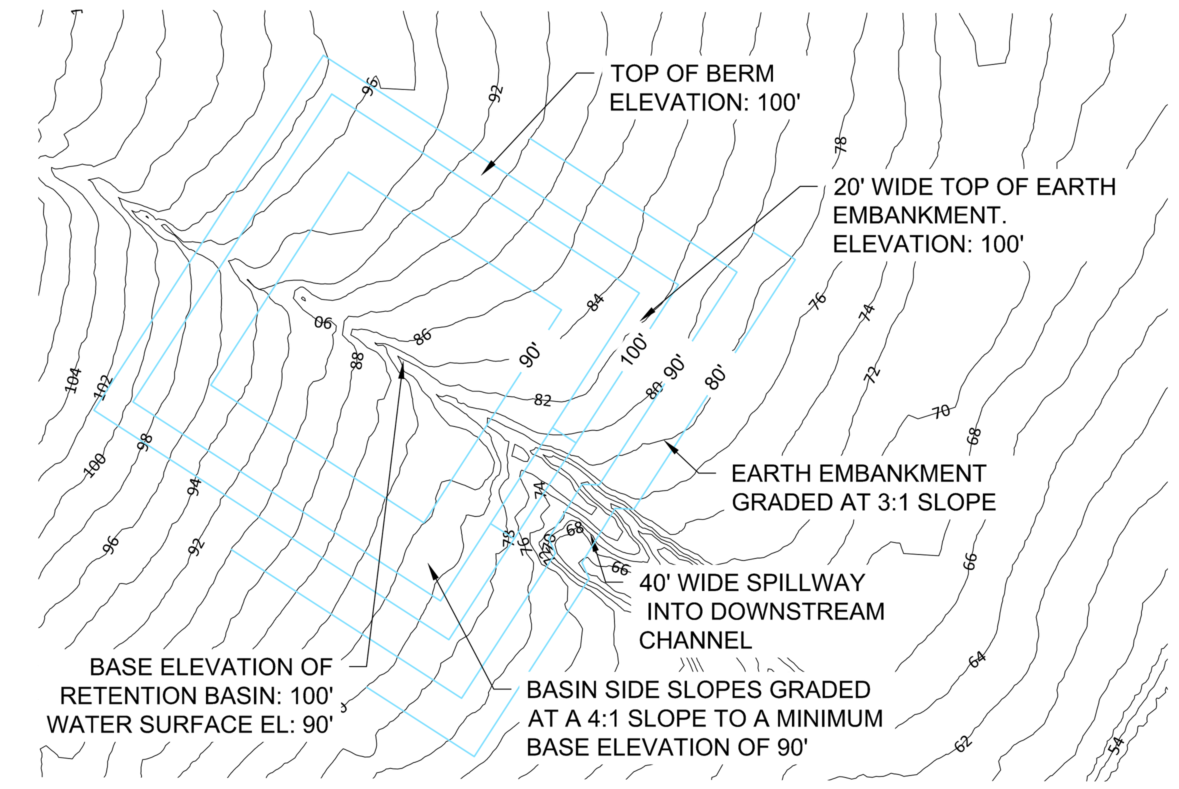
INSET MAP:
DRAINAGE BASIN #1



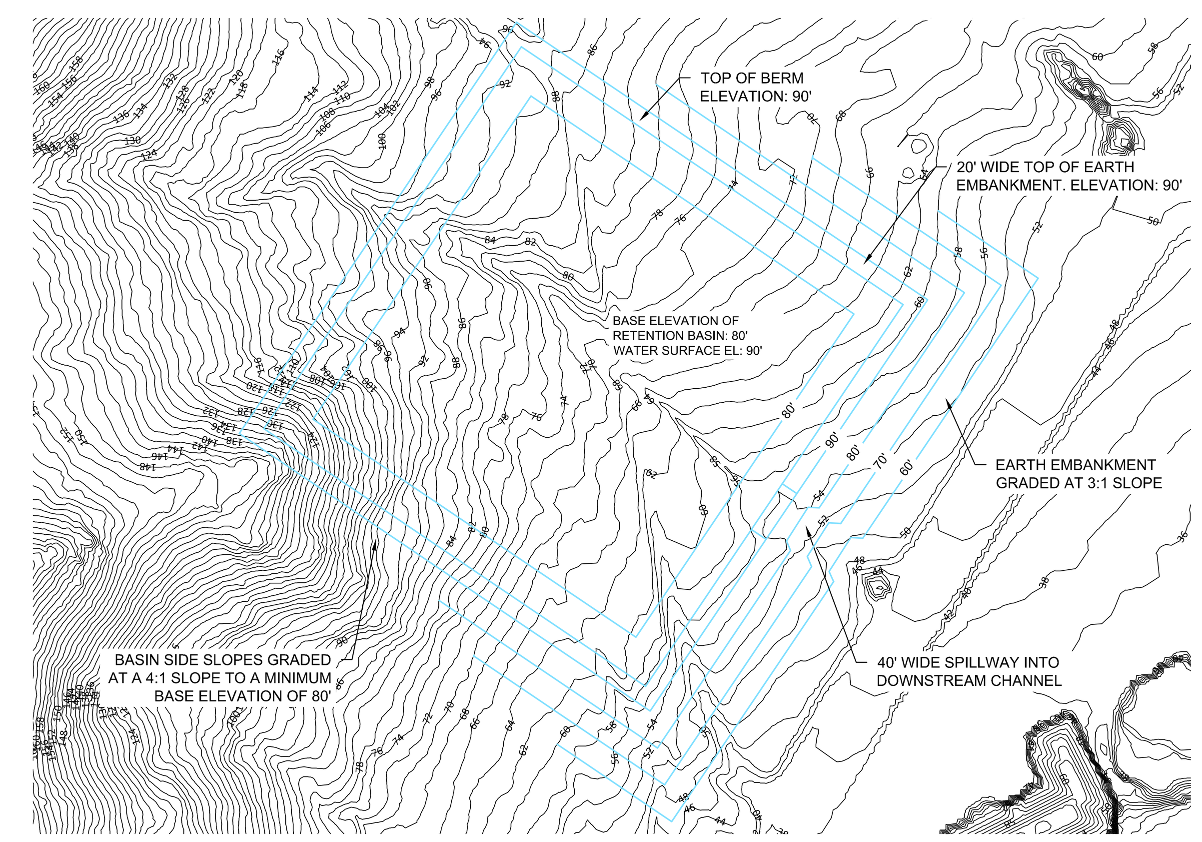
INSET MAP:
DRAINAGE BASIN #2



INSET MAP:
DRAINAGE BASIN #3



INSET MAP:
DRAINAGE BASIN #4



INSET MAP:
DRAINAGE BASIN #5

RETENTION BASIN DIMENSIONS

BASIN #	DRAINAGE AREA SERVED	LENGTH	WIDTH	DEPTH	DESIGN CAPACITY	Q50 CAPACITY (MINIMUM RETENTION)
1	DRAINAGE #1	600	600	10	2,606,333 CF	2,570,400 CF
		DRAINAGE #1 TOTAL (DESIGN CONSTRAINTS) =			**96,531 CY**	**95,200 CY**
2	DRAINAGE #2	300'	200'	6.5'	1,161,333 CF	1,115,388 CF
		DRAINAGE #2 TOTAL (DESIGN CONSTRAINTS) =			**43,012 CY**	**41,310 CY**
3	DRAINAGE #3	200'	100'	6'	366,333 CF	353,448 CF
		DRAINAGE #3 TOTAL (DESIGN CONSTRAINTS) =			**13,568 CY**	**13,090 CY**
4	DRAINAGE #4	100'	250'	6.5'	489,333 CF	449,820 CF
		DRAINAGE #4 TOTAL (DESIGN CONSTRAINTS) =			**18,123 CY**	**16,660 CY**
5	DRAINAGE #5	400'	300'	13'	2,309,333 CF	2,225,000 CF
		DRAINAGE #5 TOTAL (DESIGN CONSTRAINTS) =			**85,531 CY**	**83,334 CY**

SITE PLAN: BASIS OF DESIGN AND BASIN DIMENSIONS

EXPIRES: 04–30–2022

This work was prepared by me or under my supervision and construction will be under my observation. (Observation of construction as defined in Section 1.2 (N) in the rules and regulations of the Board of Preofessional Engineers, Architects, and Surveyors of the State of Hawaii.)

CIVIL ENGINEERING & LANDSCAPE ARCHITECTURE CONSULTANTS

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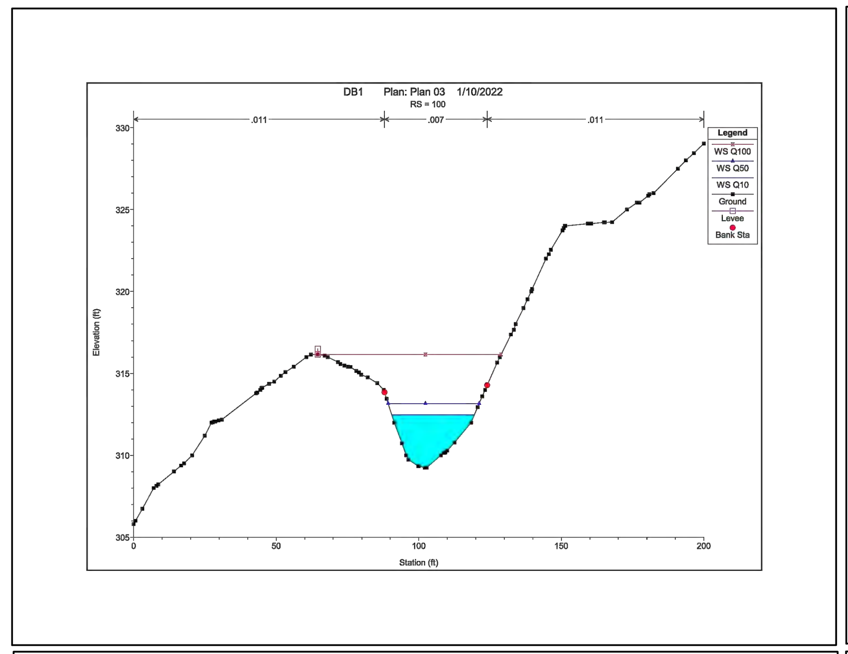
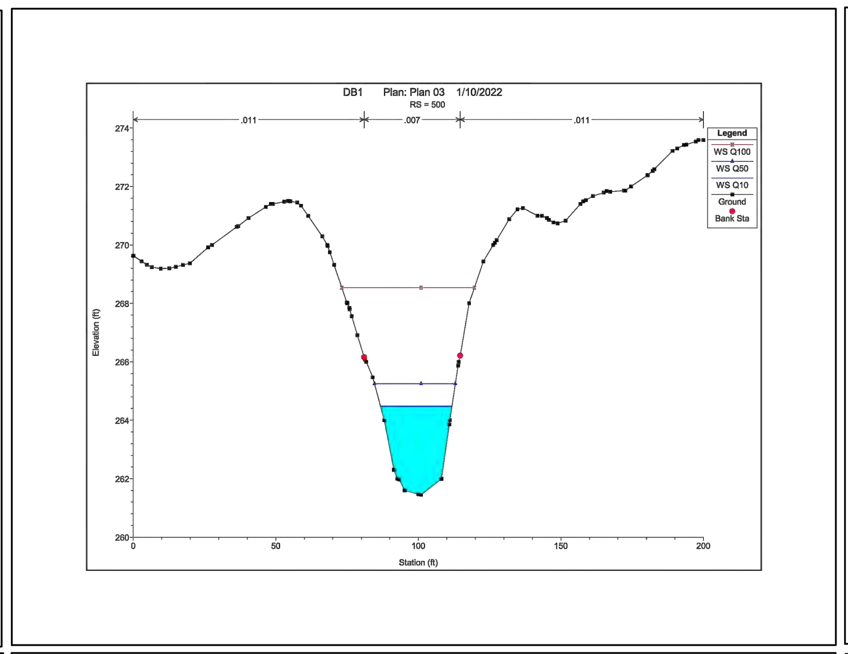
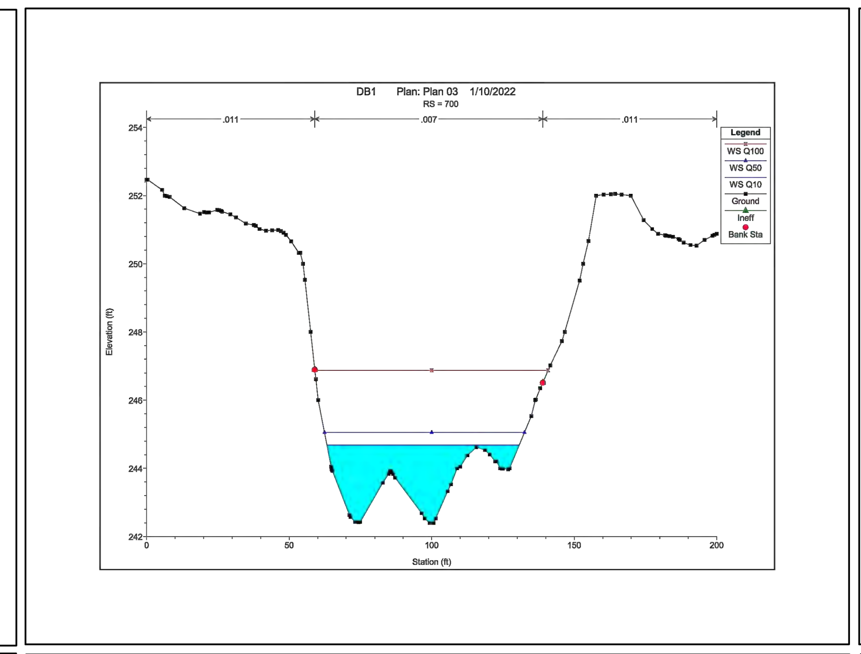
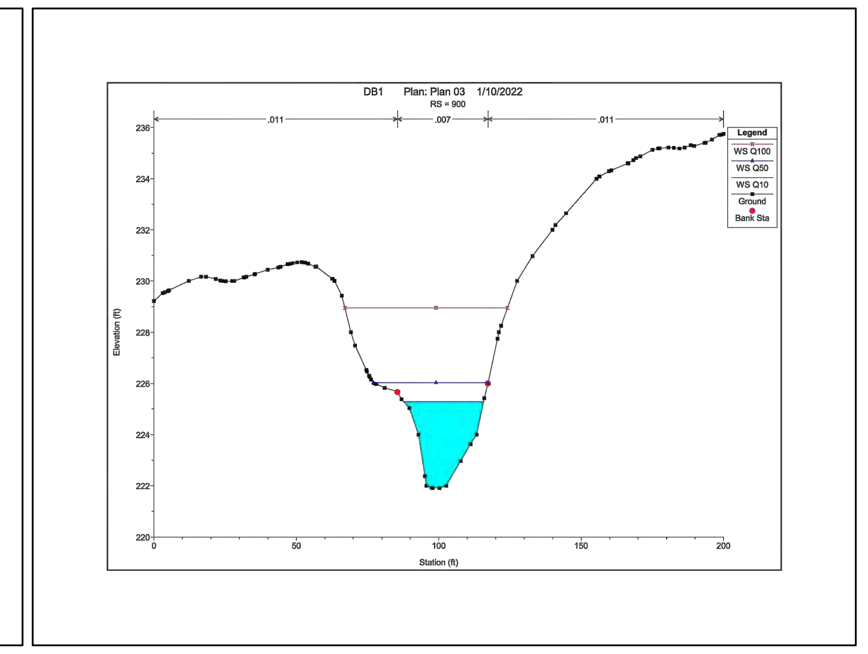
POHAKEA WATERSHED BASIS OF DESIGN
MAALAEA HARBOR
MAALAEA, HI 96793

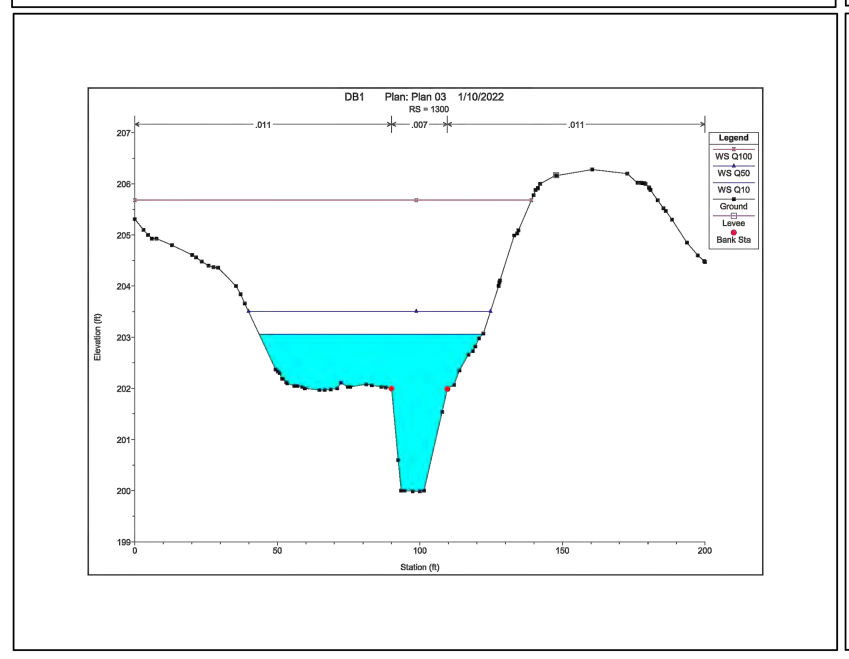
Scale: N.T.S	Site Plan	DWG No. C-1
01-28-2022	TMK: (2) 3-6-001:018	

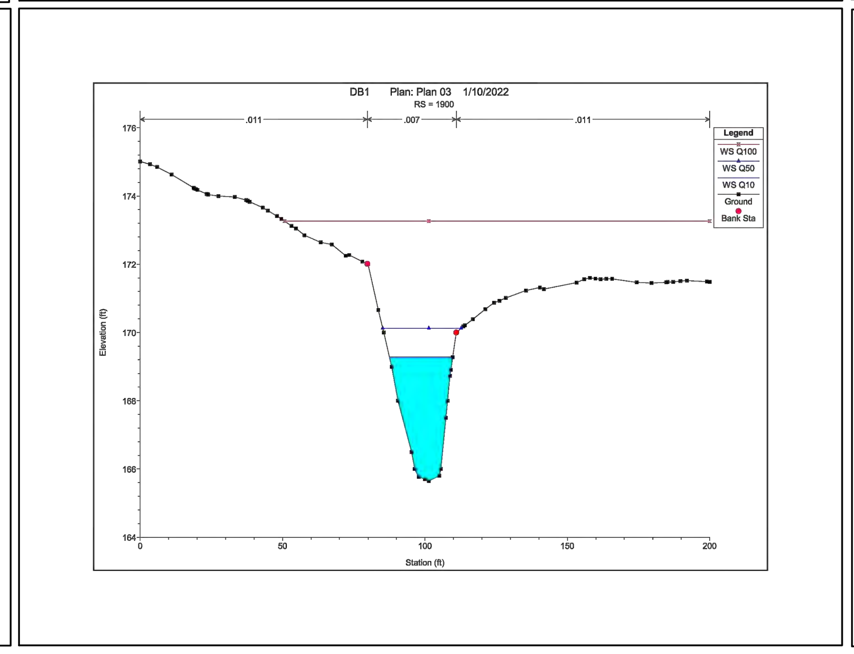


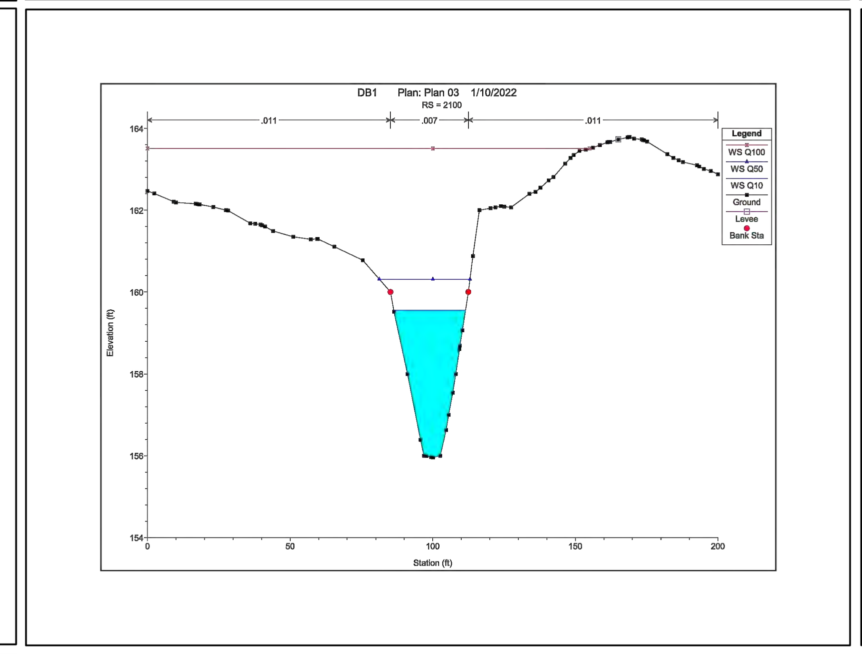


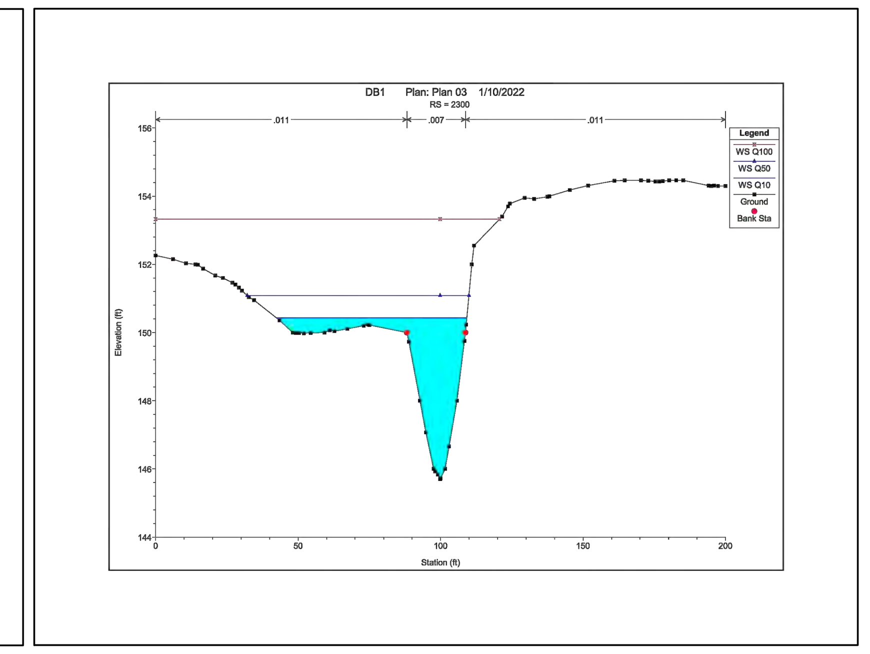


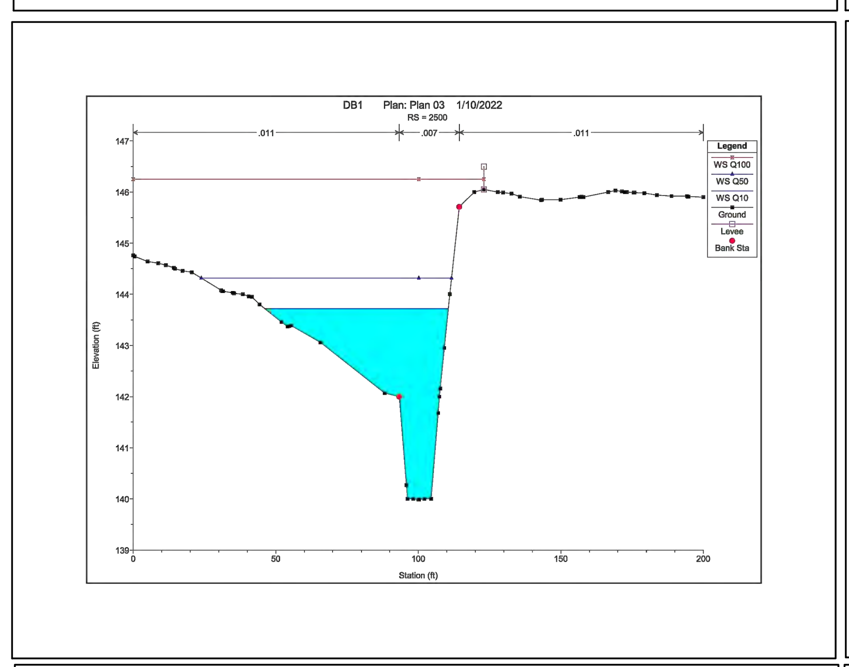


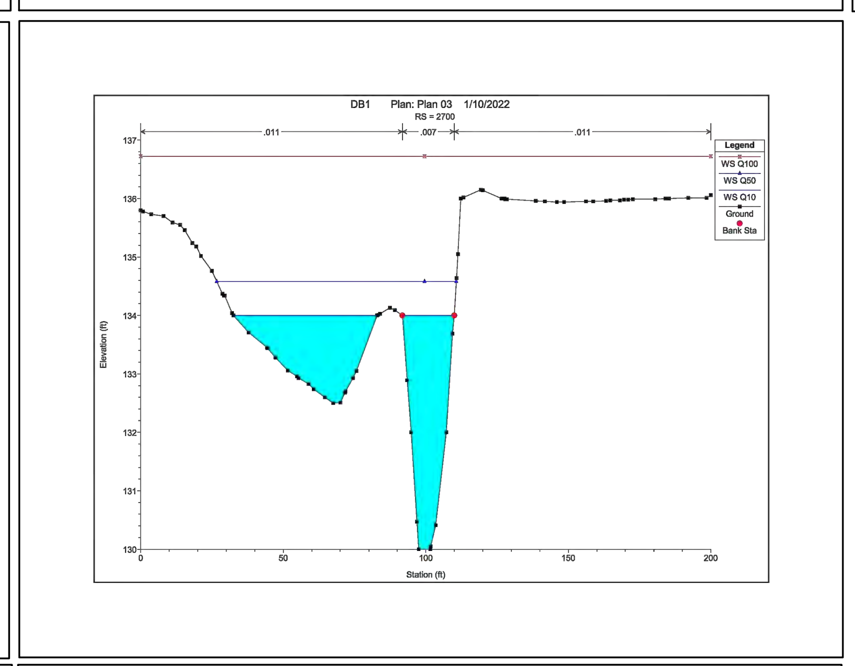


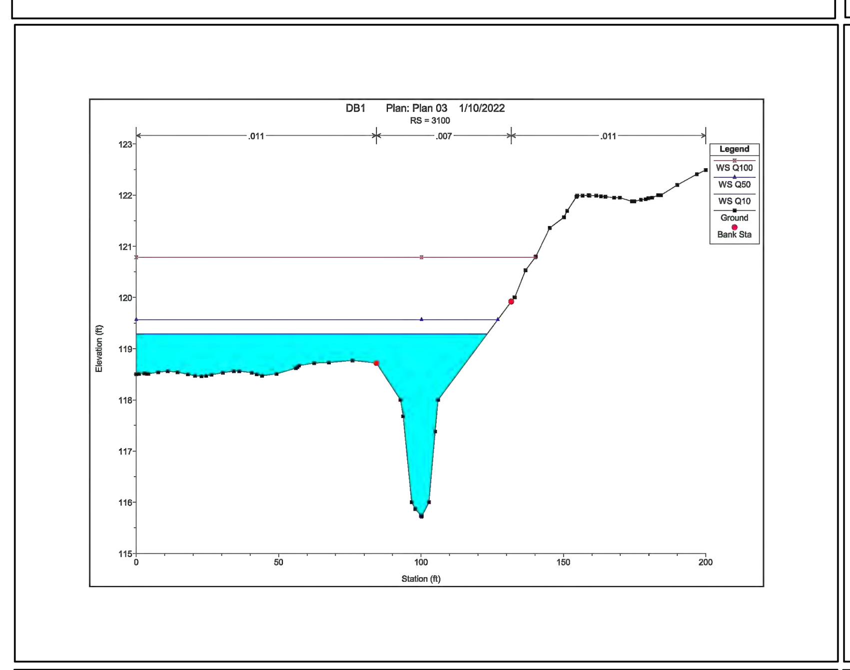


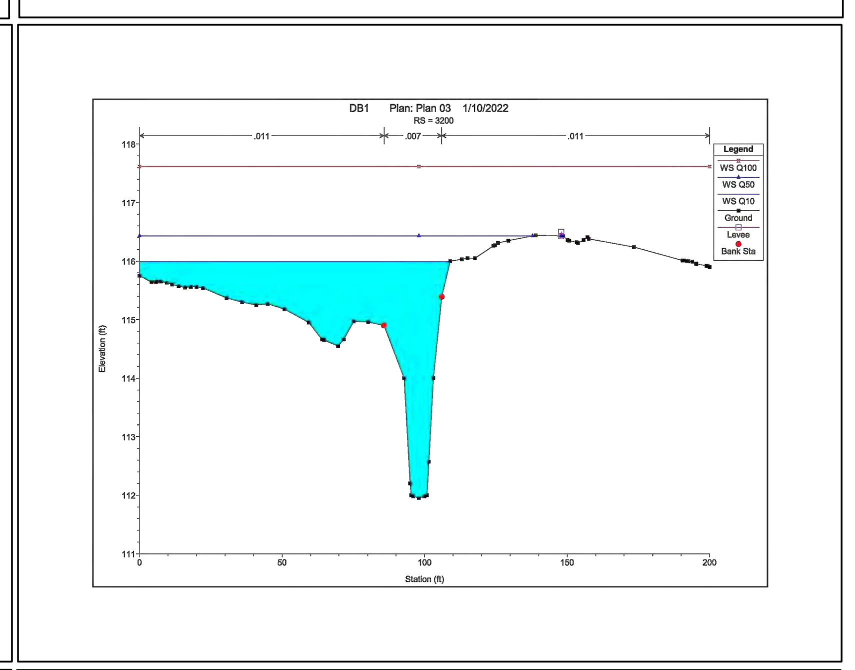


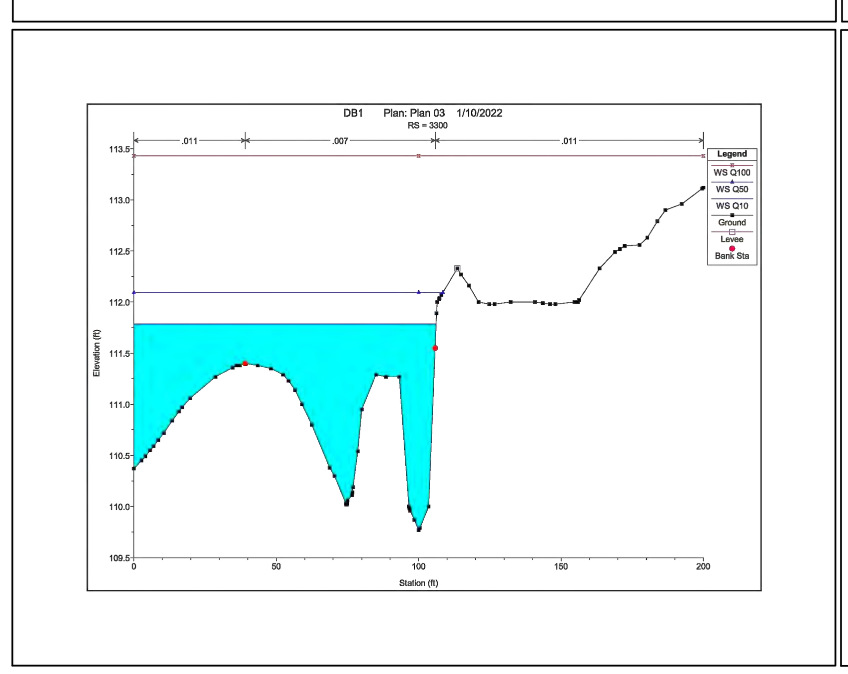


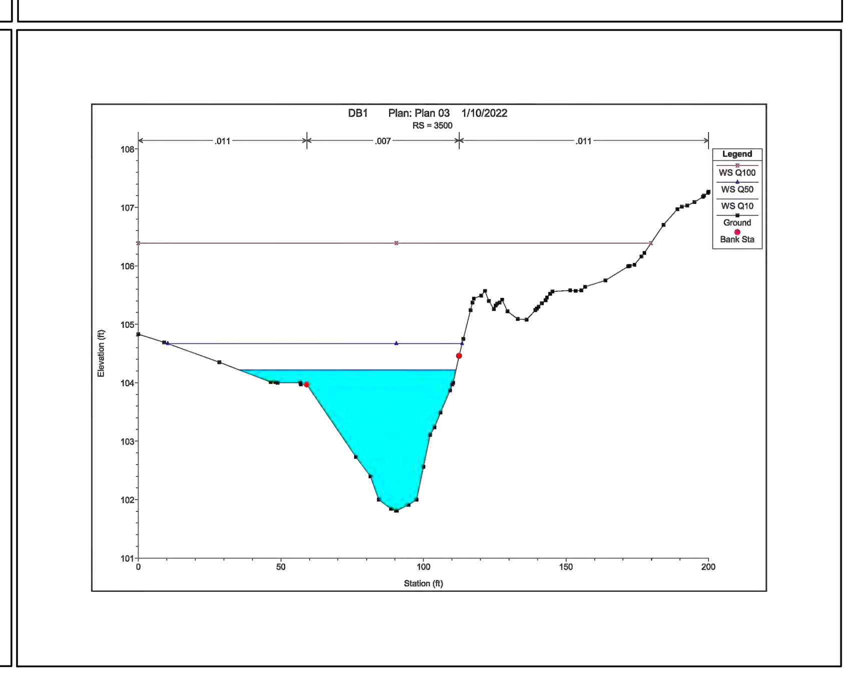












HEC-RAS Plan: Plan 03 River: DB1 200 XS Reach: DB1

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
DB1	3500	Q10	476.00	101.81	104.22	104.22	104.85	0.000581	6.41	77.67	76.11	0.95
DB1	3500	Q50	714.00	101.81	104.67	104.67	105.39	0.000488	6.98	117.83	103.23	0.91
DB1	3500	Q100	2380.00	101.81	106.39	106.39	107.44	0.000358	9.30	367.56	179.79	0.87
DB1	3400	Q10	476.00	106.14	107.09	107.09	107.60	0.001715	6.28	83.53	84.03	1.39
DB1	3400	Q50	714.00	106.14	107.41	107.41	108.06	0.001571	7.26	110.83	86.98	1.39
DB1	3400	Q100	2380.00	106.14	109.03	109.03	110.11	0.001029	11.14	305.75	155.01	1.31
DB1	3300	Q10	476.00	109.77	111.79	111.79	112.23	0.000803	5.82	95.80	106.12	1.05
DB1	3300	Q50	714.00	109.77	112.09	112.09	112.65	0.000689	6.48	132.43	147.58	1.01
DB1	3300	Q100	2380.00	109.77	113.43	113.43	114.34	0.000495	8.87	374.84	200.00	0.97
[illegible]	[illegible]	[illegible]	476.00	111.95	115.99	115.99	116.50	0.000321	6.65	118.39	108.91	0.74
[illegible]	[illegible]	[illegible]	714.00	111.95	116.43	116.43	116.93	0.000291	7.05	184.95	190.10	0.72
[illegible]	[illegible]	[illegible]	2380.00	111.95	117.62	117.62	118.49	0.000430	10.73	421.96	200.00	0.93
[illegible]	[illegible]	[illegible]	476.00	115.72	119.29	119.29	119.71	0.000519	6.02	114.32	123.21	0.89
[illegible]	[illegible]	[illegible]	714.00	115.72	119.57	119.57	120.08	0.000576	6.77	149.35	126.96	0.95
[illegible]	[illegible]	[illegible]	2380.00	115.72	120.78	120.78	121.94	0.000687	10.39	312.24	140.09	1.13
[illegible]	[illegible]	[illegible]	476.00	120.00	122.70	122.70	123.15	0.000560	6.77	112.27	109.74	0.94
[illegible]	[illegible]	[illegible]	714.00	120.00	122.97	122.97	123.56	0.000621	7.84	143.07	112.93	1.01
[illegible]	[illegible]	[illegible]	2380.00	120.00	124.44	124.44	125.59	0.000609	11.44	328.79	144.36	1.11
[illegible]	[illegible]	[illegible]	476.00	130.00	134.00	134.00	134.75	0.000437	7.78	89.92	68.75	0.85
[illegible]	[illegible]	[illegible]	714.00	130.00	134.58	134.58	135.35	0.000383	8.32	136.03	84.03	0.82
[illegible]	[illegible]	[illegible]	2380.00	130.00	136.72	136.72	137.70	0.000324	10.78	417.98	200.00	0.82
[illegible]	[illegible]	[illegible]	476.00	139.99	143.72	143.72	144.46	0.000363	7.66	90.98	64.44	0.80
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[illegible]	[illegible]	[illegible]	2380.00	139.99	146.25	146.25	147.30	0.000385	10.92	376.47	200.00	0.89
[illegible]	[illegible]	[illegible]	476.00	145.70	150.43	150.43	151.30	0.000345	7.60	75.67	66.87	0.78
[illegible]	[illegible]	[illegible]	714.00	145.70	151.08	151.08	152.00	0.000313	8.28	122.60	77.81	0.77
[illegible]	[illegible]	[illegible]	2380.00	145.70	153.33	153.33	154.65	0.000317	11.52	351.59	120.70	0.84
[illegible]	[illegible]	[illegible]	476.00	155.96	159.55	159.55	160.68	0.000594	8.52	55.88	25.17	1.01
[illegible]	[illegible]	[illegible]	714.00	155.96	160.31	160.31	161.67	0.000530	9.36	76.92	31.78	0.99
[illegible]	[illegible]	[illegible]	2380.00	155.96	163.51	163.51	164.80	0.000243	10.54	383.62	175.92	0.76
[illegible]	[illegible]	[illegible]	476.00	165.65	169.28	169.28	170.50	0.000599	8.88	53.63	22.20	1.01
[illegible]	[illegible]	[illegible]	714.00	165.65	170.12	170.12	171.57	0.000566	9.65	74.09	27.55	1.01
[illegible]	[illegible]	[illegible]	2380.00	165.65	173.26	173.26	174.50	0.000278	10.28	364.64	149.29	0.78
[illegible]	[illegible]	[illegible]	476.00	179.05	182.60	182.60	183.06	0.000317	6.26	125.54	144.55	0.74
[illegible]	[illegible]	[illegible]	714.00	179.05	182.92	182.92	183.45	0.000341	7.10	175.32	161.02	0.79
[illegible]	[illegible]	[illegible]	2380.00	179.05	184.19	184.19	185.17	0.000456	10.78	392.54	179.74	0.98
[illegible]	[illegible]	[illegible]	476.00	189.85	192.18	192.18	192.64	0.000644	7.17	112.14	112.49	1.00
[illegible]	[illegible]	[illegible]	714.00	189.85	192.46	192.46	193.04	0.000693	8.28	143.60	115.93	1.07
[illegible]	[illegible]	[illegible]	2380.00	189.85	193.86	193.86	195.05	0.000706	12.15	318.13	132.17	1.18
[illegible]	[illegible]	[illegible]	476.00	199.99	203.06	203.06	203.71	0.000376	7.35	98.54	78.51	0.82
[illegible]	[illegible]	[illegible]	714.00	199.99	203.51	203.51	204.28	0.000391	8.36	134.91	84.90	0.86
[illegible]	[illegible]	[illegible]	2380.00	199.99	205.68	205.68	206.79	0.000344	11.36	389.47	155.73	0.89
[illegible]	[illegible]	[illegible]	476.00	221.91	225.29	225.29	226.33	0.000600	8.19	58.10	28.06	1.00
[illegible]	[illegible]	[illegible]	714.00	221.91	226.02	226.02	227.24	0.000533	8.84	82.23	40.26	0.98
[illegible]	[illegible]	[illegible]	2380.00	221.91	228.95	228.95	231.15	0.000378	12.41	226.05	57.10	0.94
[illegible]	[illegible]	[illegible]	476.00	242.40	244.68	244.68	245.26	0.000686	6.09	78.18	67.44	1.00
[illegible]	[illegible]	[illegible]	714.00	242.40	245.05	245.05	245.79	0.000635	6.88	103.75	70.16	1.00
[illegible]	[illegible]	[illegible]	2380.00	242.40	246.88	246.88	248.38	0.000503	9.83	242.40	81.83	1.00
[illegible]	[illegible]	[illegible]	476.00	261.45	264.49	264.49	265.61	0.000593	8.51	55.91	25.10	1.01
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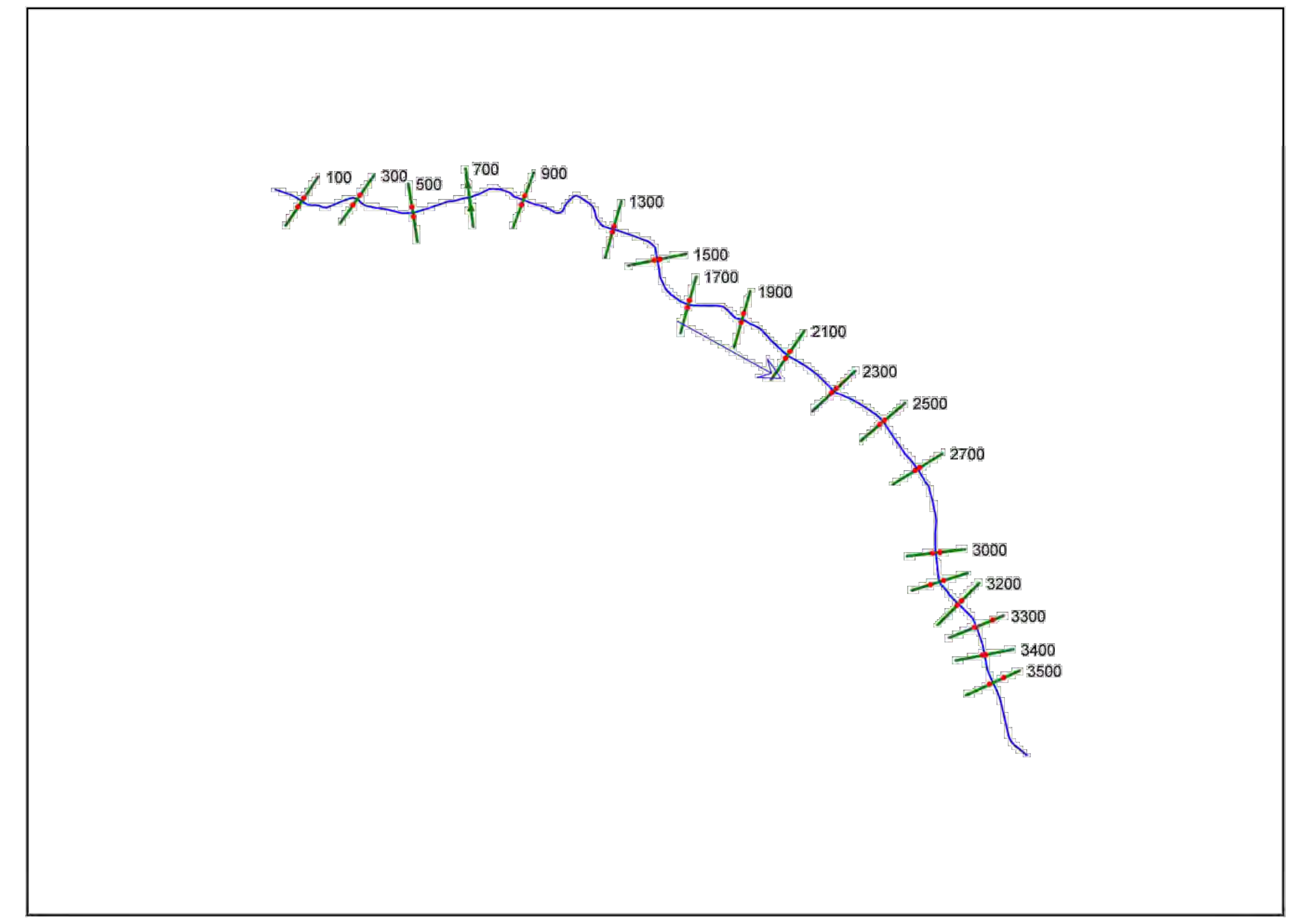
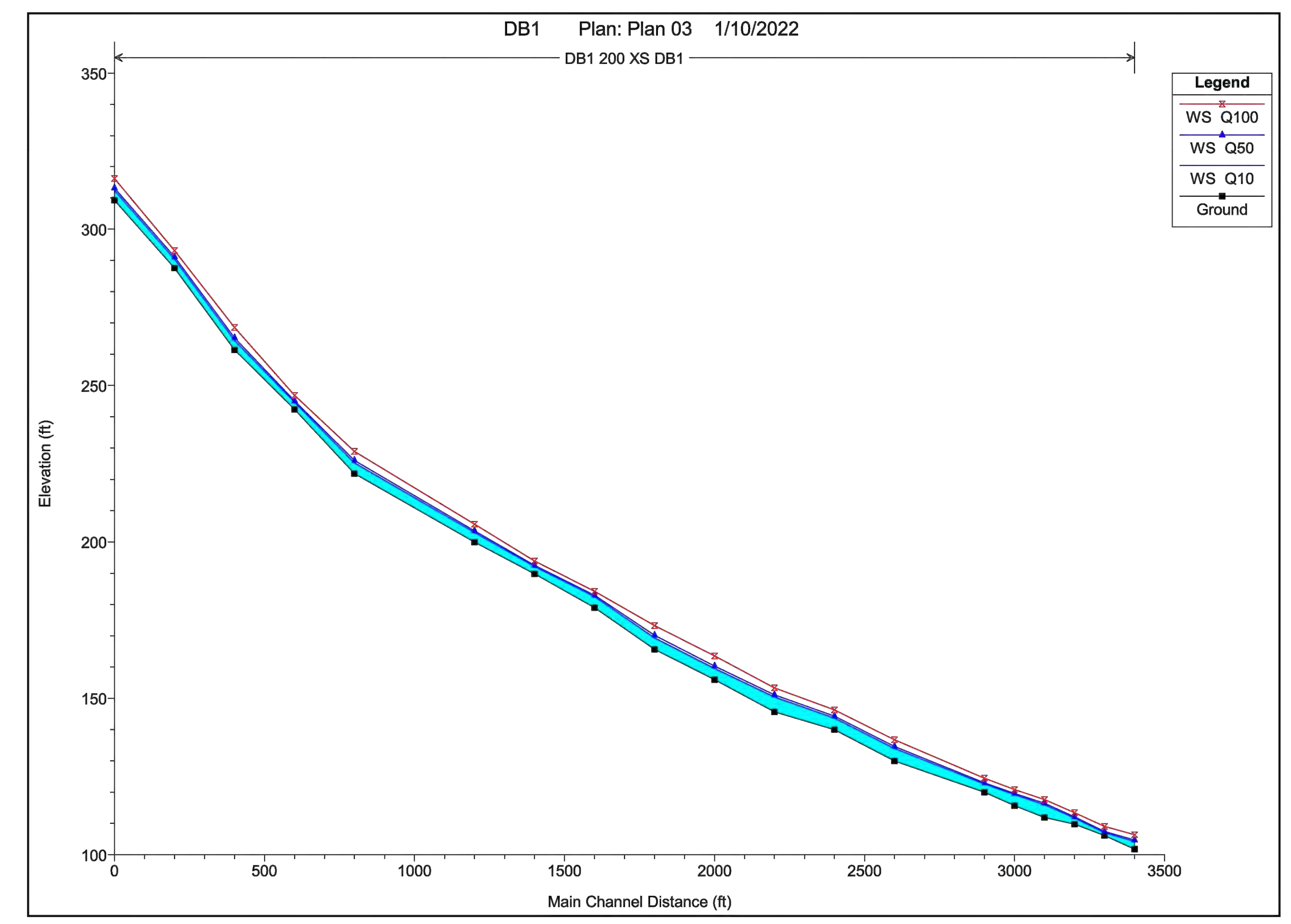
[illegible]	[illegible]	[illegible]	2380.00	261.45	268.54	268.54	271.01	0.000402	12.70	198.40	46.55	0.96
[illegible]	[illegible]	[illegible]	476.00	287.54	290.47	290.47	291.39	0.000612	7.70	61.78	33.94	1.01
[illegible]	[illegible]	[illegible]	714.00	287.54	291.09	291.09	292.21	0.000567	8.49	84.11	37.62	1.00
[illegible]	[illegible]	[illegible]	2380.00	287.54	293.13	293.13	293.84	0.000238	8.07	403.15	126.94	0.71
[illegible]	[illegible]	[illegible]	476.00	309.24	312.47	312.47	313.49	0.000591	8.09	58.83	28.98	1.00
[illegible]	[illegible]	[illegible]	714.00	309.24	313.16	313.16	314.41	0.000555	8.96	79.66	31.92	1.00
[illegible]	[illegible]	[illegible]	2380.00	309.24	316.16	316.16	316.73	0.000146	7.44	484.93	128.89	0.58





DRAINAGE BASIN #1

ESTIMATED AREA = 560 ACRES
RUNOFF COEFFICIENT = 0.34
(Q10) i = 2.5"
(Q50) i = 3.75"
(Q100) i = 12.5"

EXPIRES: 04-30-2022

This work was prepared by me or under my supervision and construction will be under my observation. (Observation of construction as defined in Section 1.2 (N) in the rules and regulations of the Board of Professional Engineers, Architects, and Surveyors of the State of Hawaii.)

CIVIL ENGINEERING & LANDSCAPE ARCHITECTURE CONSULTANTS

CDF Engineering LLC

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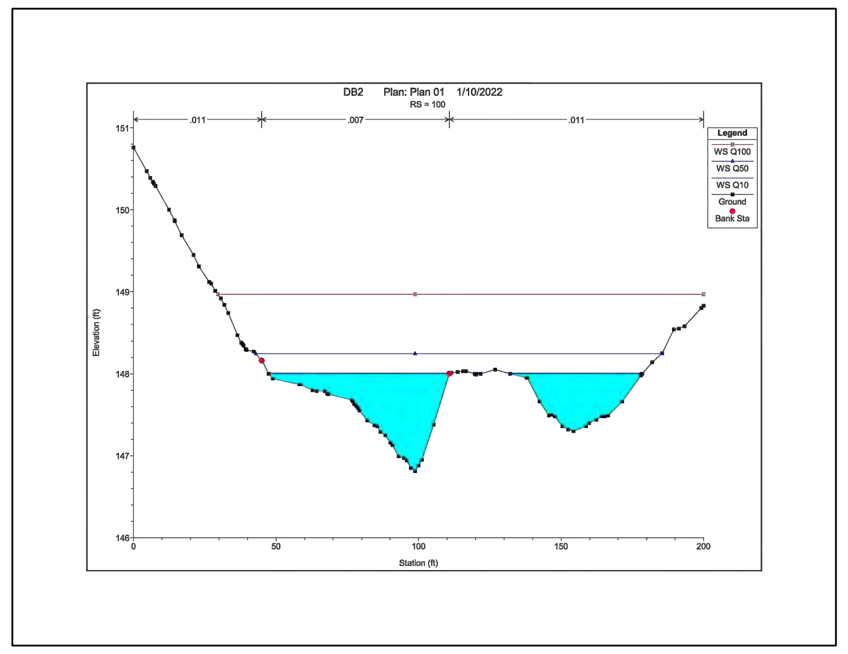
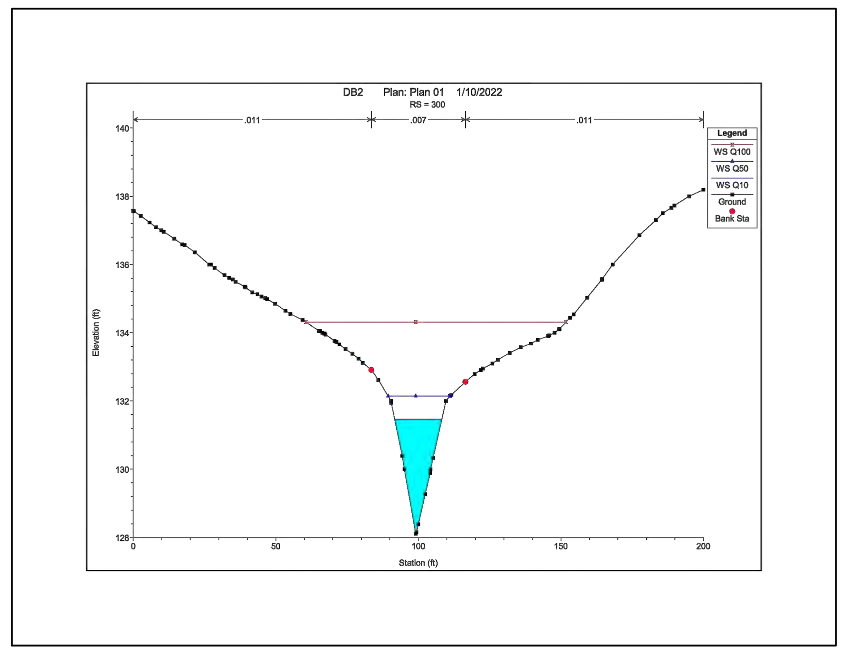
Phone: (808) 891-2400

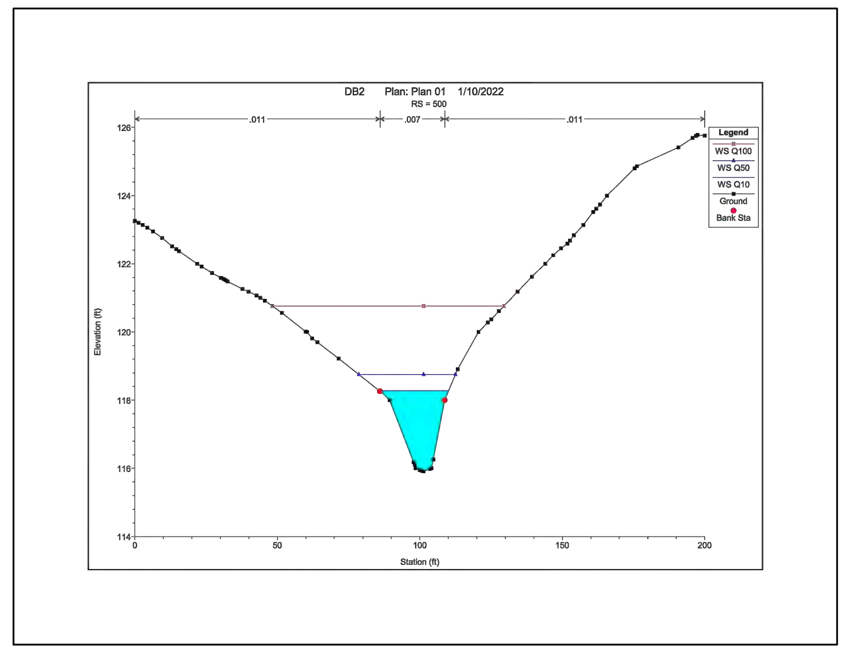
POHAKEA WATERSHED BASIS OF DESIGN

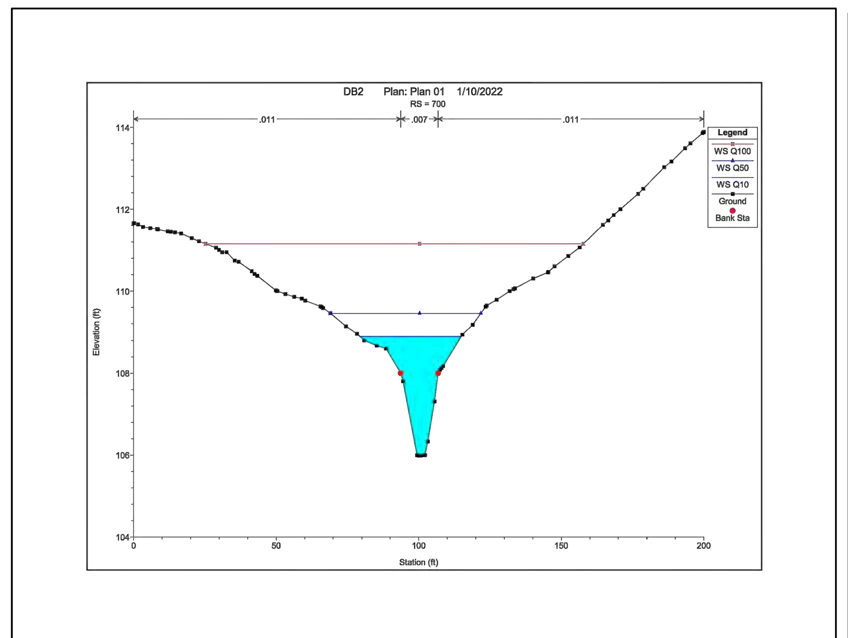
MAALAEA HARBOR
MAALAEA, HI 96793

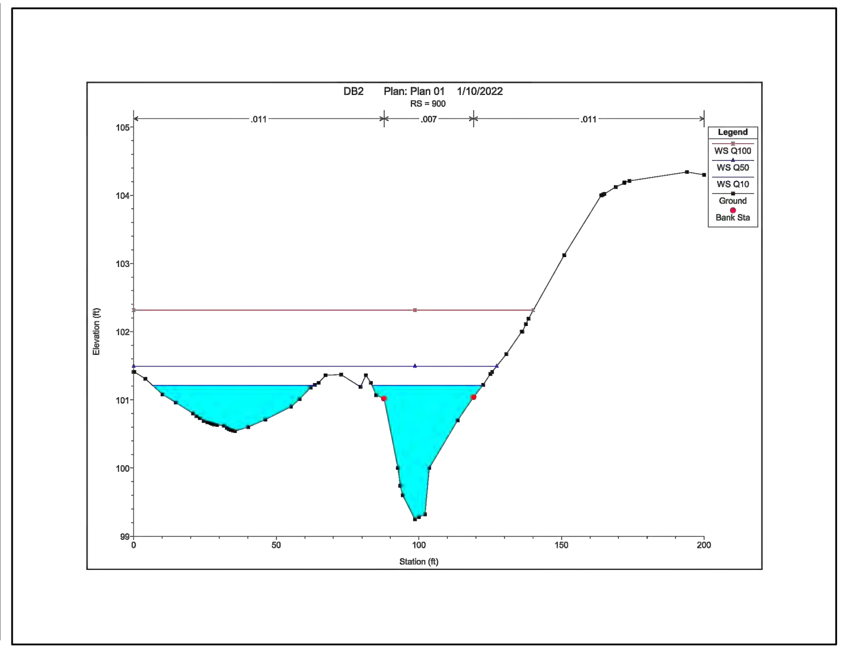
Scale:		DWG No.
N.T.S.	BASIN #1	C-2
01-28-2022	TMK: (2) 3-6-001:018	

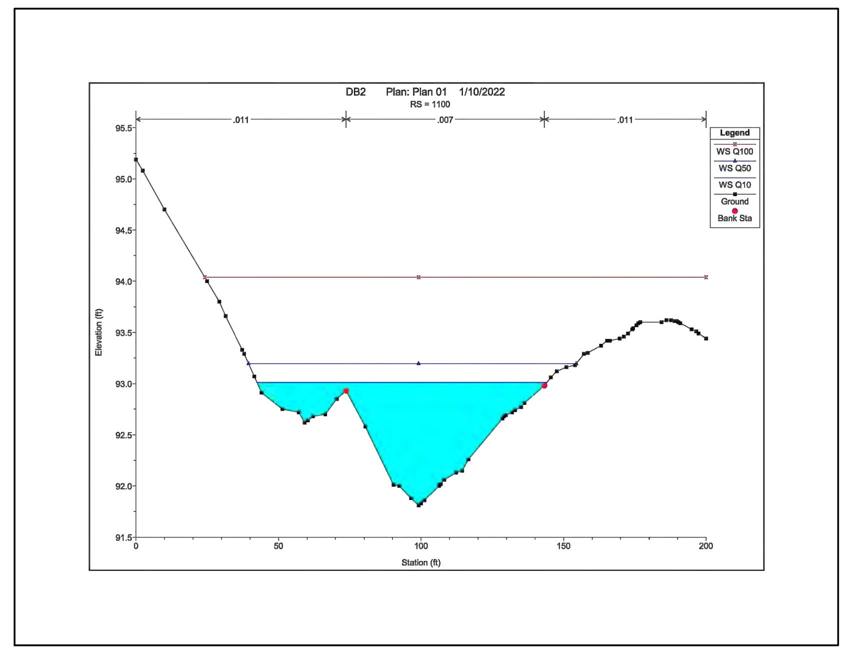


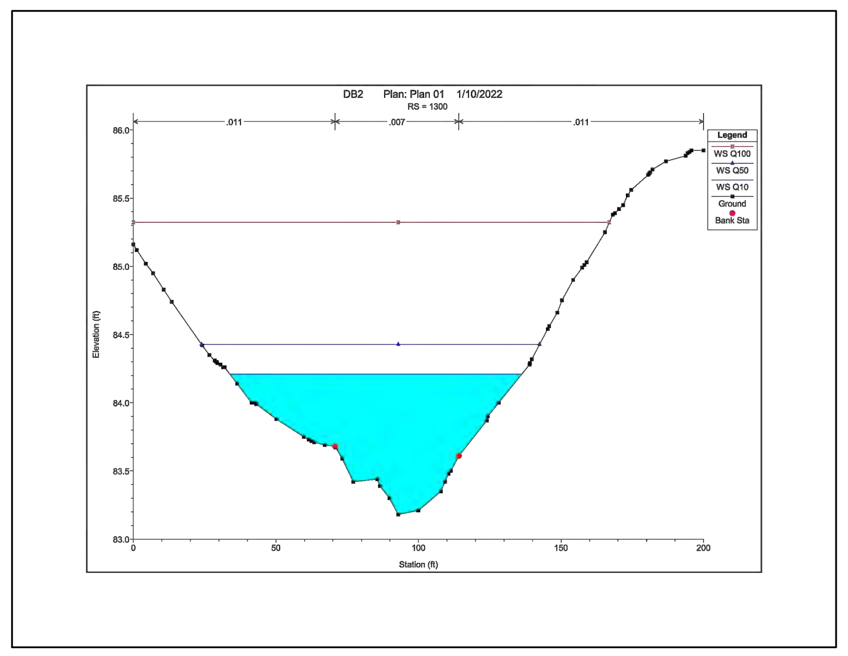


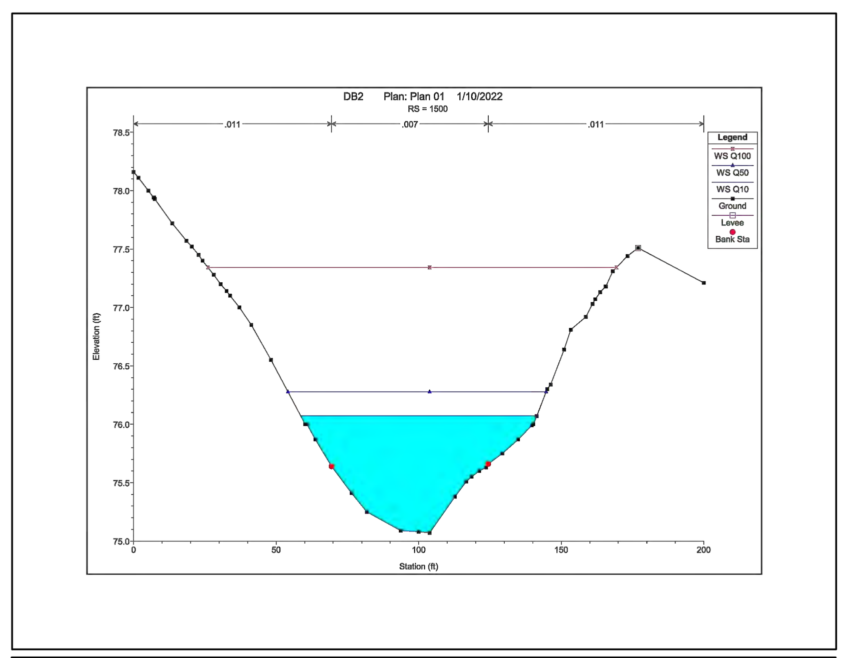


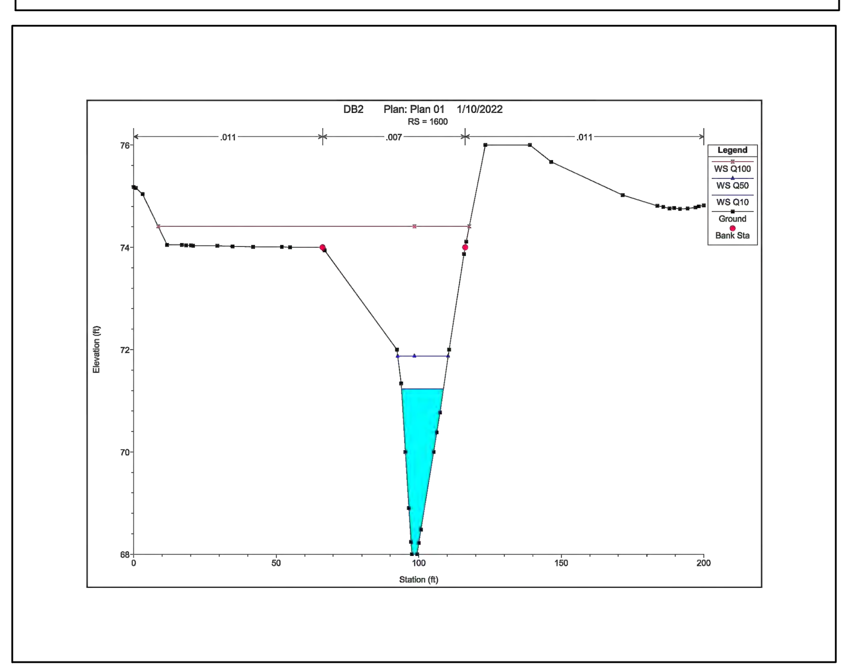


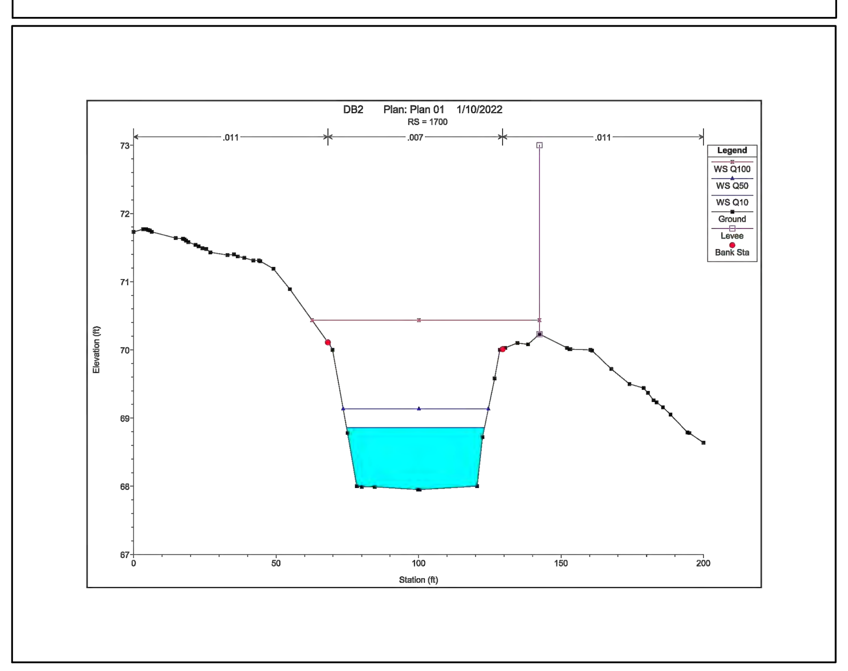


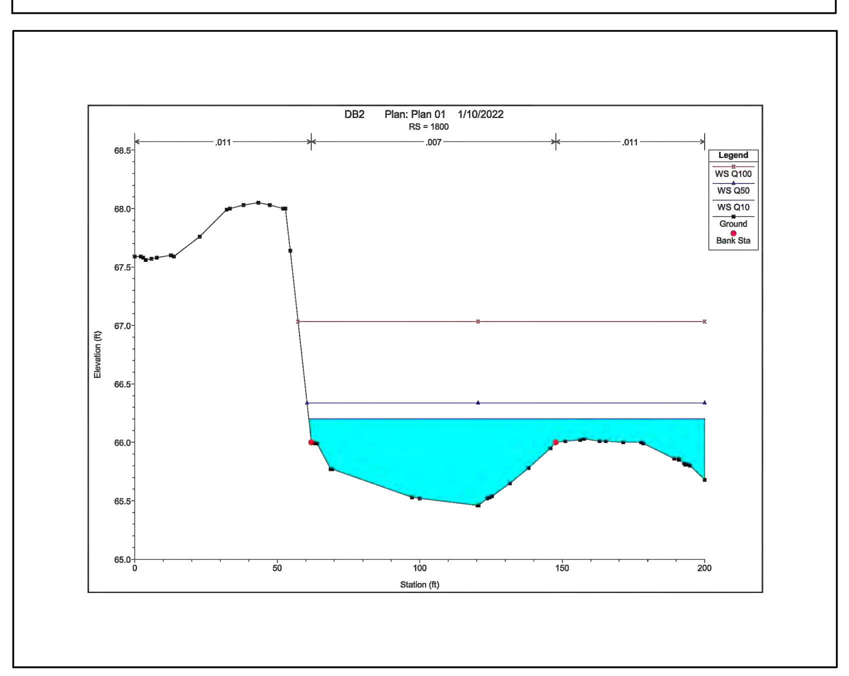


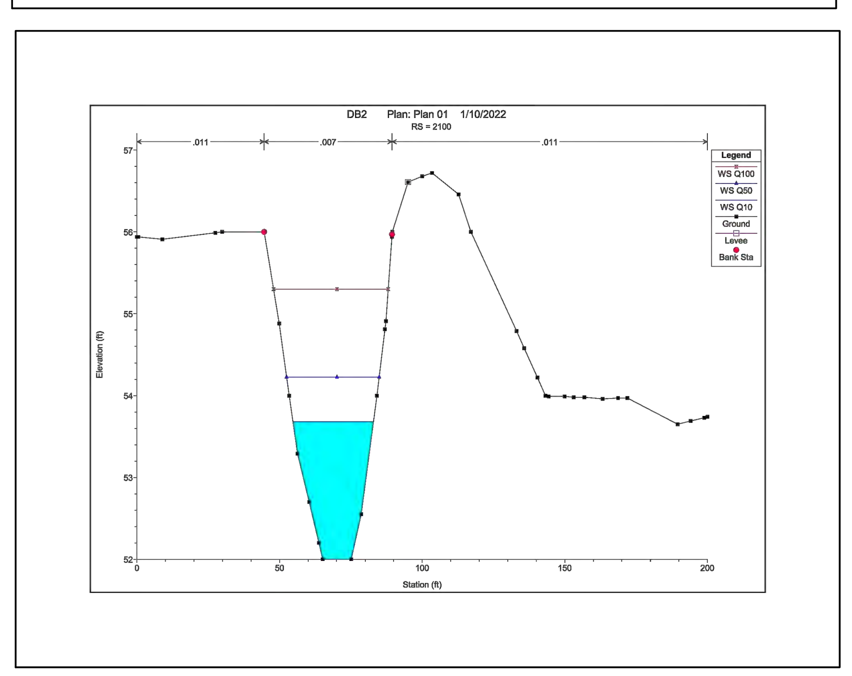






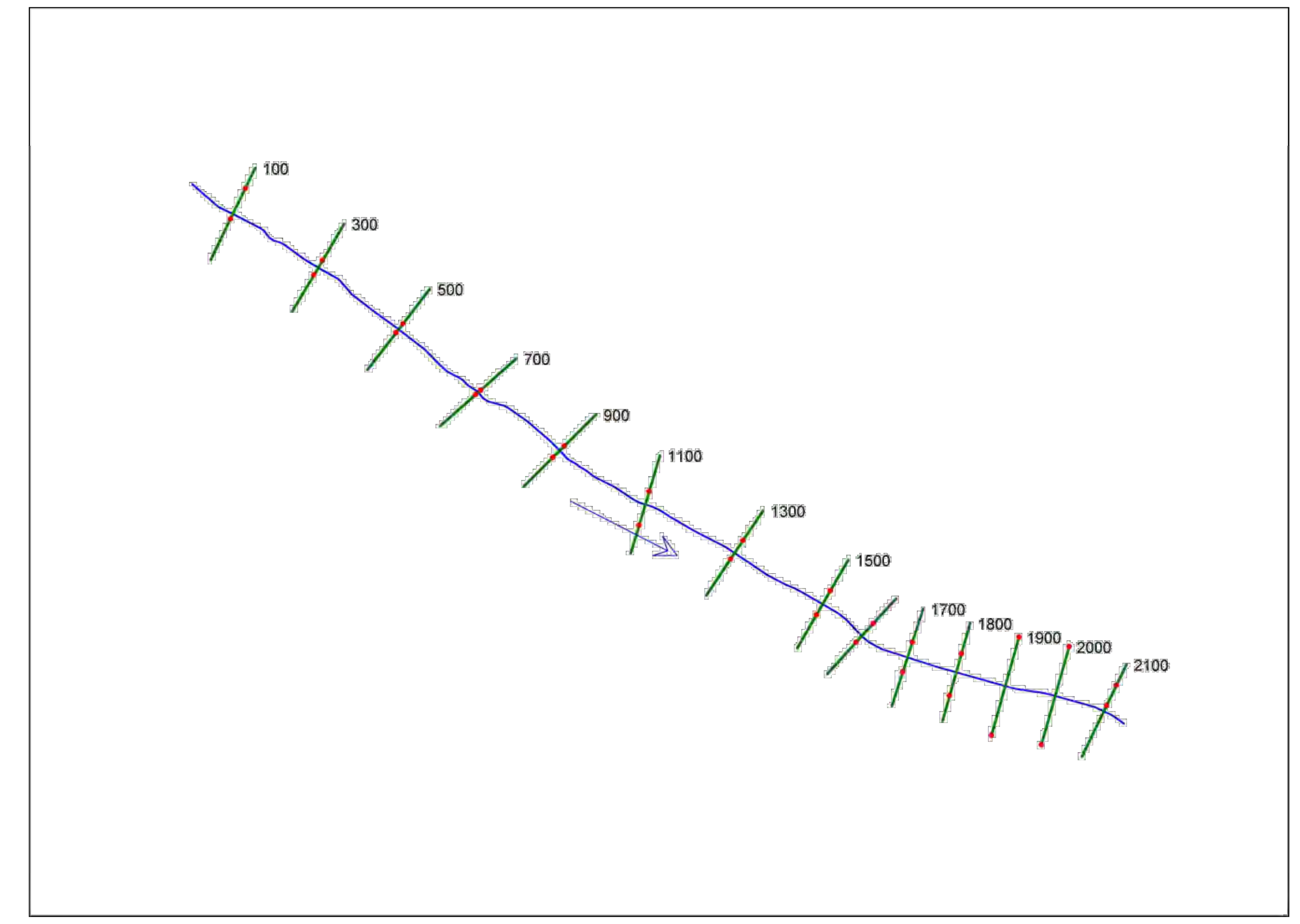


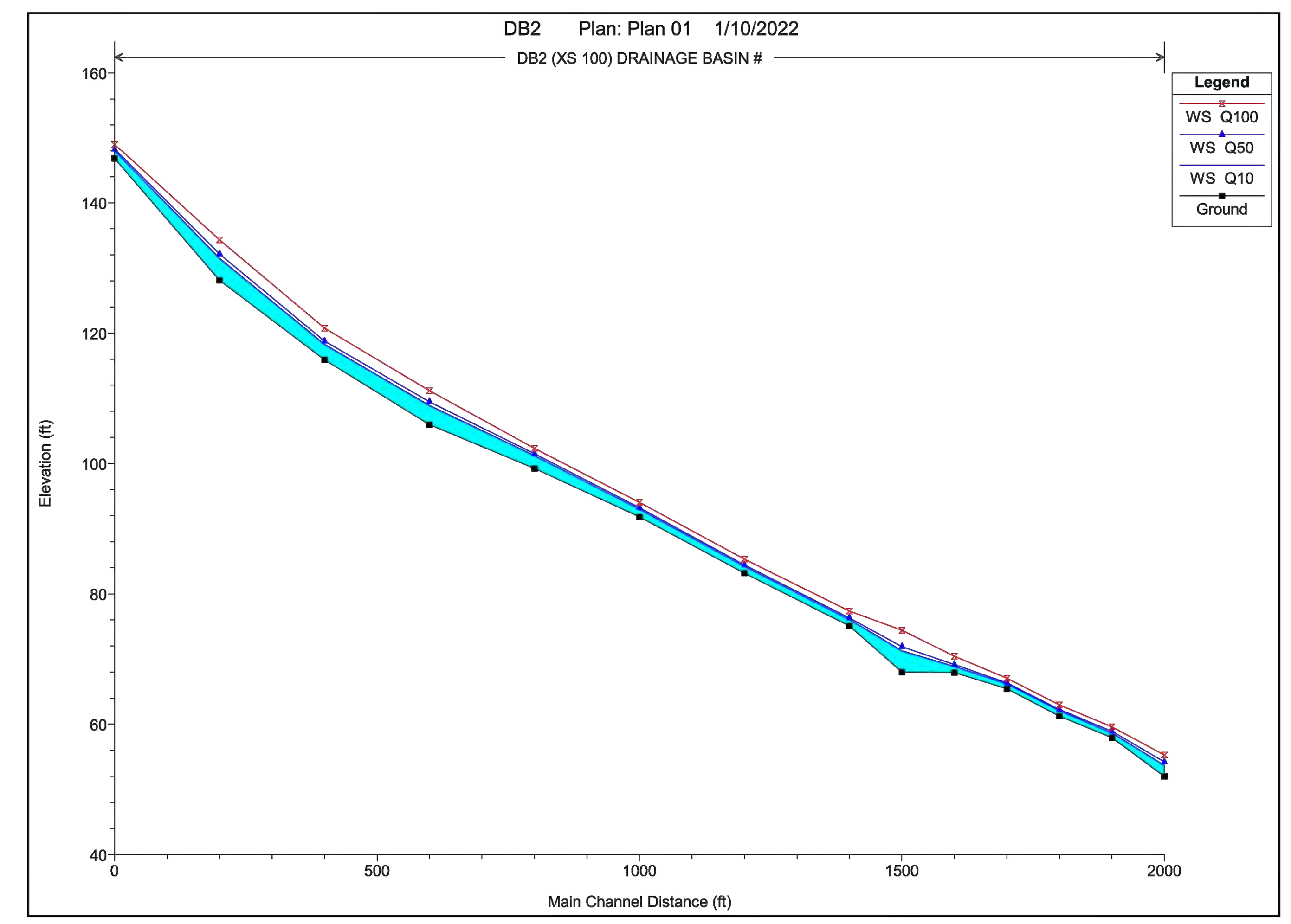




HEC-RAS Plan: Plan 01 River: DB2 (XS 100) Reach: DRAINAGE BASIN #

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
DRAINAGE BASIN #	2100	Q10	206.55	52.00	53.68	53.68	54.27	0.000675	6.15	33.69	33.58	0.99
DRAINAGE BASIN #	2100	Q50	309.83	52.00	54.22	54.22	54.68	0.000405	5.65	70.37	92.09	0.80
DRAINAGE BASIN #	2100	Q100	1032.75	52.00	55.30	55.30	56.05	0.000503	8.00	181.32	113.88	0.95
DRAINAGE BASIN #	2000	Q10	206.55	57.94	58.65	58.65	58.95	0.000871	4.40	46.90	78.82	1.01
DRAINAGE BASIN #	2000	Q50	309.83	57.94	58.91	58.91	59.19	0.000884	4.26	72.68	129.94	1.00
DRAINAGE BASIN #	2000	Q100	1032.75	57.94	59.59	59.59	60.19	0.000705	6.16	167.57	144.90	1.01
DRAINAGE BASIN #	1900	Q10	206.55	61.27	62.10	62.10	62.33	0.000982	3.86	53.48	120.02	1.02
DRAINAGE BASIN #	1900	Q50	309.83	61.27	62.24	62.24	62.54	0.000895	4.36	71.02	123.72	1.02
DRAINAGE BASIN #	1900	Q100	1032.75	61.27	62.96	62.96	63.56	0.000701	6.19	166.91	142.80	1.01
[illegible]	[illegible]		206.55	65.46	66.20	66.20	66.42	0.000760	3.94	60.79	138.96	0.93
[illegible]	[illegible]		309.83	65.46	66.34	66.34	66.63	0.000761	4.56	79.67	139.57	0.97
[illegible]	[illegible]		1032.75	65.46	67.03	67.03	67.66	0.000684	6.89	177.99	142.72	1.03
[illegible]	[illegible]		206.55	67.95	68.86	68.86	69.26	0.000767	5.16	40.04	48.44	1.00
[illegible]	[illegible]		309.83	67.95	69.13	69.13	69.65	0.000705	5.80	53.45	50.93	1.00
[illegible]	[illegible]		1032.75	67.95	70.44	70.44	71.13	0.000424	7.09	183.63	137.36	0.87
[illegible]	[illegible]		206.55	68.00	71.23	71.23	72.15	0.000683	7.69	26.86	14.67	1.00
[illegible]	[illegible]		309.83	68.00	71.87	71.87	72.95	0.000661	8.33	37.21	17.70	1.01
[illegible]	[illegible]		1032.75	68.00	74.41	74.41	75.33	0.000411	7.80	150.50	109.14	0.86
[illegible]	[illegible]		206.55	75.07	76.07	76.07	76.40	0.000682	4.67	48.84	82.96	0.94
[illegible]	[illegible]		309.83	75.07	76.28	76.28	76.69	0.000659	5.36	66.45	90.57	0.96
[illegible]	[illegible]		1032.75	75.07	77.34	77.34	78.05	0.000469	7.40	189.09	153.50	0.91
[illegible]	[illegible]		206.55	83.18	84.21	84.21	84.52	0.000649	4.81	55.55	102.51	0.93
[illegible]	[illegible]		309.83	83.18	84.43	84.43	84.79	0.000588	5.34	79.66	118.59	0.92
[illegible]	[illegible]		1032.75	83.18	85.32	85.32	85.94	0.000526	7.60	209.16	166.94	0.96
[illegible]	[illegible]		206.55	91.81	93.01	93.01	93.29	0.000739	4.33	52.78	101.79	0.95
[illegible]	[illegible]		309.83	91.81	93.19	93.19	93.54	0.000682	4.90	72.24	114.90	0.95
[illegible]	[illegible]		1032.75	91.81	94.04	94.04	94.64	0.000531	6.90	200.54	175.89	0.94
[illegible]	[illegible]		206.55	99.25	101.21	101.21	101.54	0.000533	5.05	56.73	96.67	0.87
[illegible]	[illegible]		309.83	99.25	101.49	101.49	101.83	0.000442	5.37	89.06	127.28	0.82
[illegible]	[illegible]		1032.75	99.25	102.31	102.31	102.97	0.000541	8.18	199.23	140.06	0.98
[illegible]	[illegible]		206.55	105.98	108.90	108.90	109.61	0.000426	6.97	36.27	35.51	0.84
[illegible]	[illegible]		309.83	105.98	109.46	109.46	110.18	0.000350	7.39	61.26	52.68	0.79
[illegible]	[illegible]		1032.75	105.98	111.16	111.16	112.00	0.000311	9.66	220.54	132.51	0.81
[illegible]	[illegible]		206.55	115.91	118.28	118.28	118.97	0.000679	6.67	31.12	24.33	1.01
[illegible]	[illegible]		309.83	115.91	118.75	118.75	119.57	0.000548	7.32	44.96	33.89	0.95
[illegible]	[illegible]		1032.75	115.91	120.76	120.76	121.92	0.000347	9.53	157.96	81.32	0.86
[illegible]	[illegible]		206.55	128.11	131.47	131.47	132.33	0.000684	7.44	27.75	16.54	1.01
[illegible]	[illegible]		309.83	128.11	132.14	132.14	133.06	0.000631	7.70	40.23	21.63	1.00
[illegible]	[illegible]		1032.75	128.11	134.31	134.31	135.36	0.000361	8.63	153.48	91.18	0.84
[illegible]	[illegible]		206.55	146.81	148.01	148.01	148.34	0.001529	5.07	48.92	114.66	1.29
[illegible]	[illegible]		309.83	146.81	148.24	148.24	148.54	0.000871	4.92	80.96	142.41	1.04
[illegible]	[illegible]		1032.75	146.81	148.97	148.97	149.55	0.000702	7.10	195.57	170.44	1.05





DRAINAGE BASIN #2

ESTIMATED AREA = 243 ACRES
RUNOFF COEFFICIENT = 0.34
(Q10) i = 2.5"
(Q50) i = 3.75"
(Q100) i = 12.5"

JACOB R. FREEMAN
LICENSED PROFESSIONAL ENGINEER
HAWAII, U.S.A.

EXPIRES: 04-30-2022

This work was prepared by me or under my supervision and construction will be under my observation. (Observation of construction as defined in Section 1.2 (N) in the rules and regulations of the Board of Professional Engineers, Architects, and Surveyors of the State of Hawaii.)

CIVIL ENGINEERING & LANDSCAPE ARCHITECTURE CONSULTANTS

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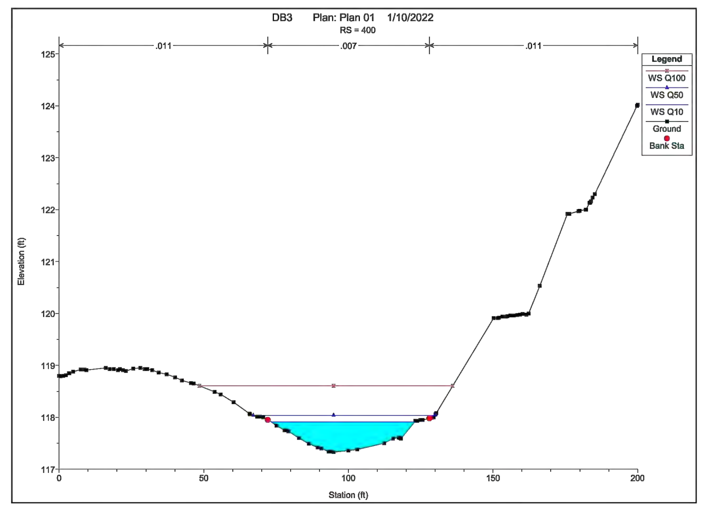
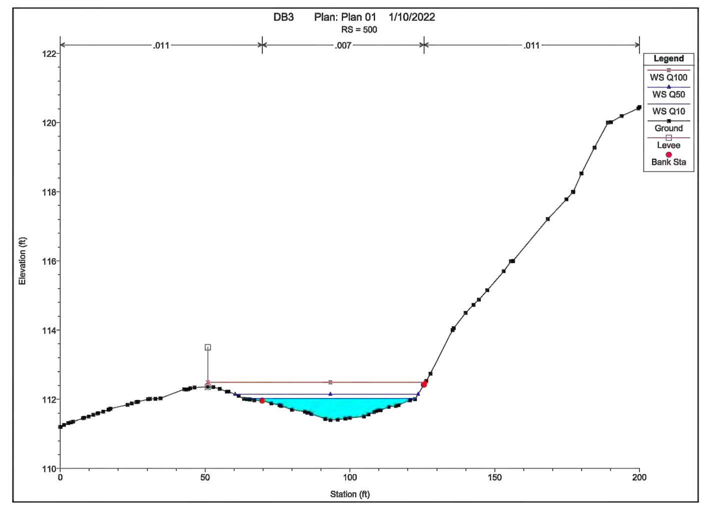
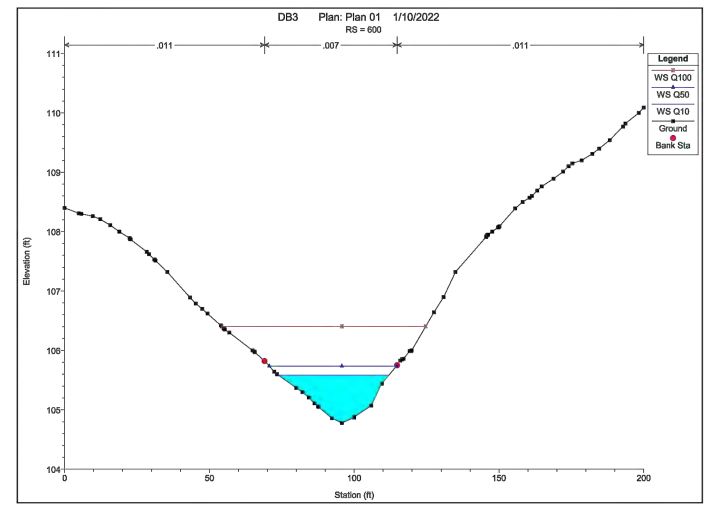
Phone: (808) 891-2400

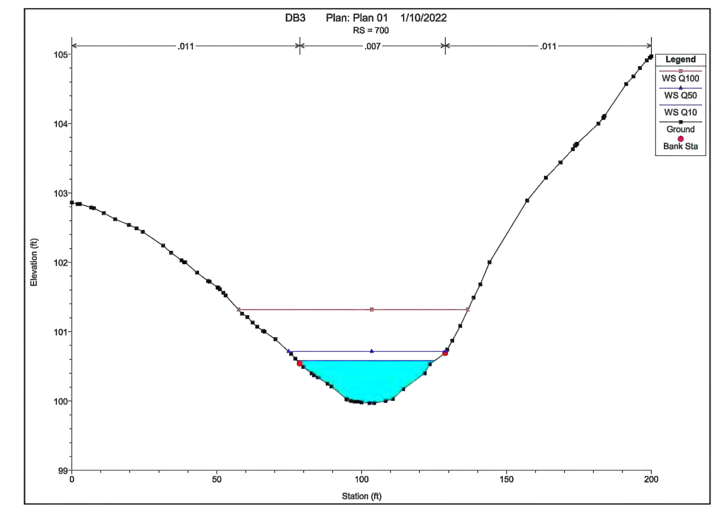
POHAKEA WATERSHED BASIS OF DESIGN
MAALAEA HARBOR
MAALAEA, HI 96793

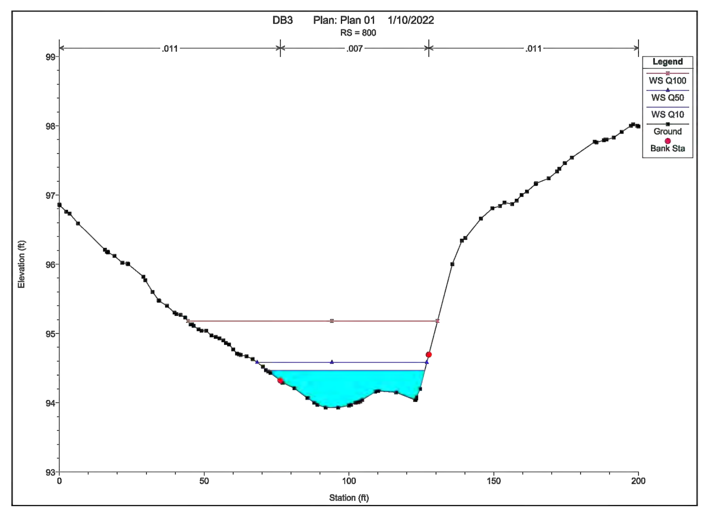
Scale:		DWG No.
N.T.S.	BASIN #2	C-3
01-28-2022	TMK: (2) 3-6-001:018	

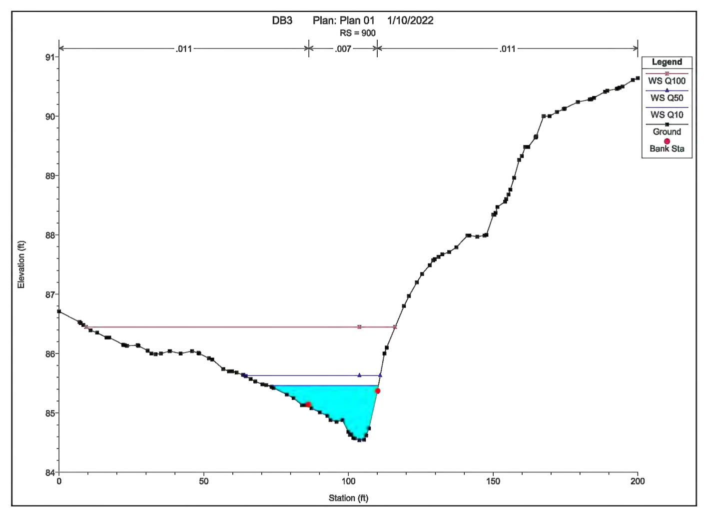


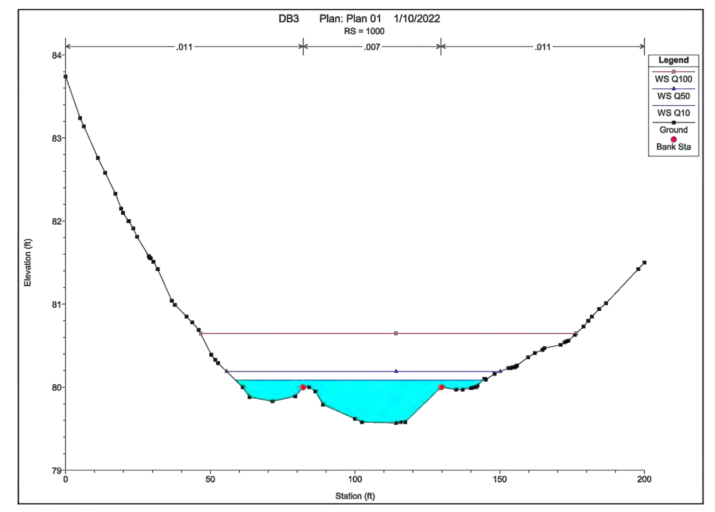


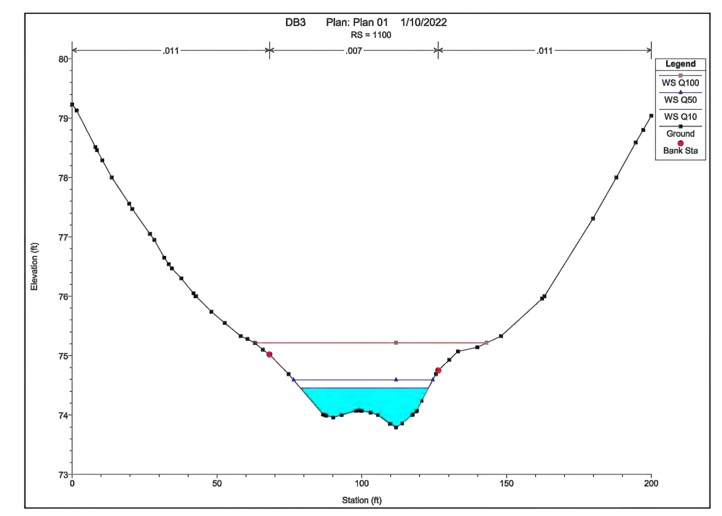


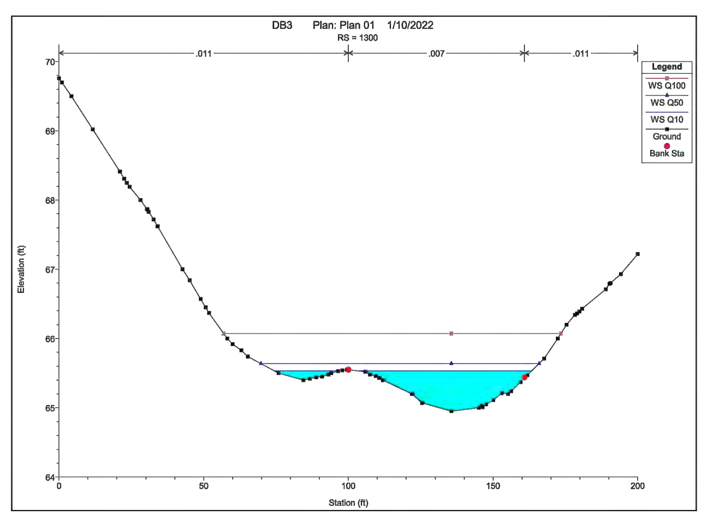


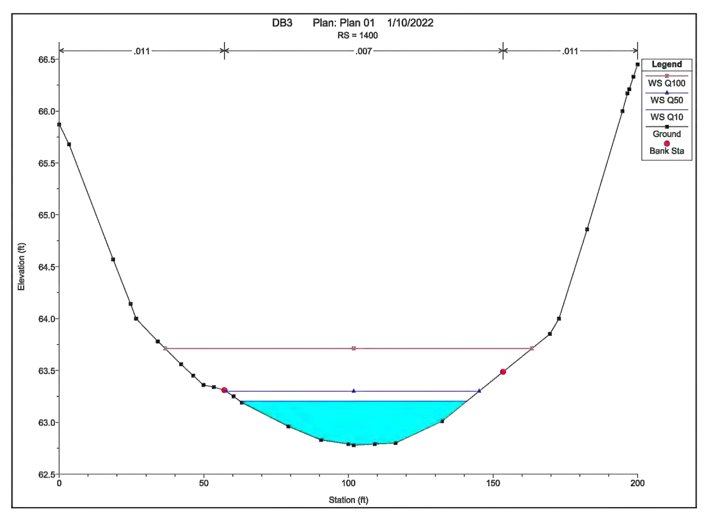


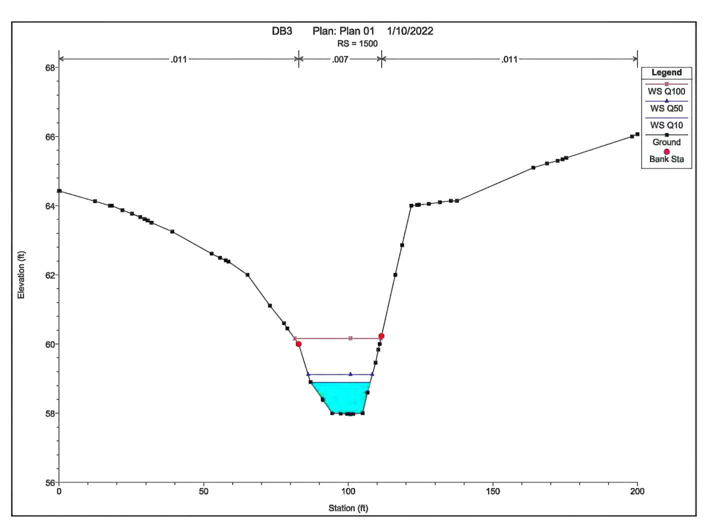


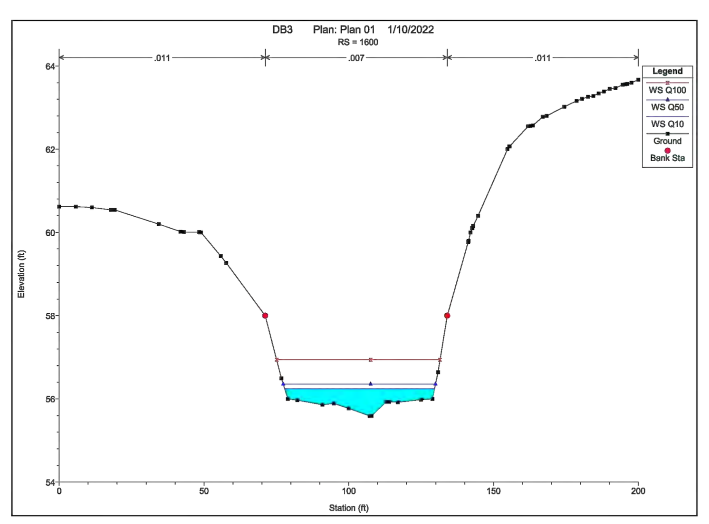


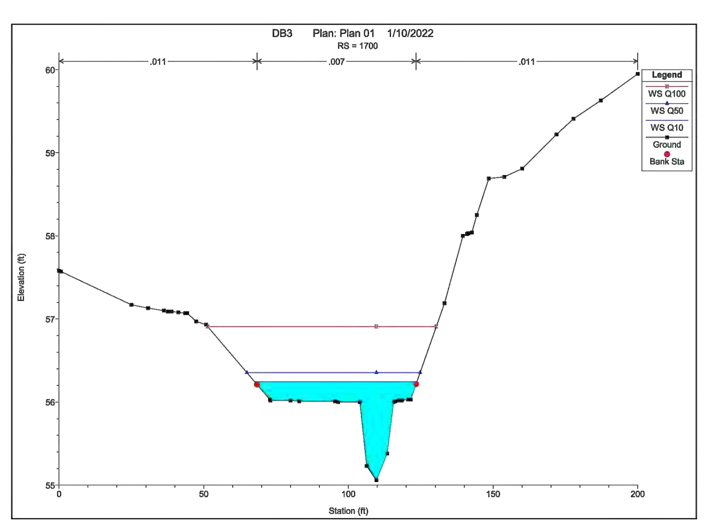






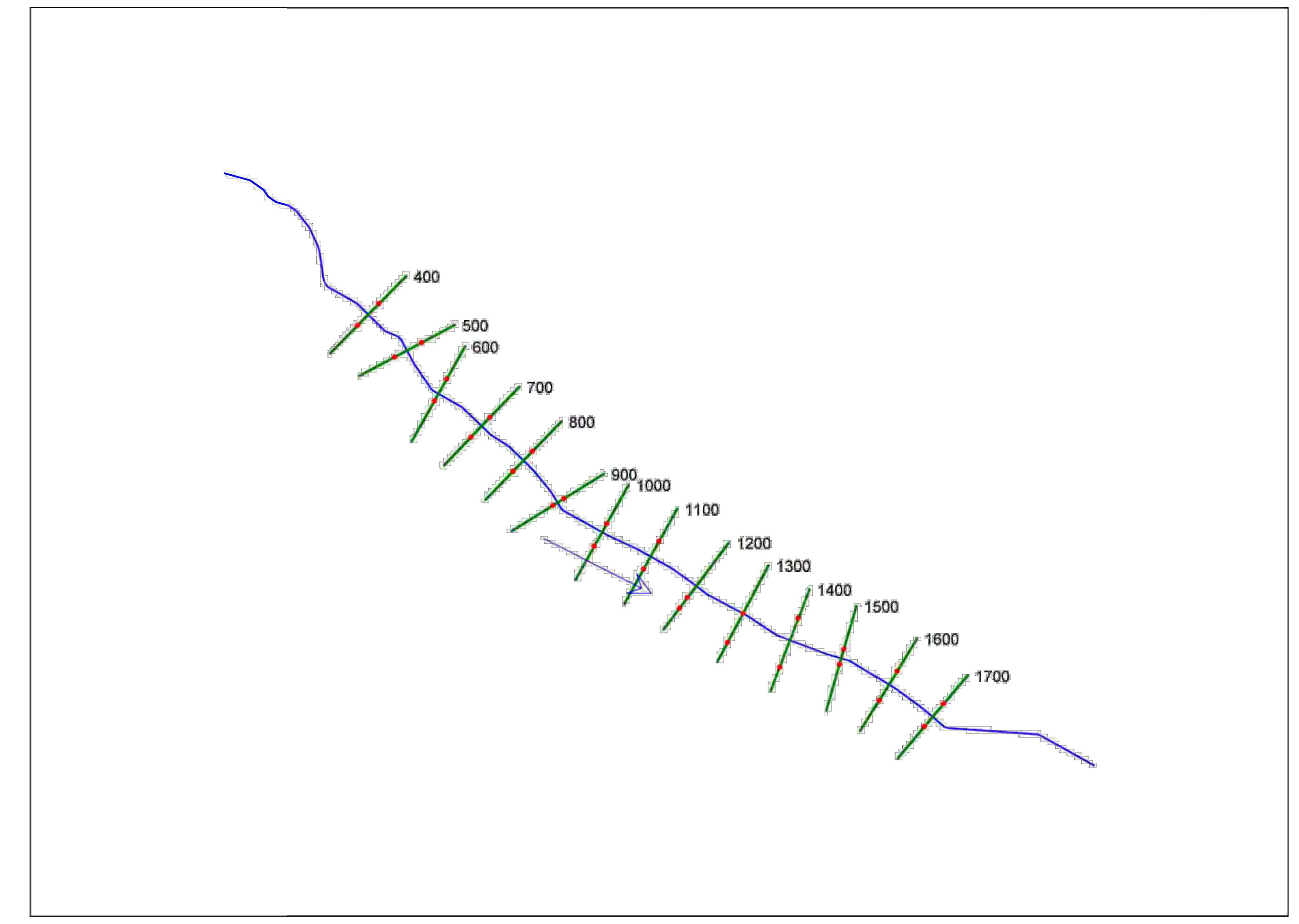


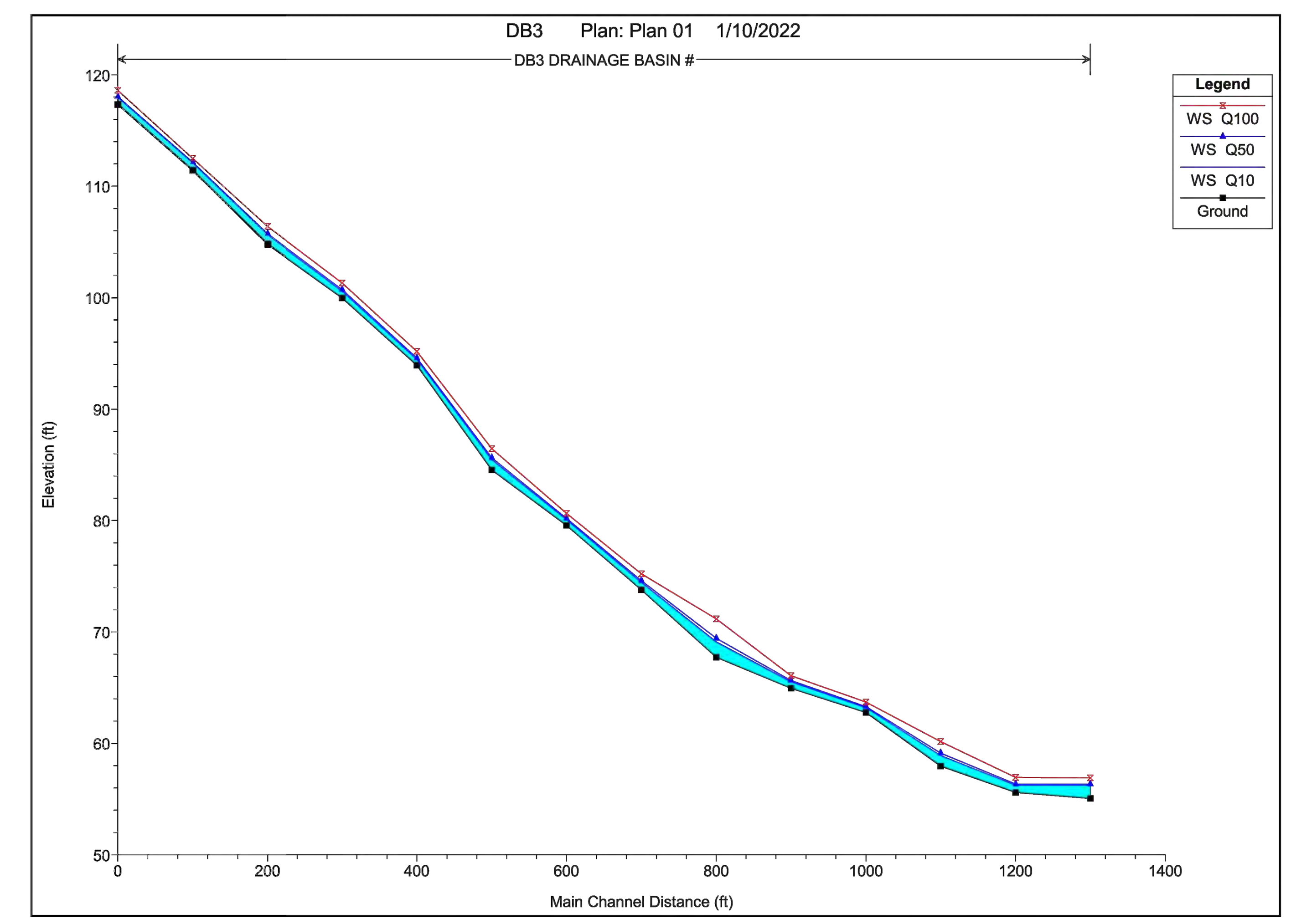




HEC-RAS Plan: Plan 01 River: DB3 Reach: DRAINAGE BASIN #

Reach	River Sta	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
DRAINAGE BASIN #	1700	[illegible]	65.45	55.06	56.24	56.24	56.42	0.000998	3.35	19.54	56.06	0.99
DRAINAGE BASIN #	1700	[illegible]	98.18	55.06	56.35	56.35	56.58	0.000912	3.83	25.89	59.85	0.99
DRAINAGE BASIN #	1700	[illegible]	327.30	55.06	56.91	56.91	57.37	0.000678	5.58	64.42	79.04	0.97
DRAINAGE BASIN #	1600	[illegible]	65.45	55.59	56.24	56.24	56.43	0.001029	3.47	18.86	51.73	1.01
DRAINAGE BASIN #	1600	[illegible]	98.18	55.59	56.35	56.35	56.60	0.000945	3.95	24.85	52.60	1.01
DRAINAGE BASIN #	1600	[illegible]	327.30	55.59	56.94	56.94	57.46	0.000730	5.75	56.94	56.47	1.01
DRAINAGE BASIN #	1500	[illegible]	65.45	57.97	58.89	58.89	59.23	0.000835	4.70	13.93	20.59	1.01
DRAINAGE BASIN #	1500	[illegible]	98.18	57.97	59.12	59.12	59.54	0.000773	5.23	18.76	22.19	1.00
DRAINAGE BASIN #	1500	[illegible]	327.30	57.97	60.16	60.16	60.96	0.000631	7.20	45.58	29.83	1.00
DRAINAGE BASIN #	1400	[illegible]	65.45	62.78	63.20	63.20	63.35	0.001116	3.01	21.73	78.52	1.01
DRAINAGE BASIN #	1400	[illegible]	98.18	62.78	63.30	63.30	63.47	0.001034	3.31	29.62	87.53	1.00
DRAINAGE BASIN #	1400	[illegible]	327.30	62.78	63.71	63.71	64.04	0.000756	4.65	74.76	126.88	0.97
DRAINAGE BASIN #	1300	[illegible]	65.45	64.95	65.53	65.53	65.69	0.000888	3.15	22.18	83.31	0.94
DRAINAGE BASIN #	1300	[illegible]	98.18	64.95	65.64	65.64	65.82	0.000816	3.49	31.64	96.15	0.93
DRAINAGE BASIN #	1300	[illegible]	327.30	64.95	66.07	66.07	66.43	0.000702	5.14	78.60	116.64	0.97
DRAINAGE BASIN #	1200	[illegible]	65.45	67.73	69.09	69.09	69.60	0.000773	5.71	11.46	11.46	1.01
DRAINAGE BASIN #	1200	[illegible]	98.18	67.73	69.43	69.43	70.05	0.000728	6.32	15.52	12.62	1.01
DRAINAGE BASIN #	1200	[illegible]	327.30	67.73	71.18	71.18	71.97	0.000466	7.24	50.93	44.67	0.87
DRAINAGE BASIN #	1100	[illegible]	65.45	73.79	74.46	74.46	74.66	0.000963	3.62	18.06	44.22	1.00
DRAINAGE BASIN #	1100	[illegible]	98.18	73.79	74.59	74.59	74.84	0.000896	4.03	24.35	48.10	1.00
DRAINAGE BASIN #	1100	[illegible]	327.30	73.79	75.22	75.22	75.68	0.000669	5.51	62.18	80.18	0.97
DRAINAGE BASIN #	1000	[illegible]	65.45	79.57	80.09	80.09	80.24	0.000907	3.30	23.49	85.70	0.96
DRAINAGE BASIN #	1000	[illegible]	98.18	79.57	80.19	80.19	80.38	0.000822	3.70	32.75	94.59	0.95
DRAINAGE BASIN #	1000	[illegible]	327.30	79.57	80.65	80.65	80.99	0.000690	5.32	84.77	129.89	0.97
DRAINAGE BASIN #	900	[illegible]	65.45	84.54	85.46	85.46	85.73	0.000784	4.29	17.06	38.19	0.96
DRAINAGE BASIN #	900	[illegible]	98.18	84.54	85.63	85.63	85.96	0.000725	4.84	24.31	46.89	0.96
DRAINAGE BASIN #	900	[illegible]	327.30	84.54	86.45	86.45	86.86	0.000437	6.05	86.94	106.87	0.84
DRAINAGE BASIN #	800	[illegible]	65.45	93.93	94.47	94.47	94.65	0.000958	3.45	19.26	54.69	0.99
DRAINAGE BASIN #	800	[illegible]	98.18	93.93	94.58	94.58	94.82	0.000882	3.92	25.85	58.60	0.99
DRAINAGE BASIN #	800	[illegible]	327.30	93.93	95.18	95.18	95.61	0.000597	5.46	69.27	86.23	0.93
DRAINAGE BASIN #	700	[illegible]	65.45	99.97	100.58	100.58	100.78	0.000971	3.56	18.41	47.46	1.00
DRAINAGE BASIN #	700	[illegible]	98.18	99.97	100.71	100.71	100.96	0.000884	3.94	25.15	54.37	0.99
DRAINAGE BASIN #	700	[illegible]	327.30	99.97	101.32	101.32	101.78	0.000618	5.61	65.60	79.22	0.94
DRAINAGE BASIN #	600	[illegible]	65.45	104.78	105.58	105.58	105.81	0.000953	3.84	17.07	38.06	1.01
DRAINAGE BASIN #	600	[illegible]	98.18	104.78	105.74	105.74	106.01	0.000903	4.19	23.43	43.95	1.01
DRAINAGE BASIN #	600	[illegible]	327.30	104.78	106.41	106.41	106.92	0.000607	5.83	61.87	70.55	0.95
DRAINAGE BASIN #	500	[illegible]	65.45	111.40	112.02	112.02	112.20	0.000989	3.40	19.50	59.53	0.99
DRAINAGE BASIN #	500	[illegible]	98.18	111.40	112.14	112.14	112.36	0.000868	3.80	26.71	63.18	0.97
DRAINAGE BASIN #	500	[illegible]	327.30	111.40	112.49	112.49	112.81	0.000787	5.14	83.34	126.10	1.01
DRAINAGE BASIN #	400	[illegible]	65.45	117.33	117.91	117.91	118.10	0.000987	3.49	18.76	49.54	1.00
DRAINAGE BASIN #	400	[illegible]	98.18	117.33	118.04	118.04	118.26	0.000921	3.83	25.87	62.80	1.00
DRAINAGE BASIN #	400	[illegible]	327.30	117.33	118.61	118.61	119.04	0.000626	5.40	68.02	87.55	0.94





DRAINAGE BASIN #3

ESTIMATED AREA = 77 ACRES
RUNOFF COEFFICIENT = 0.34
(Q10) i = 2.5"
(Q50) i = 3.75"
(Q100) i = 12.5"

EXPIRES: 04-30-2022

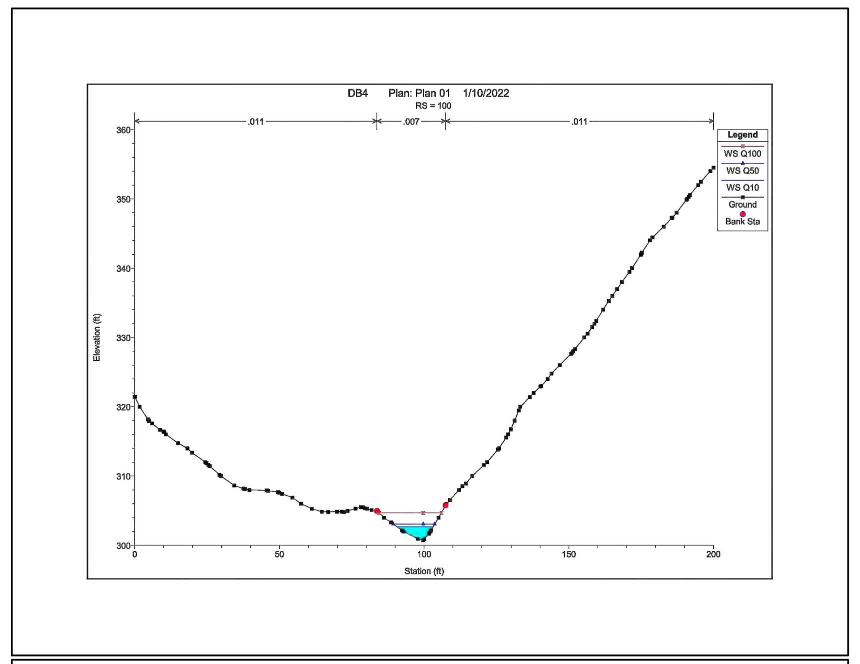
This work was prepared by me or under my supervision and construction will be under my observation. (Observation of construction as defined in Section 1.2 (N) in the rules and regulations of the Board of Professional Engineers, Architects, and Surveyors of the State of Hawaii.)

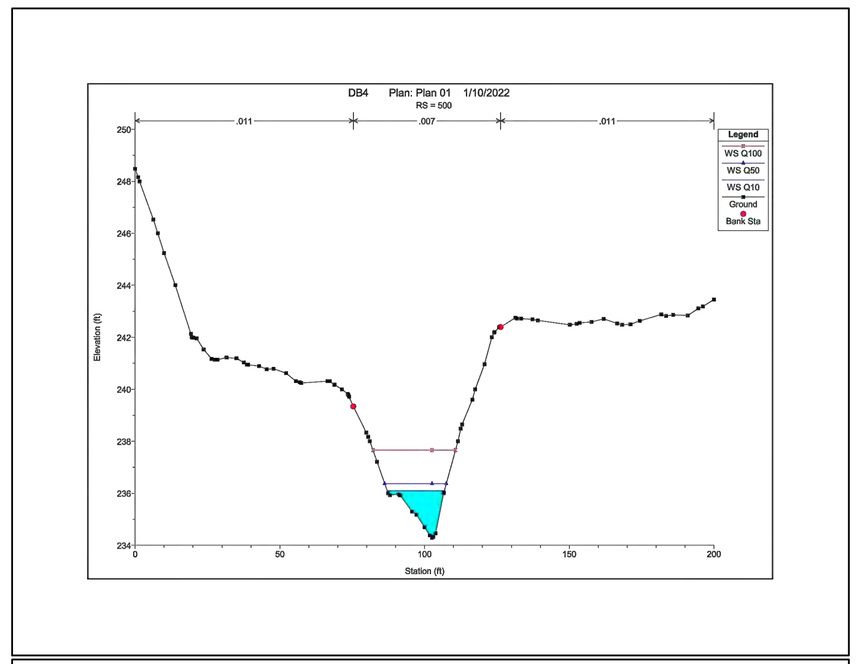
CIVIL ENGINEERING & LANDSCAPE ARCHITECTURE CONSULTANTS

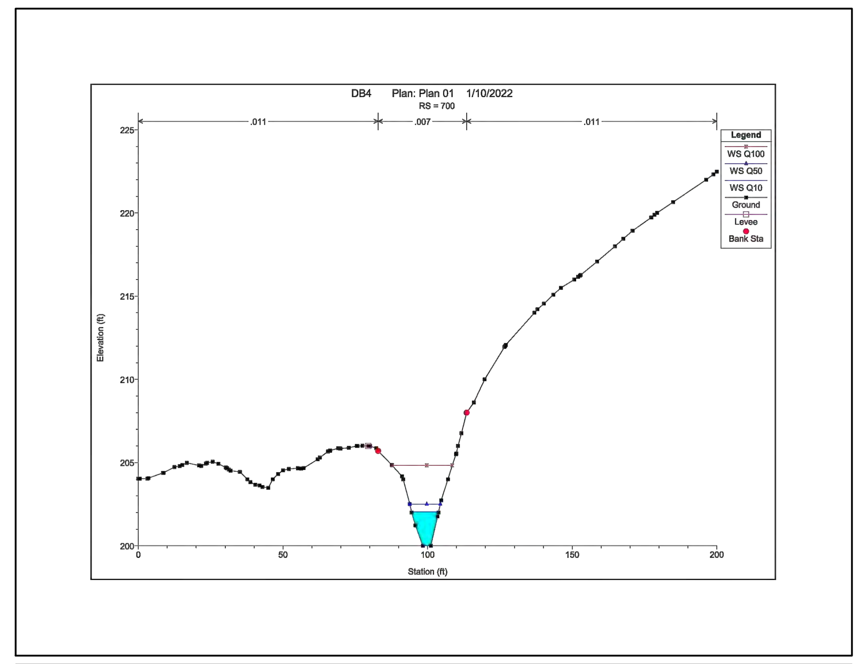
CDF Engineering LLC
PO Box 2985, Wailuku, HI 96793
Phone: (808) 891-2400

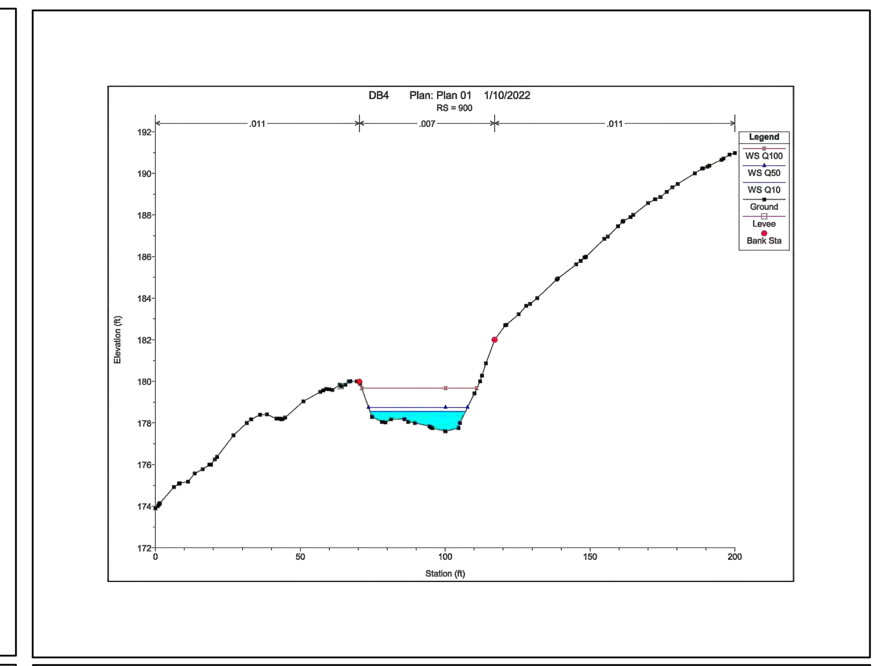
POHAKEA WATERSHED BASIS OF DESIGN
MAALAEA HARBOR
MAALAEA, HI 9673

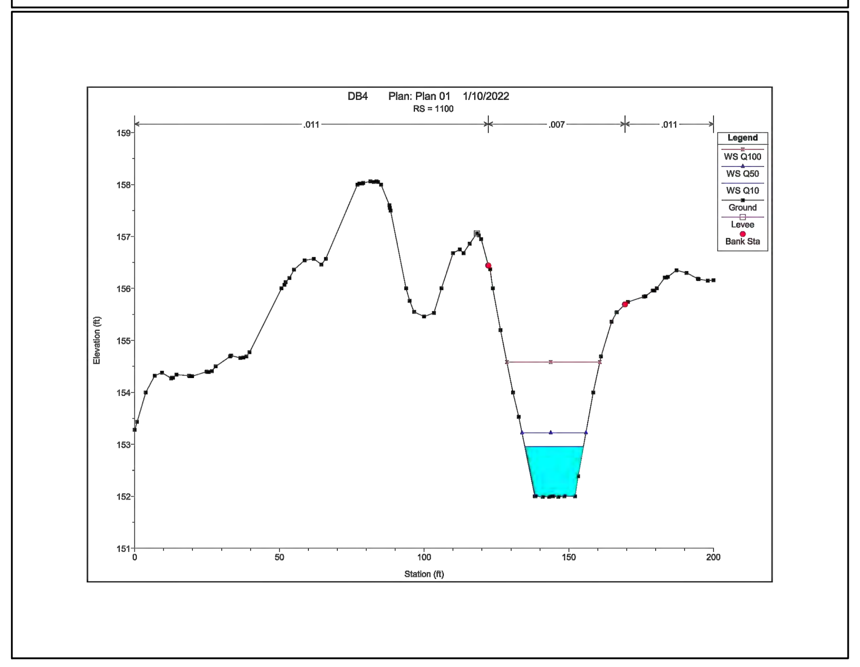
Scale:		DWG No.
N.T.S.	BASIN #3	C-4
01-28-2022	TMK: (2) 3-6-001:018	

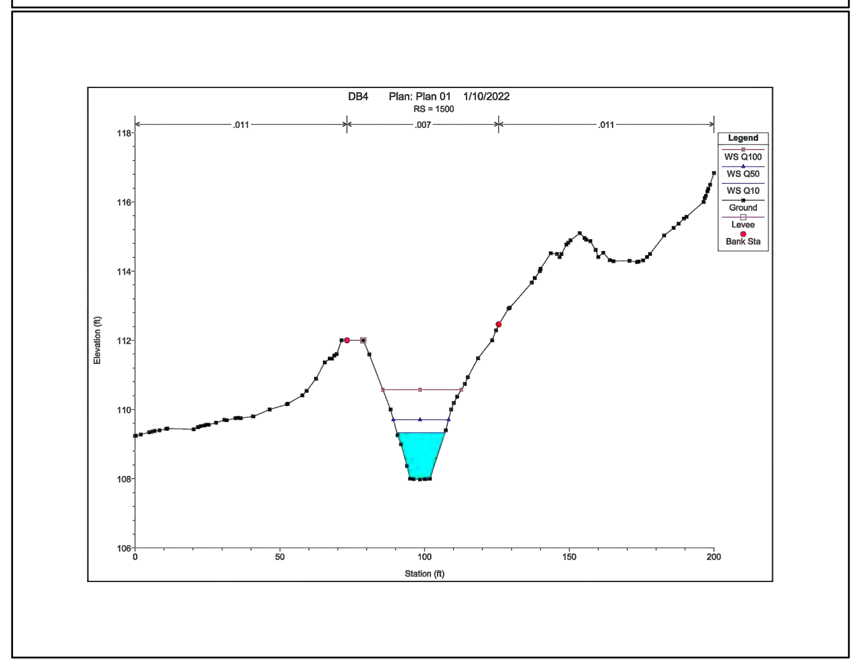


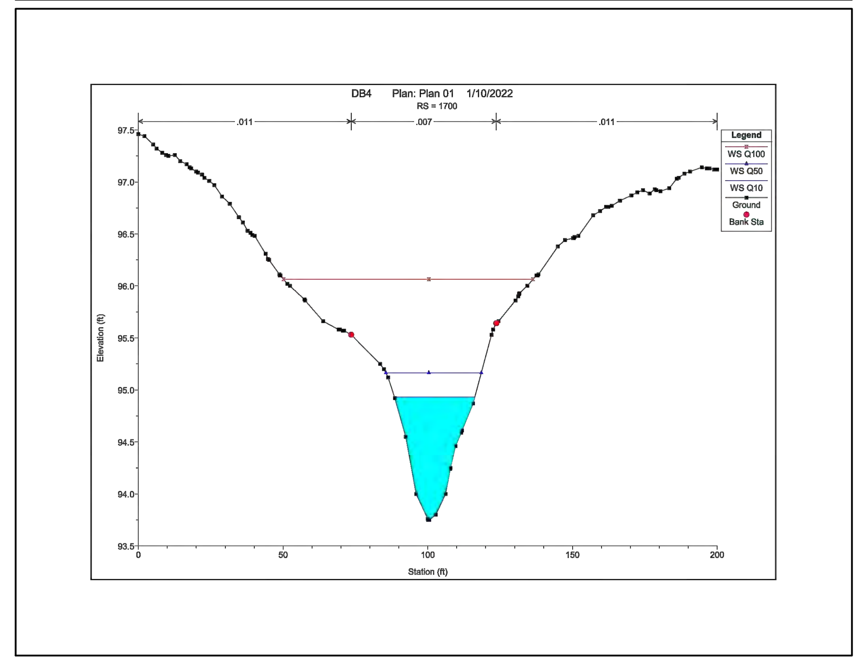


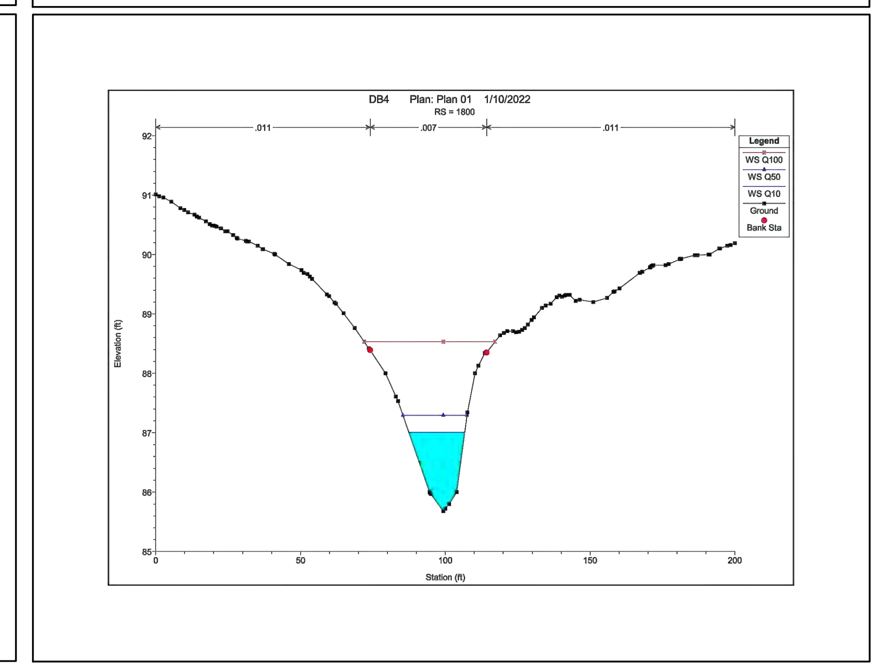


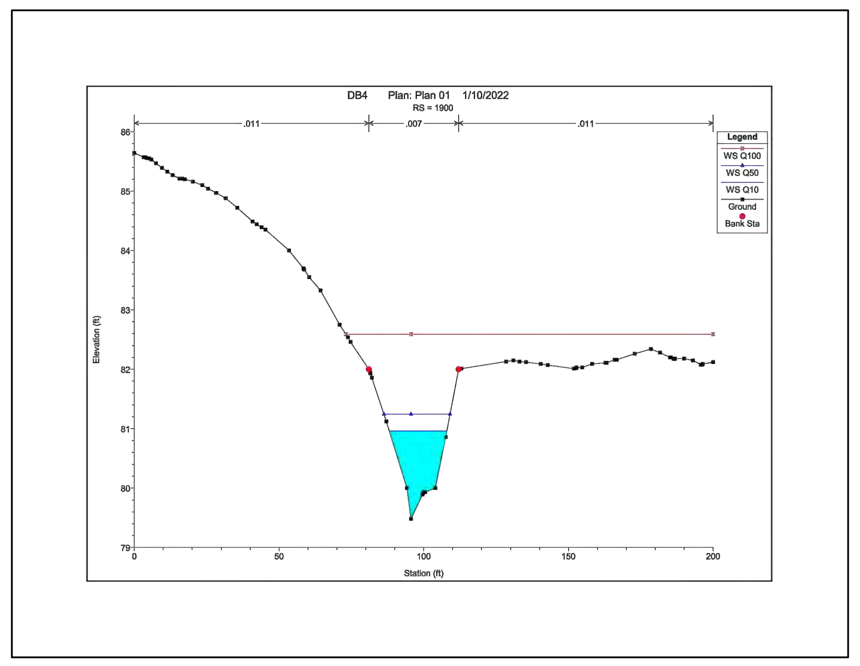


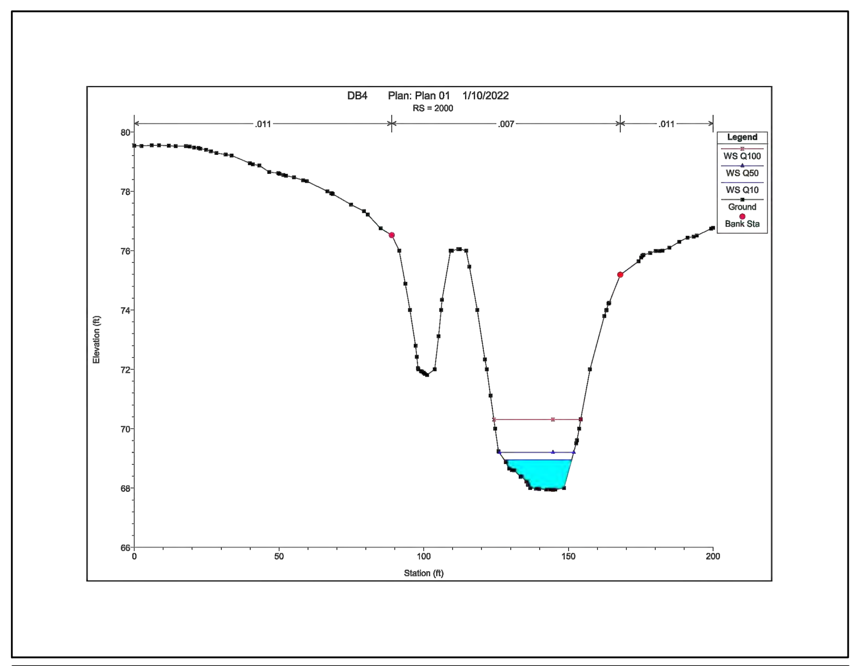


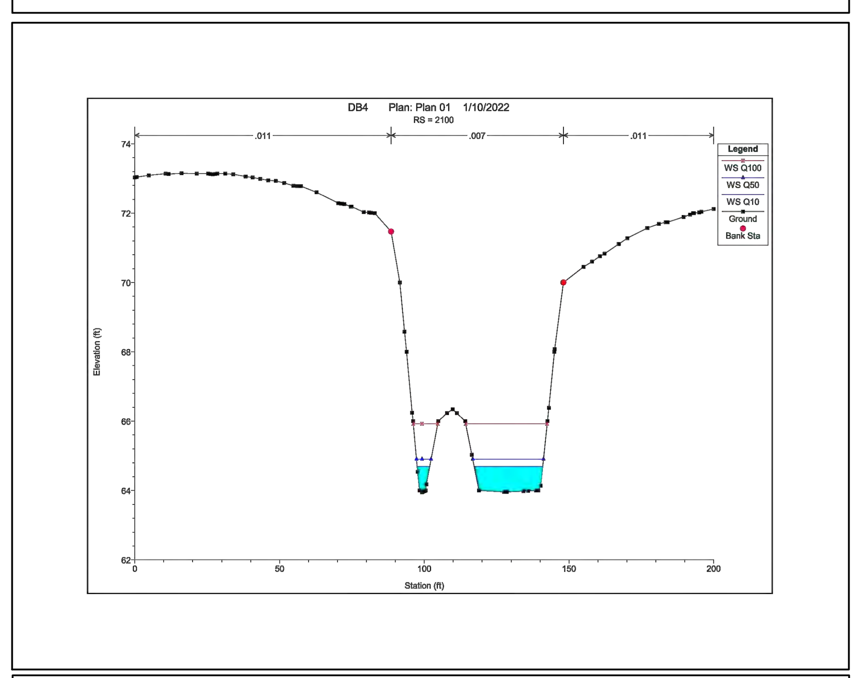


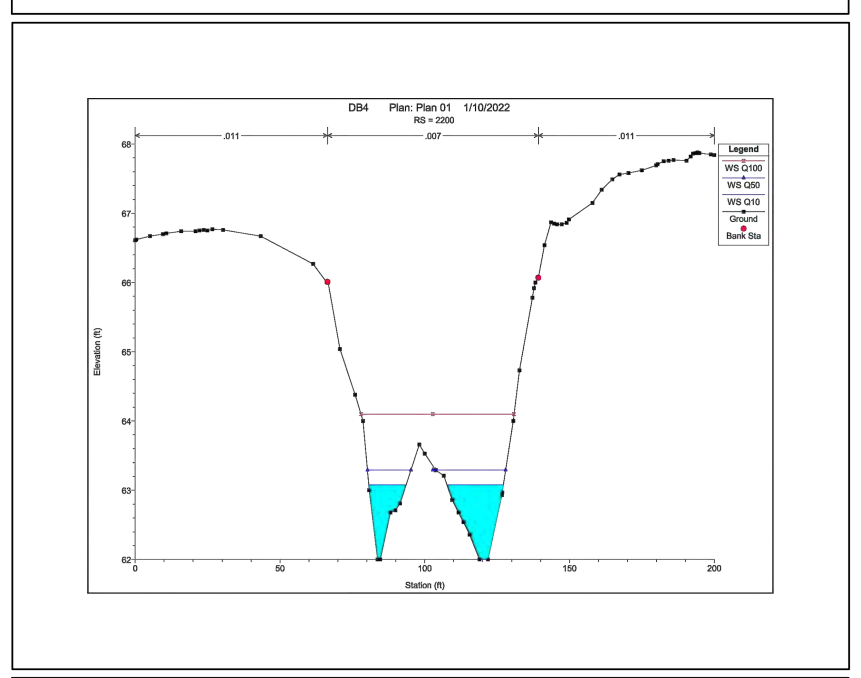


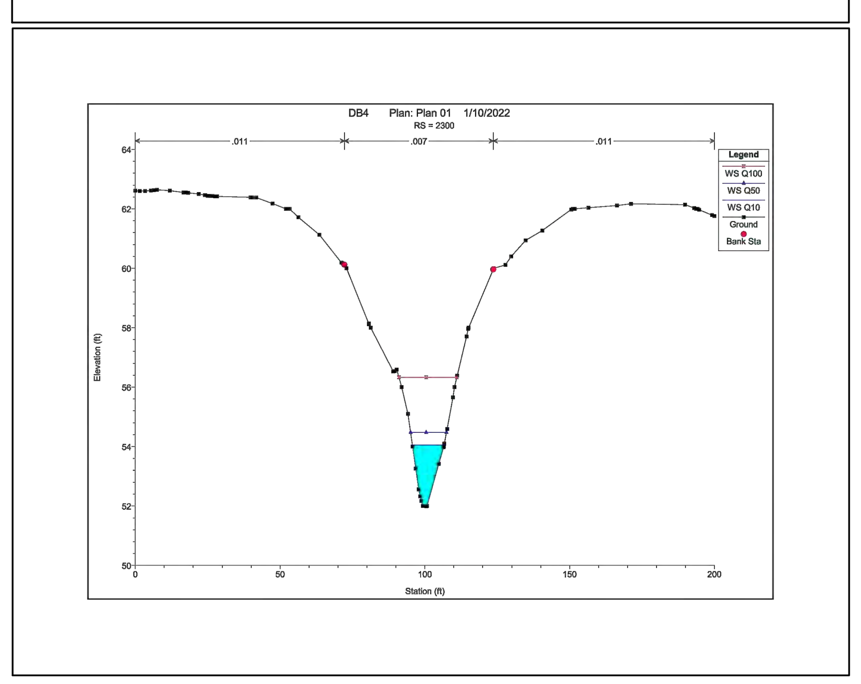


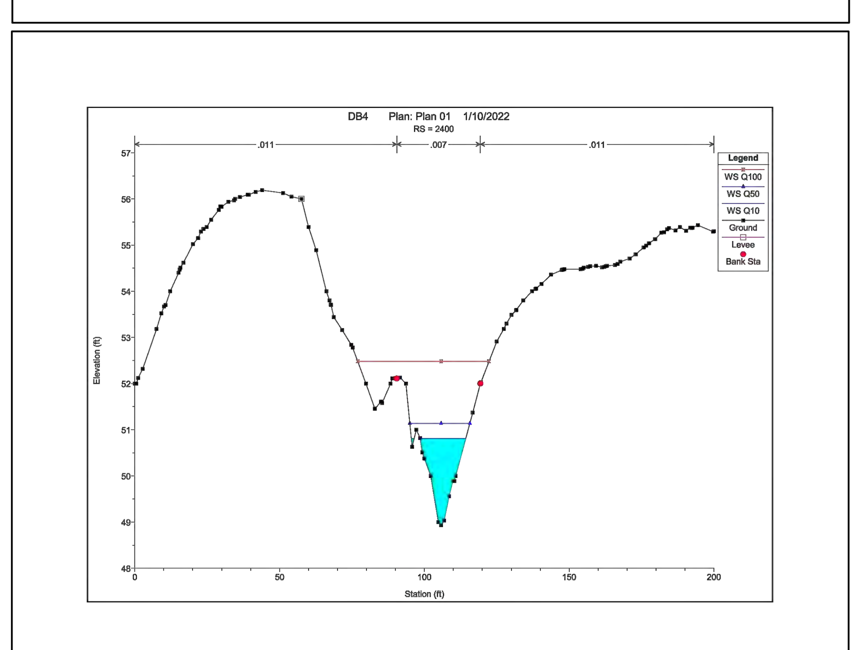


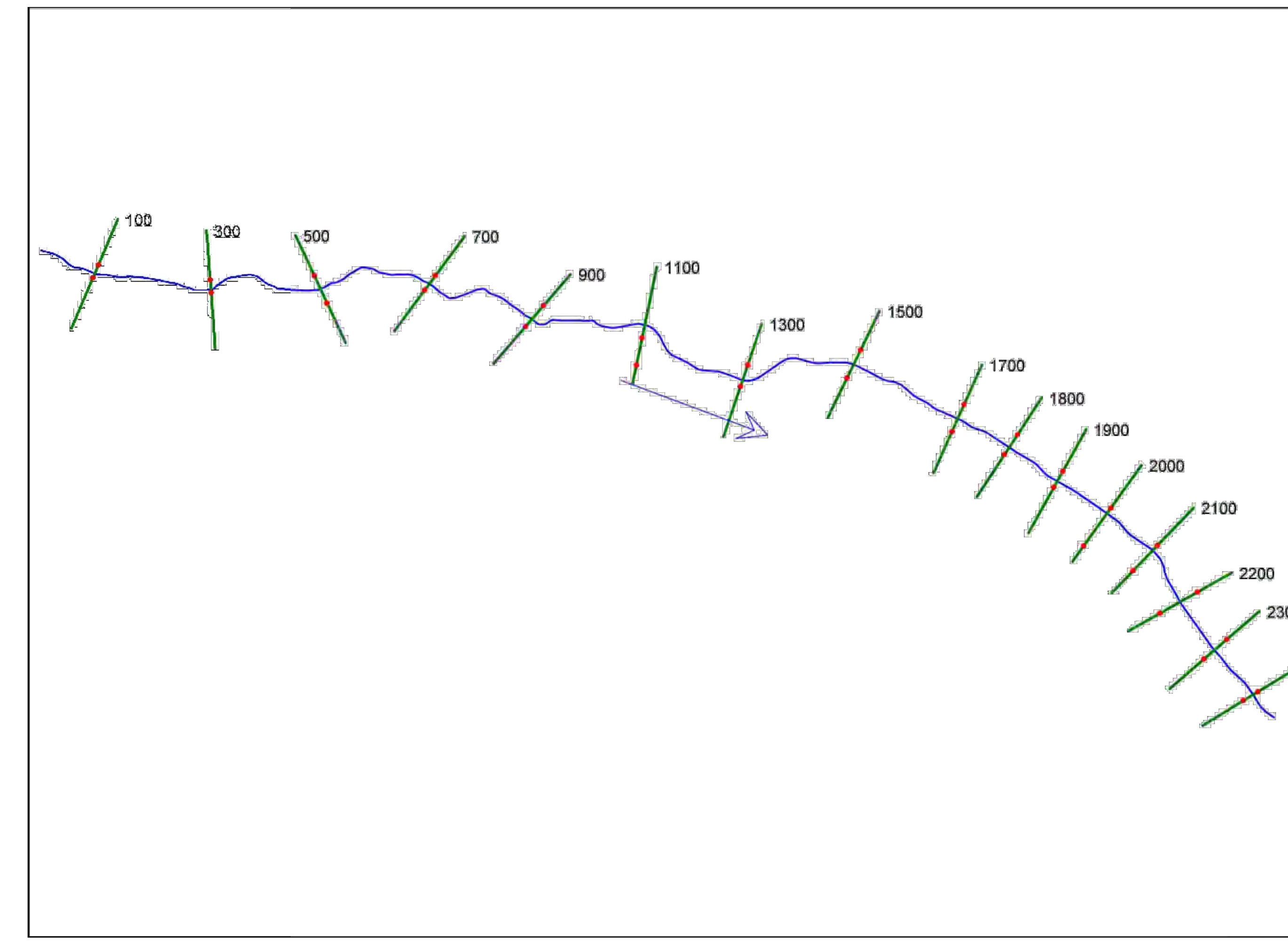


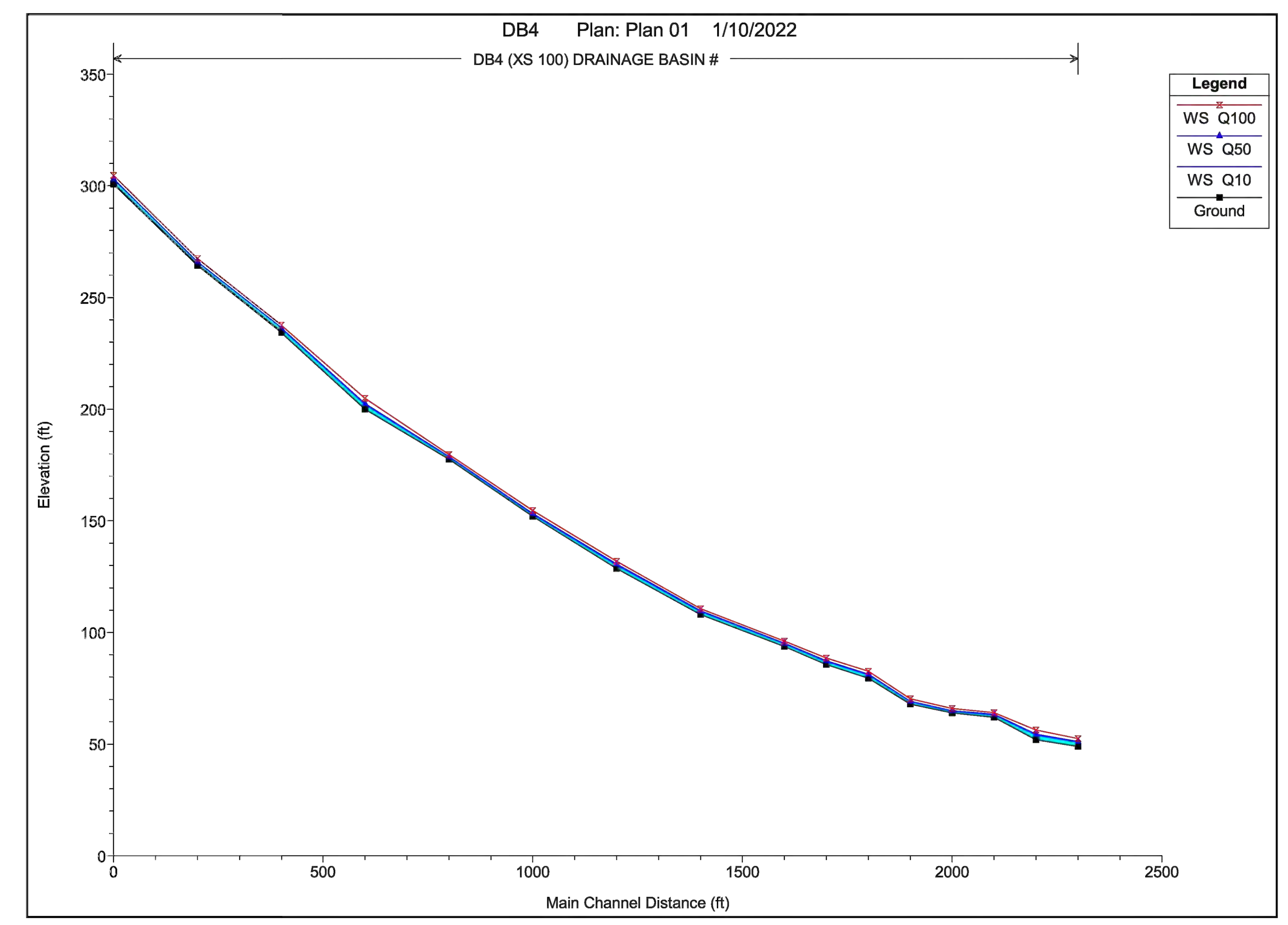












HEC-RAS Plan: Plan 01 River: DB4 (XS 100) Reach: DRAINAGE BASIN #

Reach	River Sta	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
DRAINAGE BASIN #	2400	[illegible]	83.30	48.93	50.81	50.81	51.28	0.000787	5.46	15.25	16.76	1.01
DRAINAGE BASIN #	2400	[illegible]	124.95	48.93	51.14	51.14	51.66	0.000755	5.83	21.45	20.73	1.01
DRAINAGE BASIN #	2400	[illegible]	416.50	48.93	52.48	52.48	53.25	0.000511	7.19	65.03	48.96	0.92
DRAINAGE BASIN #	2300	[illegible]	83.30	51.99	54.05	54.05	54.67	0.000763	6.30	13.23	10.96	1.01
DRAINAGE BASIN #	2300	[illegible]	124.95	51.99	54.47	54.47	55.21	0.000715	6.89	18.14	12.41	1.00
DRAINAGE BASIN #	2300	[illegible]	416.50	51.99	56.33	56.33	57.52	0.000608	8.74	47.65	20.03	1.00
DRAINAGE BASIN #	2200	[illegible]	83.30	62.00	63.08	63.08	63.38	0.000894	4.40	18.94	32.39	1.01
DRAINAGE BASIN #	2200	[illegible]	124.95	62.00	63.29	63.29	63.64	0.000849	4.72	26.48	39.22	1.01
DRAINAGE BASIN #	2200	[illegible]	416.50	62.00	64.10	64.10	64.73	0.000697	6.38	65.26	52.87	1.01
DRAINAGE BASIN #	2100	[illegible]	83.30	63.95	64.69	64.69	65.02	0.000866	4.59	18.14	28.04	1.01
DRAINAGE BASIN #	2100	[illegible]	124.95	63.95	64.90	64.90	65.32	0.000802	5.15	24.24	29.52	1.00
DRAINAGE BASIN #	2100	[illegible]	416.50	63.95	65.93	65.93	66.73	0.000667	7.17	58.11	36.67	1.00
DRAINAGE BASIN #	2000	[illegible]	83.30	67.94	68.95	68.95	69.33	0.000817	4.89	17.04	23.33	1.01
DRAINAGE BASIN #	2000	[illegible]	124.95	67.94	69.20	69.20	69.66	0.000761	5.41	23.10	25.72	1.01
DRAINAGE BASIN #	2000	[illegible]	416.50	67.94	70.31	70.31	71.23	0.000619	7.68	54.21	30.02	1.01
DRAINAGE BASIN #	1900	[illegible]	83.30	79.48	80.96	80.96	81.38	0.000803	5.17	16.11	19.89	1.01
DRAINAGE BASIN #	1900	[illegible]	124.95	79.48	81.24	81.24	81.74	0.000753	5.64	22.14	22.85	1.01
DRAINAGE BASIN #	1900	[illegible]	416.50	79.48	82.59	82.59	83.05	0.000315	5.84	104.08	126.96	0.74
DRAINAGE BASIN #	1800	[illegible]	83.30	85.68	87.01	87.01	87.43	0.000785	5.20	16.02	19.33	1.01
DRAINAGE BASIN #	1800	[illegible]	124.95	85.68	87.29	87.29	87.80	0.000746	5.70	21.92	22.15	1.01
DRAINAGE BASIN #	1800	[illegible]	416.50	85.68	88.53	88.53	89.28	0.000632	6.92	60.59	45.27	1.00
DRAINAGE BASIN #	1700	[illegible]	83.30	93.75	94.93	94.93	95.26	0.000849	4.62	18.02	27.77	1.01
DRAINAGE BASIN #	1700	[illegible]	124.95	93.75	95.16	95.16	95.55	0.000801	4.99	25.05	32.99	1.01
DRAINAGE BASIN #	1700	[illegible]	416.50	93.75	96.06	96.06	96.62	0.000561	6.06	76.43	86.26	0.93
DRAINAGE BASIN #	1500	[illegible]	83.30	107.98	109.33	109.33	109.78	0.000733	5.40	15.61	20.86	0.99
DRAINAGE BASIN #	1500	[illegible]	124.95	107.98	109.70	109.70	110.10	0.000515	5.23	29.93	51.48	0.86
DRAINAGE BASIN #	1500	[illegible]	416.50	107.98	110.58	110.58	111.05	0.000544	6.50	93.27	86.74	0.92
DRAINAGE BASIN #	1300	[illegible]	83.30	128.62	130.26	130.26	130.75	0.000753	5.61	14.85	15.15	1.00
DRAINAGE BASIN #	1300	[illegible]	124.95	128.62	130.62	130.62	131.17	0.000727	5.90	21.18	19.59	1.00
DRAINAGE BASIN #	1300	[illegible]	416.50	128.62	131.92	131.92	132.00	0.000094	2.69	193.54	109.47	0.38
DRAINAGE BASIN #	1100	[illegible]	83.30	151.99	152.96	152.96	153.36	0.000781	5.10	16.35	20.26	1.00
DRAINAGE BASIN #	1100	[illegible]	124.95	151.99	153.22	153.22	153.73	0.000741	5.69	21.95	22.07	1.01
DRAINAGE BASIN #	1100	[illegible]	416.50	151.99	154.59	154.59	155.29	0.000479	6.85	68.85	62.36	0.89
DRAINAGE BASIN #	900	[illegible]	83.30	177.60	178.56	178.56	178.85	0.000861	4.33	19.25	33.02	1.00
DRAINAGE BASIN #	900	[illegible]	124.95	177.60	178.75	178.75	179.12	0.000791	4.89	25.55	34.16	1.00
DRAINAGE BASIN #	900	[illegible]	416.50	177.60	179.67	179.67	180.43	0.000638	6.97	59.77	39.75	1.00
DRAINAGE BASIN #	700	[illegible]	83.30	200.00	202.05	202.05	202.73	0.000767	6.62	12.59	9.35	1.00
DRAINAGE BASIN #	700	[illegible]	124.95	200.00	202.51	202.51	203.33	0.000738	7.28	17.15	10.57	1.01
DRAINAGE BASIN #	700	[illegible]	416.50	200.00	204.83	204.83	205.57	0.000412	7.27	75.33	66.67	0.82
DRAINAGE BASIN #	500	[illegible]	83.30	234.29	236.10	236.10	236.52	0.000837	5.22	15.96	19.78	1.02
DRAINAGE BASIN #	500	[illegible]	124.95	234.29	236.37	236.37	236.89	0.000771	5.81	21.50	21.29	1.02
DRAINAGE BASIN #	500	[illegible]	416.50	234.29	237.66	237.66	238.60	0.000610	7.78	53.54	28.52	1.00
DRAINAGE BASIN #	300	[illegible]	83.30	264.36	265.66	265.66	266.14	0.000784	5.58	14.92	15.70	1.01
DRAINAGE BASIN #	300	[illegible]	124.95	264.36	265.97	265.97	266.58	0.000733	6.27	19.94	16.59	1.01
DRAINAGE BASIN #	300	[illegible]	416.50	264.36	267.47	267.47	268.65	0.000614	8.70	47.87	20.59	1.01
DRAINAGE BASIN #	100	[illegible]	83.30	300.72	302.67	302.67	303.24	0.000765	6.04	13.80	12.48	1.01
DRAINAGE BASIN #	100	[illegible]	124.95	300.72	303.06	303.06	303.73	0.000724	6.60	18.92	14.29	1.01
DRAINAGE BASIN #	100	[illegible]	416.50	300.72	304.69	304.69	305.84	0.000616	8.61	48.40	21.45	1.01

DRAINAGE BASIN #4

ESTIMATED AREA = 98 ACRES
RUNOFF COEFFICIENT = 0.34
(Q10) i = 2.5"
(Q50) i = 3.75"
(Q100) i = 12.5"

EXPIRES: 04-30-2022

This work was prepared by me or under my supervision and construction will be under my observation. (Observation of construction as defined in Section 1.2 (N) in the rules and regulations of the Board of Professional Engineers, Architects, and Surveyors of the State of Hawaii.)

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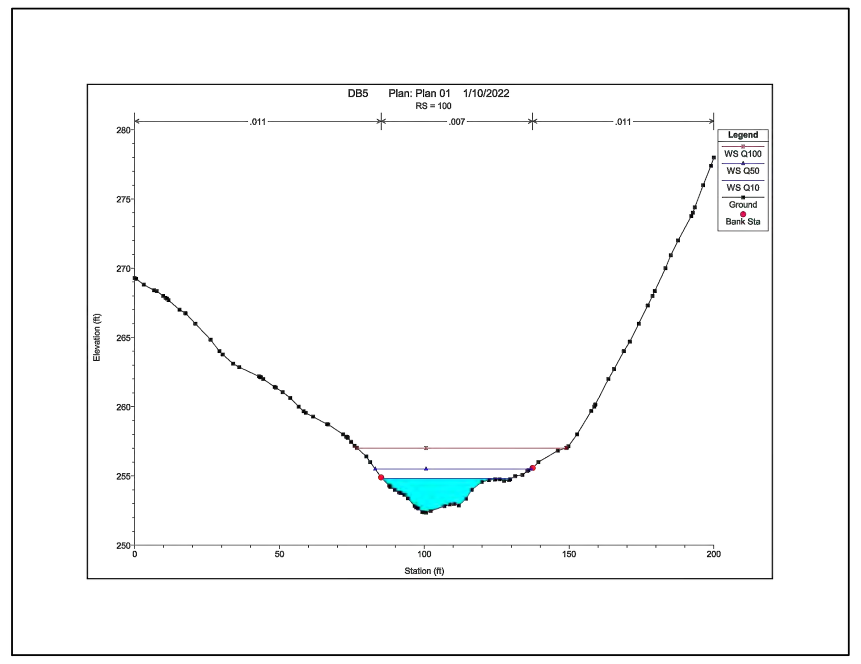
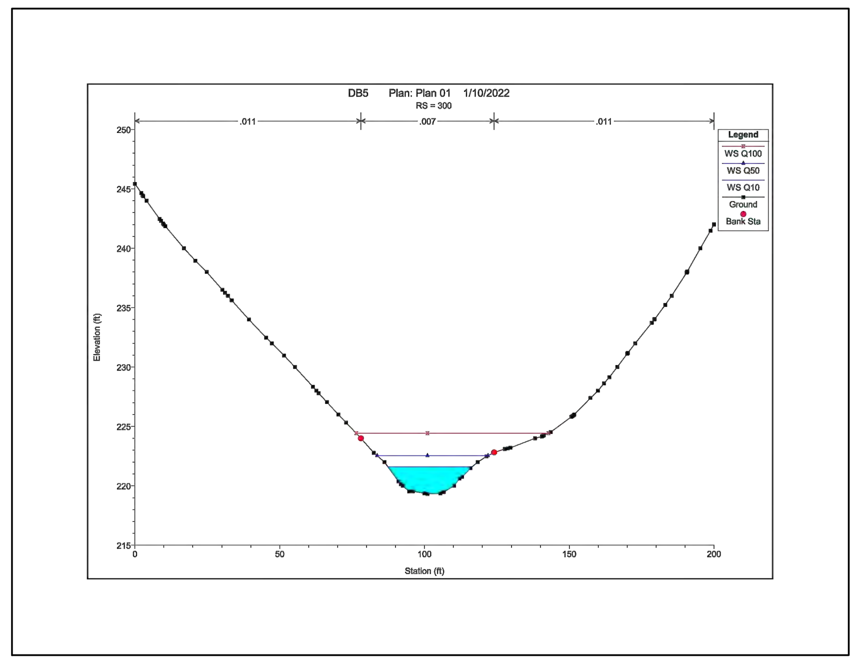
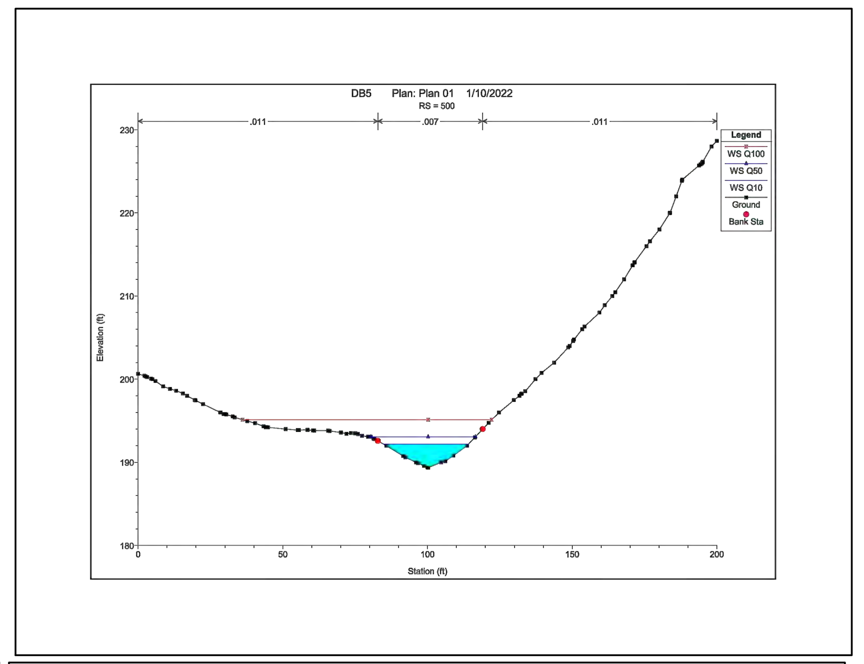
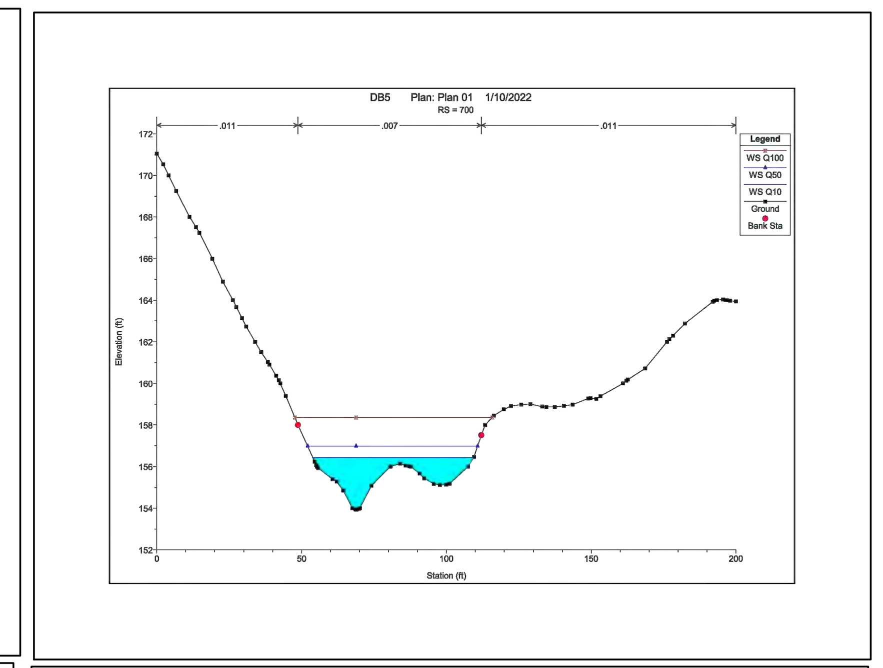
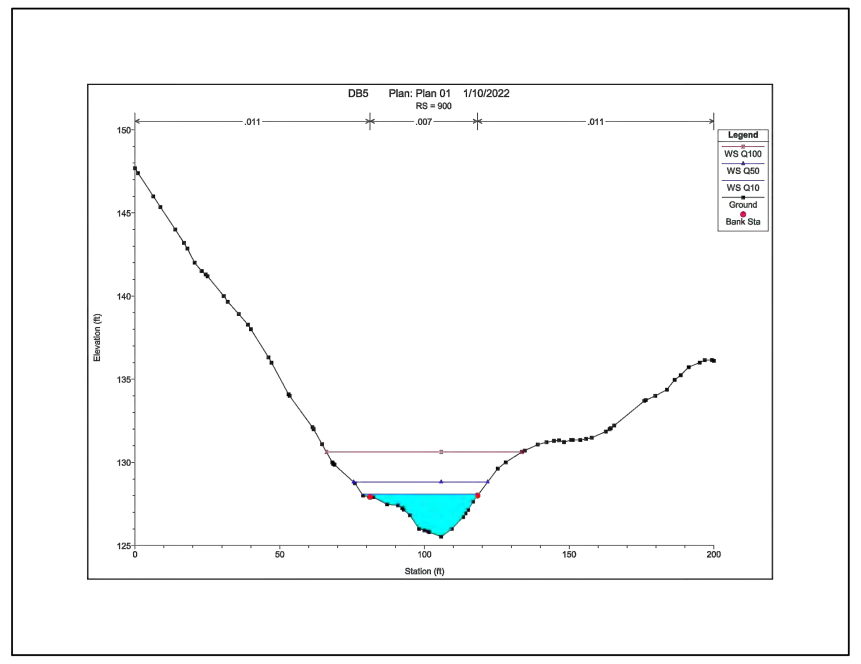
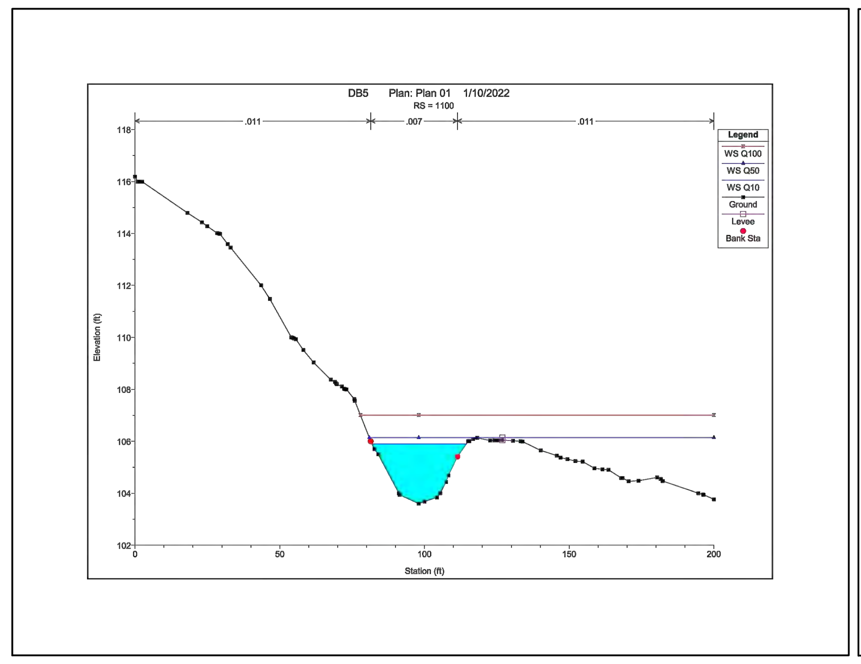
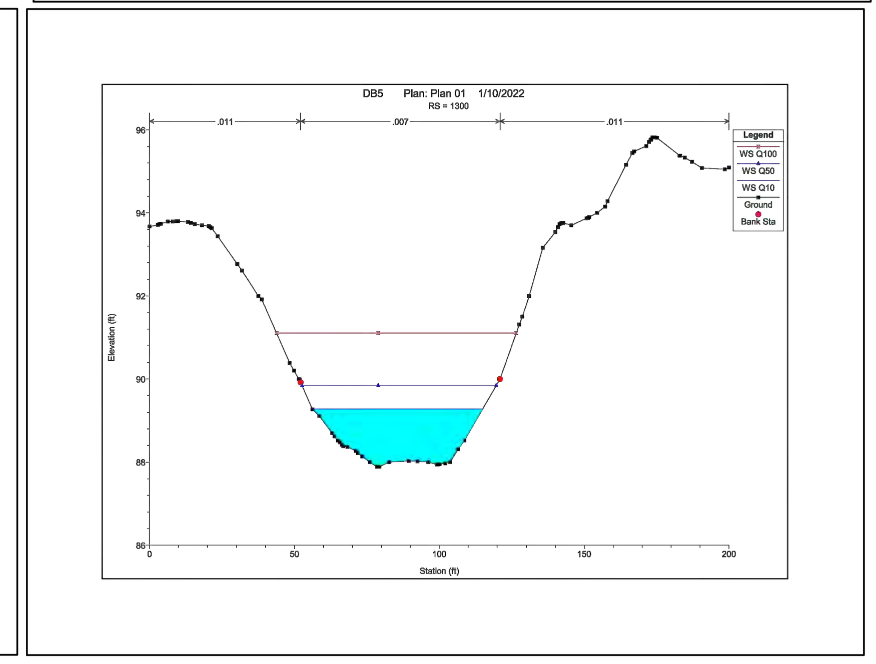
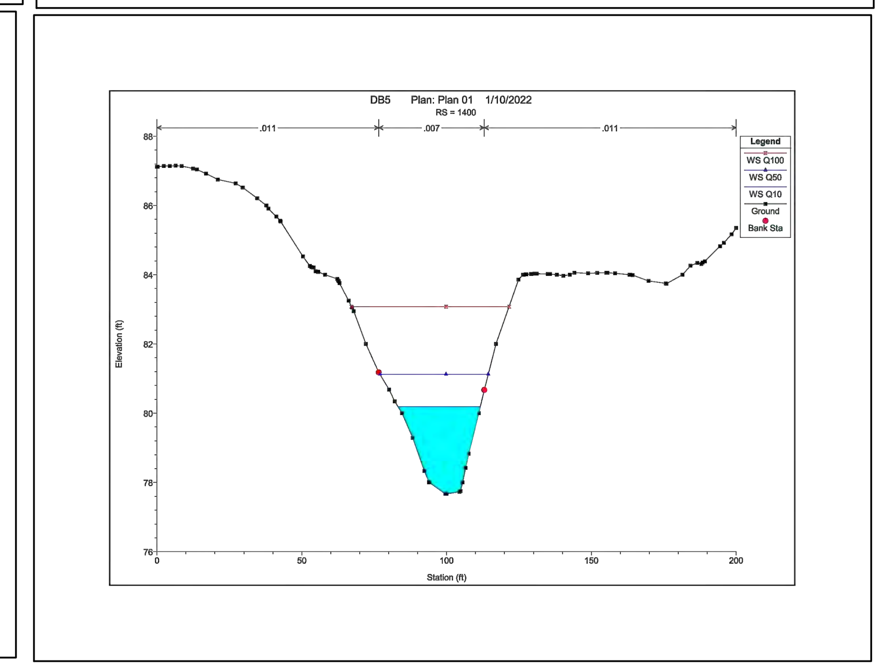
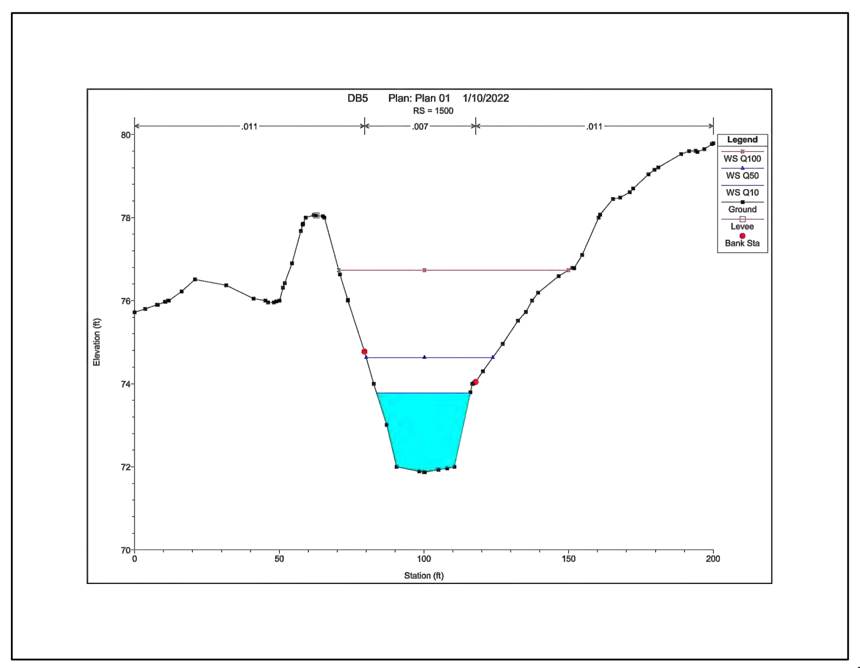
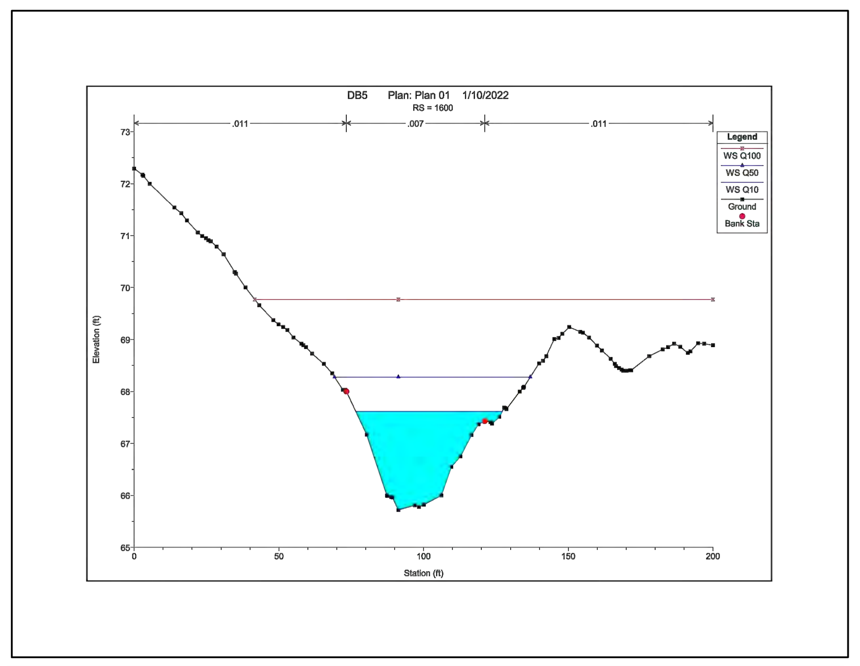
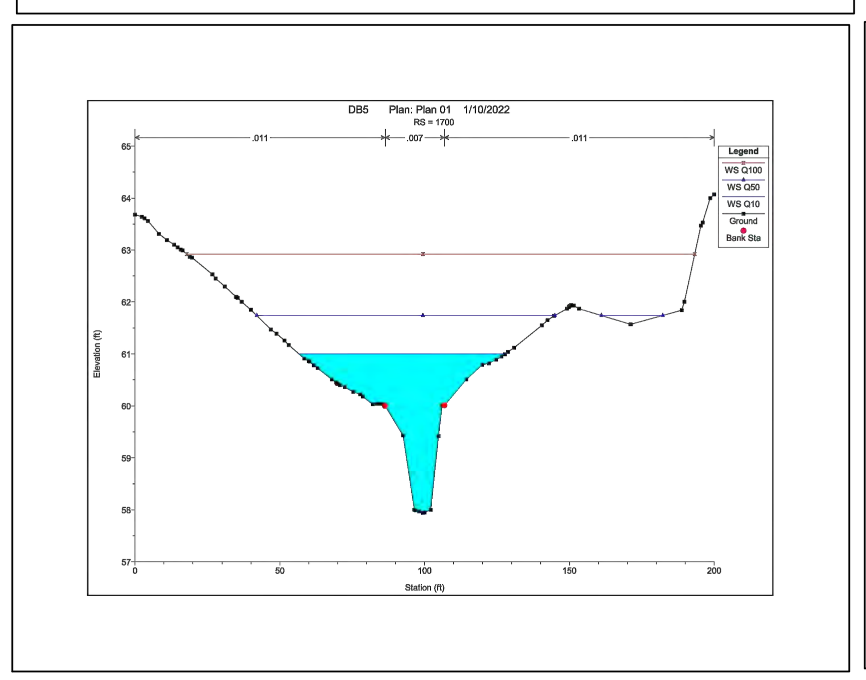
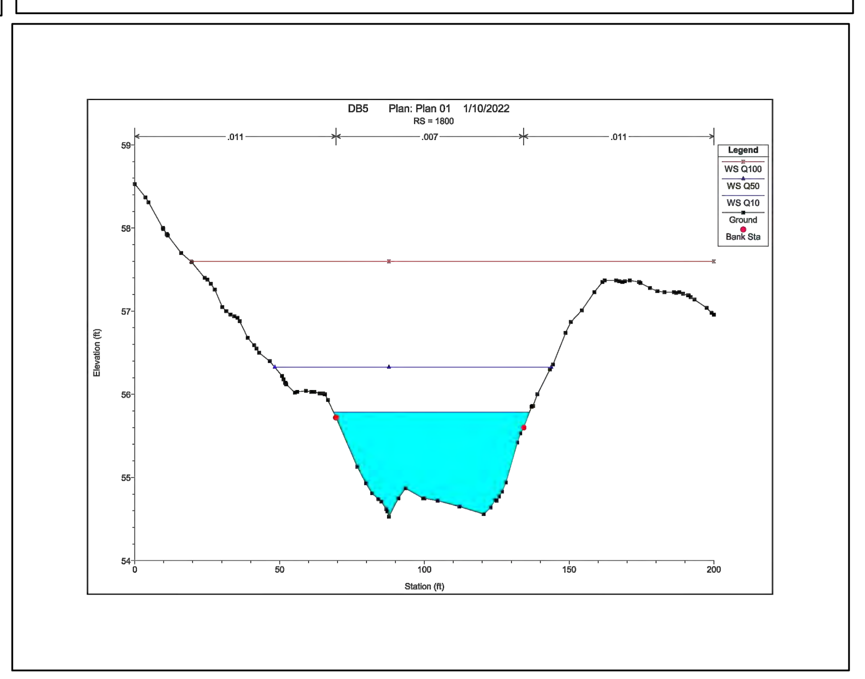
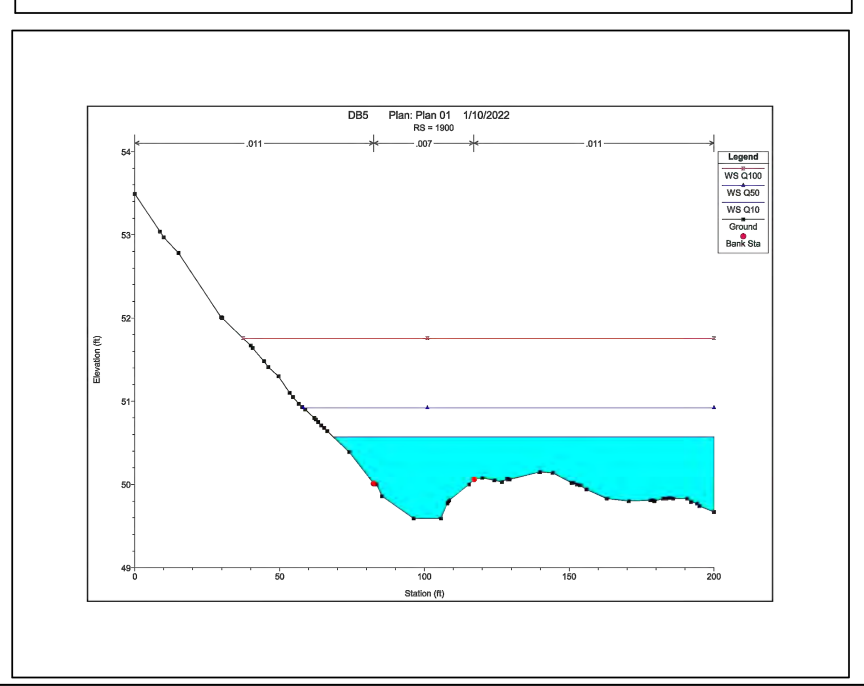
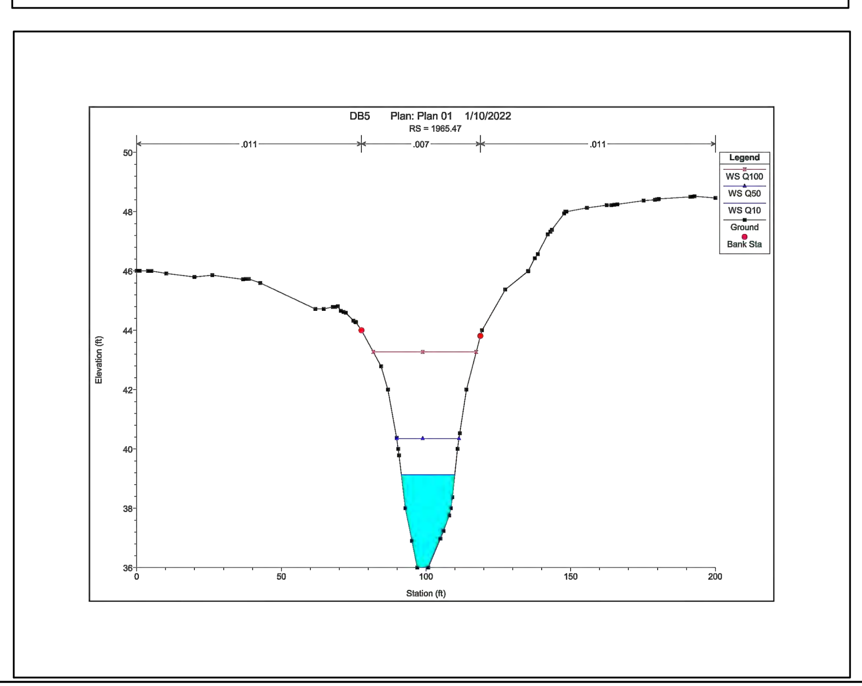
Phone: (808) 891-2400

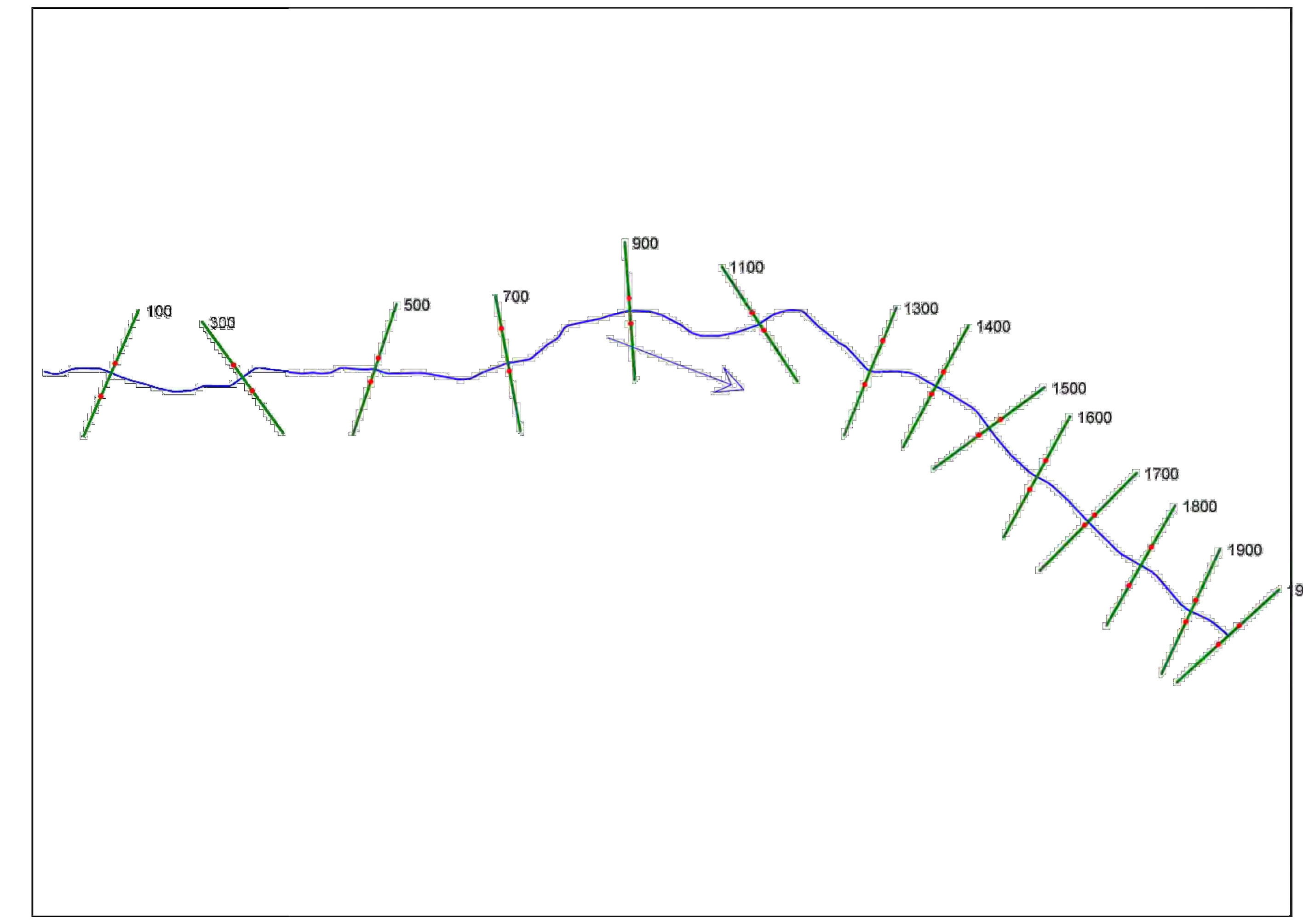
POHAKEA WATERSHED BASIS OF DESIGN
MAALAEA HARBOR
MAALAEA, HI 9673

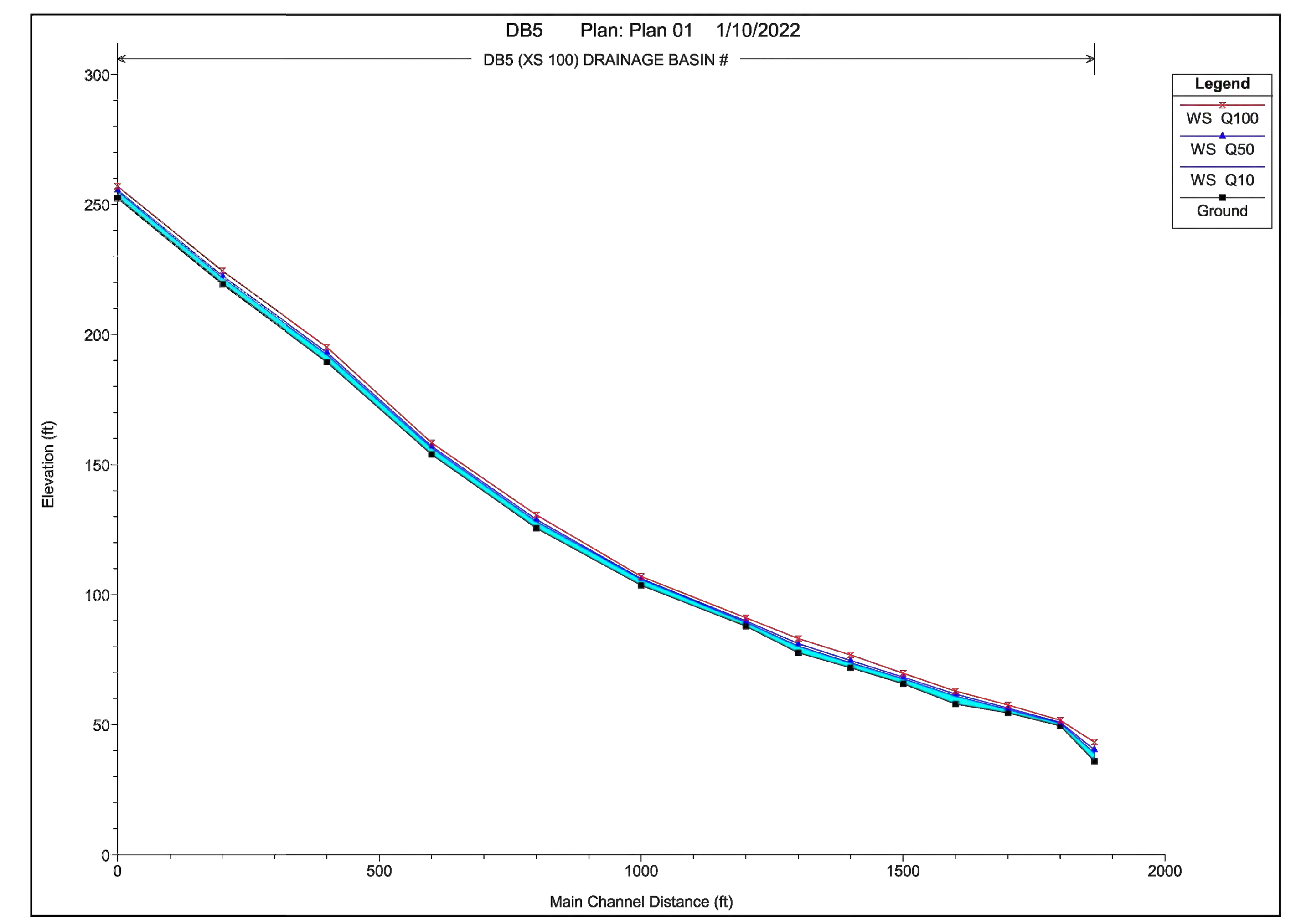
Scale: N.T.S.	BASIN #4	DWG No. C-5
01-28-2022	TMK: (2) 3-6-001:018	

HEC-RAS Plan: Plan 01 River: DB5 (XS 100) Reach: DRAINAGE BASIN #

Reach	River Sta	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
DRAINAGE BASIN #	1965.47	[illegible]	327.00	36.00	39.13	39.13	40.20	0.000617	8.29	39.44	18.47	1.00
DRAINAGE BASIN #	1965.47	[illegible]	625.00	36.00	40.35	40.35	41.85	0.000580	9.82	63.67	21.54	1.01
DRAINAGE BASIN #	1965.47	[illegible]	1636.00	36.00	43.27	43.27	45.30	0.000517	11.43	143.14	35.58	1.00
DRAINAGE BASIN #	1900	[illegible]	327.00	49.59	50.57	50.57	50.89	0.000948	5.69	84.44	131.48	1.11
DRAINAGE BASIN #	1900	[illegible]	625.00	49.59	50.92	50.92	51.39	0.000883	6.98	132.20	141.91	1.14
DRAINAGE BASIN #	1900	[illegible]	1636.00	49.59	51.76	51.76	52.58	0.000796	9.50	259.33	162.63	1.18
DRAINAGE BASIN #	1800	[illegible]	327.00	54.53	55.78	55.78	56.25	0.000744	5.48	59.87	67.62	1.01
DRAINAGE BASIN #	1800	[illegible]	625.00	54.53	56.33	56.33	56.96	0.000558	6.46	103.99	95.50	0.94
DRAINAGE BASIN #	1800	[illegible]	1636.00	54.53	57.60	57.60	58.48	0.000373	8.01	270.22	180.64	0.85
DRAINAGE BASIN #	1700	[illegible]	327.00	57.94	61.00	61.00	61.60	0.000388	6.65	68.24	71.34	0.81
DRAINAGE BASIN #	1700	[illegible]	625.00	57.94	61.74	61.74	62.43	0.000350	7.72	134.38	124.06	0.81
DRAINAGE BASIN #	1700	[illegible]	1636.00	57.94	62.92	62.92	63.77	0.000360	9.90	322.32	175.46	0.87
DRAINAGE BASIN #	1600	[illegible]	327.00	65.72	67.62	67.62	68.21	0.000677	6.17	53.84	50.63	1.00
DRAINAGE BASIN #	1600	[illegible]	625.00	65.72	68.28	68.28	69.07	0.000554	7.24	92.90	67.62	0.96
DRAINAGE BASIN #	1600	[illegible]	1636.00	65.72	69.77	69.77	70.69	0.000335	8.49	276.26	158.36	0.83
DRAINAGE BASIN #	1500	[illegible]	327.00	71.87	73.78	73.78	74.52	0.000648	6.90	47.41	32.37	1.00
DRAINAGE BASIN #	1500	[illegible]	625.00	71.87	74.63	74.63	75.62	0.000557	8.00	79.49	43.77	0.98
DRAINAGE BASIN #	1500	[illegible]	1636.00	71.87	76.73	76.73	77.94	0.000294	9.27	235.98	132.96	0.80
DRAINAGE BASIN #	1400	[illegible]	327.00	77.67	80.19	80.19	81.00	0.000638	7.21	45.36	28.44	1.01
DRAINAGE BASIN #	1400	[illegible]	625.00	77.67	81.12	81.12	82.18	0.000579	8.25	75.99	37.41	1.00
DRAINAGE BASIN #	1400	[illegible]	1636.00	77.67	83.08	83.08	84.83	0.000413	10.77	165.77	54.46	0.95
DRAINAGE BASIN #	1300	[illegible]	327.00	87.89	89.28	89.28	89.78	0.000731	5.66	57.78	58.89	1.01
DRAINAGE BASIN #	1300	[illegible]	625.00	87.89	89.84	89.84	90.54	0.000652	6.73	92.91	66.97	1.01
DRAINAGE BASIN #	1300	[illegible]	1636.00	87.89	91.11	91.11	92.35	0.000500	8.99	188.30	82.74	0.98
DRAINAGE BASIN #	1100	[illegible]	327.00	103.60	105.90	105.90	106.67	0.000610	7.03	47.16	32.63	0.99
DRAINAGE BASIN #	1100	[illegible]	625.00	103.60	106.14	106.14	106.60	0.000470	6.71	144.58	119.06	0.89
DRAINAGE BASIN #	1100	[illegible]	1636.00	103.60	107.01	107.01	107.96	0.000615	10.00	249.03	122.12	1.08
DRAINAGE BASIN #	900	[illegible]	327.00	125.53	128.08	128.08	128.74	0.000648	6.54	50.33	40.23	0.99
DRAINAGE BASIN #	900	[illegible]	625.00	125.53	128.82	128.82	129.79	0.000537	7.96	82.13	46.31	0.97
DRAINAGE BASIN #	900	[illegible]	1636.00	125.53	130.62	130.62	132.19	0.000401	10.43	184.22	67.48	0.93
DRAINAGE BASIN #	700	[illegible]	327.00	153.93	156.43	156.43	156.94	0.000699	5.70	57.39	55.50	0.99
DRAINAGE BASIN #	700	[illegible]	625.00	153.93	156.99	156.99	157.75	0.000634	7.00	89.30	58.74	1.00
DRAINAGE BASIN #	700	[illegible]	1636.00	153.93	158.36	158.36	159.73	0.000517	9.38	175.69	68.16	1.00
DRAINAGE BASIN #	500	[illegible]	327.00	189.36	192.17	192.17	192.97	0.000638	7.14	45.80	29.22	1.01
DRAINAGE BASIN #	500	[illegible]	625.00	189.36	193.07	193.07	194.16	0.000561	8.39	75.03	36.19	1.00
DRAINAGE BASIN #	500	[illegible]	1636.00	189.36	195.12	195.12	196.50	0.000345	9.89	208.33	86.09	0.86
DRAINAGE BASIN #	300	[illegible]	327.00	219.32	221.59	221.59	222.39	0.000640	7.17	45.63	29.05	1.01
DRAINAGE BASIN #	300	[illegible]	625.00	219.32	222.54	222.54	223.56	0.000588	8.10	77.14	38.28	1.01
DRAINAGE BASIN #	300	[illegible]	1636.00	219.32	224.43	224.43	225.94	0.000430	9.97	176.50	66.44	0.94
DRAINAGE BASIN #	100	[illegible]	327.00	252.35	254.82	254.82	255.41	0.000680	6.16	53.08	44.71	1.00
DRAINAGE BASIN #	100	[illegible]	625.00	252.35	255.49	255.49	256.31	0.000605	7.27	86.40	53.64	0.99
DRAINAGE BASIN #	100	[illegible]	1636.00	252.35	257.02	257.02	258.44	0.000453	9.67	180.23	72.26	0.96





DRAINAGE BASIN #5

ESTIMATED AREA = 385 ACRES
RUNOFF COEFFICIENT = 0.34
(Q10) i = 2.5"
(Q50) i = 3.75"
(Q100) i = 12.5"

EXPIRES: 04–30–2022

This work was prepared by me or under my supervision and construction will be under my observation. (Observation of construction as defined in Section 1.2 (N) in the rules and regulations of the Board of Preofessional Engineers, Architects, and Surveyors of the State of Hawaii.)

CIVIL ENGINEERING & LANDSCAPE ARCHITECTURE CONSULTANTS

CDF Engineering LLC
PO Box 2985, Wailuku, HI 96793
Phone: (808) 891-2400

POHAKEA WATERSHED BASIS OF DESIGN
MAALAEA HARBOR
MAALAEA, HI 9673

Scale:		DWG No.
N.T.S.	BASIN #5	C-6
01-28-2022	TMK: (2) 3-6-001:018	

EXHIBITS

1. Soil Survey Report

United States Department of Agriculture

NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for

Island of Maui, Hawaii

Pohakea Watershed

December 31, 2021

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

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Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

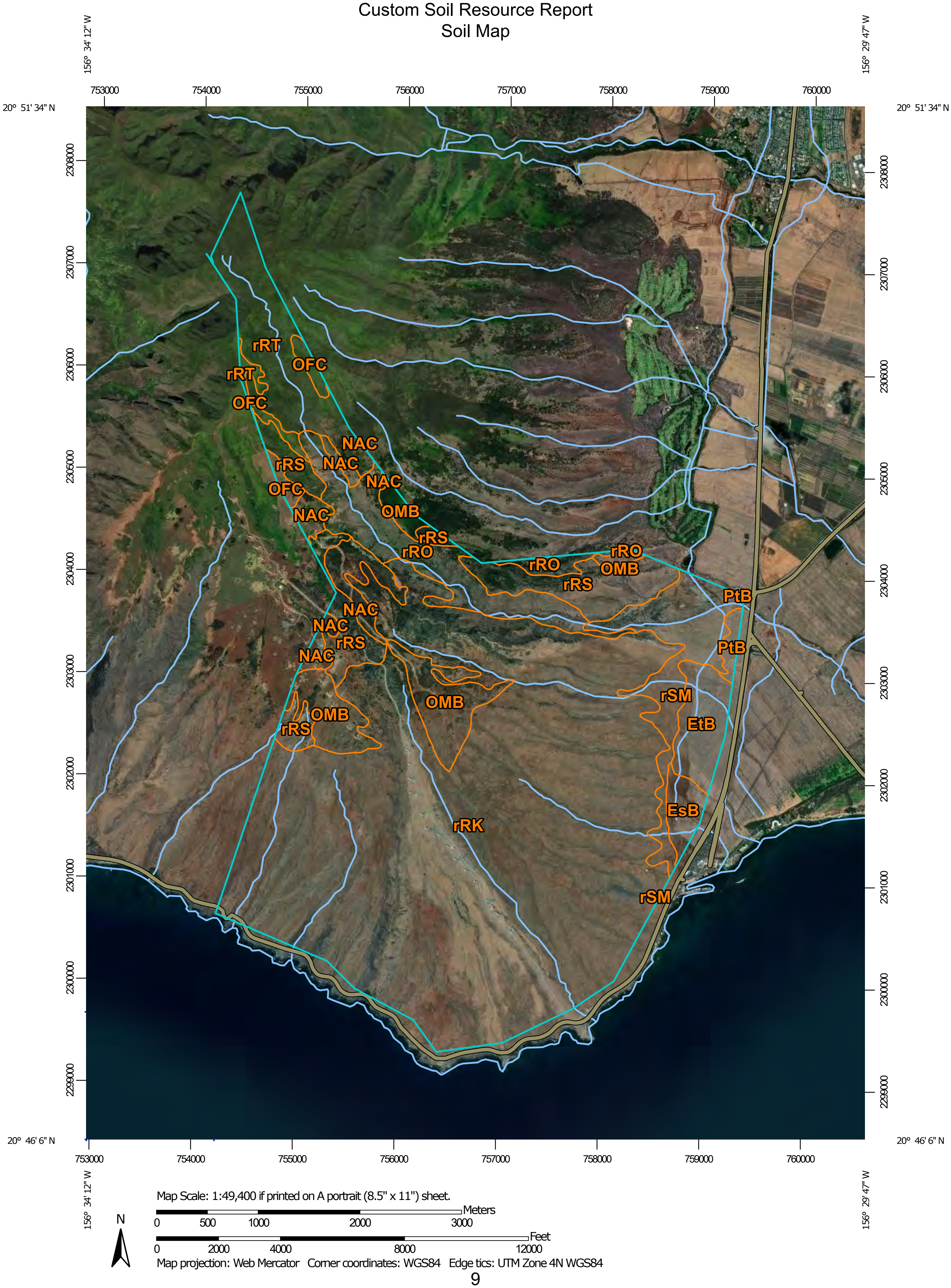
Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Soil Map


156° 34' 12" W
156° 29' 47" W
20° 51' 34" N
20° 46' 6" N
753000
754000
755000
756000
757000
758000
759000
760000
2308000
2307000
2306000
2305000
2304000
2303000
2302000
2301000
2300000
2299000
rRT
OFC
NAC
rRS
OMB
rRO
PtB
rSM
EtB
EsB
rRK
N
Map Scale: 1:49,400 if printed on A portrait (8.5" x 11") sheet.
Meters
0 500 1000 2000 3000
Feet
0 2000 4000 8000 12000
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 4N WGS84

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features

- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMA

The soil surveys that comprise your AOI w
1:24,000.

Please rely on the bar scale on each map
measurements.

Source of Map: Natural Resources Con
Web Soil Survey URL:
Coordinate System: Web Mercator (EPS

Maps from the Web Soil Survey are base
projection, which preserves direction and
distance and area. A projection that prese
Albers equal-area conic projection, should
accurate calculations of distance or area

This product is generated from the USDA
of the version date(s) listed below.

Soil Survey Area: Island of Maui, Hawa
Survey Area Data: Version 19, Sep 15,

Soil map units are labeled (as space allow
1:50,000 or larger.

Date(s) aerial images were photographed
11, 2020

The orthophoto or other base map on wh
compiled and digitized probably differs fro
imagery displayed on these maps. As a r
shifting of map unit boundaries may be ev

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
EsB	Ewa silty clay, 3 to 7 percent slopes, MLRA 163	56.1	1.1%
EtB	Ewa cobbly silty clay, 3 to 7 percent slopes, MLRA 163	127.5	2.5%
NAC	Naiwa silty clay loam, 13 to 45 percent slopes, MLRA 164	141.4	2.7%
OFC	Olelo silty clay, 15 to 50 percent slopes, MLRA 164	64.2	1.2%
OMB	Oli medial silt loam, 13 to 45 percent slopes, MLRA 164	273.8	5.3%
PtB	Pulehu cobbly clay loam, 3 to 7 percent slopes	23.0	0.4%
rRK	Rock land	3,264.7	63.1%
rRO	Rock outcrop	313.6	6.1%
rRS	Rough broken and stony land	344.1	6.7%
rRT	Rough mountainous land	305.4	5.9%
rSM	Stony alluvial land	258.8	5.0%
Totals for Area of Interest		**5,172.5**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Island of Maui, Hawaii

EsB—Ewa silty clay, 3 to 7 percent slopes, MLRA 163

Map Unit Setting

National map unit symbol: 2yyry
Elevation: 0 to 320 feet
Mean annual precipitation: 17 to 25 inches
Mean annual air temperature: 73 to 75 degrees F
Frost-free period: 365 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Ewa and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Ewa

Setting

Landform: Alluvial fans
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Tread
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Basic igneous rocks

Typical profile

Ap1 - 0 to 13 inches: silty clay
Ap2 - 13 to 18 inches: silty clay loam
Bw1 - 18 to 45 inches: silty clay loam
Bw2 - 45 to 60 inches: silty clay loam

Properties and qualities

Slope: 3 to 7 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Moderate (about 6.4 inches)

Interpretive groups

Land capability classification (irrigated): 2e
Land capability classification (nonirrigated): 4c
Hydrologic Soil Group: B
Ecological site: R158XY002HI - Isohyperthermic Torric Naturalized Grassland
Hydric soil rating: No

EtB—Ewa cobbly silty clay, 3 to 7 percent slopes, MLRA 163

Map Unit Setting

National map unit symbol: 2yyrz
Elevation: 20 to 190 feet
Mean annual precipitation: 17 to 22 inches
Mean annual air temperature: 73 to 75 degrees F
Frost-free period: 365 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Ewa, cobbly, and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Ewa, Cobbly

Setting

Landform: Alluvial fans
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Tread
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Basic igneous rocks

Typical profile

Ap1 - 0 to 13 inches: cobbly silty clay
Ap2 - 13 to 18 inches: cobbly silty clay loam
Bw1 - 18 to 45 inches: silty clay loam
Bw2 - 45 to 60 inches: silty clay loam

Properties and qualities

Slope: 3 to 7 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Moderate (about 6.4 inches)

Interpretive groups

Land capability classification (irrigated): 2e
Land capability classification (nonirrigated): 4s
Hydrologic Soil Group: B
Hydric soil rating: No

NAC—Naiwa silty clay loam, 13 to 45 percent slopes, MLRA 164

Map Unit Setting

National map unit symbol: 2xh0y
Elevation: 600 to 3,030 feet
Mean annual precipitation: 45 to 95 inches
Mean annual air temperature: 57 to 63 degrees F
Frost-free period: 365 days
Farmland classification: Not prime farmland

Map Unit Composition

Naiwa and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Naiwa

Setting

Landform: Spurs, ridges
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope, rise
Down-slope shape: Convex, linear
Across-slope shape: Convex
Parent material: Volcanic ash and/or residuum

Typical profile

Ap - 0 to 4 inches: silty clay loam
A - 4 to 11 inches: silty clay loam
Bw1 - 11 to 14 inches: loam
Bw2 - 14 to 26 inches: loam
Bw3 - 26 to 40 inches: loam
C - 40 to 52 inches: very gravelly loam
Cr - 52 to 60 inches: bedrock

Properties and qualities

Slope: 13 to 45 percent
Depth to restrictive feature: 40 to 60 inches to paralithic bedrock
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Low (about 5.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: A
Hydric soil rating: No

Minor Components

Olelo

Percent of map unit: 5 percent
Landform: Ridges
Landform position (two-dimensional): Backslope, summit
Landform position (three-dimensional): Mountainflank, mountaintop, interfluve
Down-slope shape: Linear
Across-slope shape: Convex
Hydric soil rating: No

Naiwa, severely eroded

Percent of map unit: 5 percent
Landform: Spurs, ridges
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope, rise
Down-slope shape: Convex, linear
Across-slope shape: Convex
Hydric soil rating: No

OFC—Olelo silty clay, 15 to 50 percent slopes, MLRA 164

Map Unit Setting

National map unit symbol: 2xh0v
Elevation: 1,430 to 3,420 feet
Mean annual precipitation: 60 to 100 inches
Mean annual air temperature: 55 to 61 degrees F
Frost-free period: 365 days
Farmland classification: Not prime farmland

Map Unit Composition

Olelo and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Olelo

Setting

Landform: Ridges
Landform position (two-dimensional): Backslope, summit
Landform position (three-dimensional): Mountainflank, mountaintop, interfluve
Down-slope shape: Linear
Across-slope shape: Convex
Parent material: Residuum weathered from basalt

Typical profile

A1 - 0 to 4 inches: silty clay
A2 - 4 to 10 inches: silty clay
Bw - 10 to 14 inches: silty clay
Bt1 - 14 to 19 inches: silty clay
Bt2 - 19 to 37 inches: silty clay

Cr - 37 to 60 inches: silty clay

Properties and qualities

Slope: 15 to 50 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Moderate (about 6.6 inches)

Interpretive groups

Land capability classification (irrigated): 7e
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: D
Hydric soil rating: No

OMB—Oli medial silt loam, 13 to 45 percent slopes, MLRA 164

Map Unit Setting

National map unit symbol: 2xn0y
Elevation: 1,680 to 2,520 feet
Mean annual precipitation: 41 to 82 inches
Mean annual air temperature: 59 to 61 degrees F
Frost-free period: 365 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Oli and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Oli

Setting

Landform: Ridges, mountain slopes, ash fields
Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Mountaintop, upper third of mountainflank
Down-slope shape: Convex, linear
Across-slope shape: Convex, concave
Parent material: Volcanic ash derived from volcanic rock over residuum weathered from andesite

Typical profile

A - 0 to 13 inches: medial silt loam
Bw - 13 to 30 inches: medial silt loam
2R - 30 to 40 inches: bedrock

Properties and qualities

Slope: 13 to 45 percent

Depth to restrictive feature: 24 to 40 inches to lithic bedrock
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Low (about 3.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: B
Hydric soil rating: No

Minor Components

Naiwa

Percent of map unit: 10 percent
Landform: Ridges, ash fields, mountain slopes
Landform position (two-dimensional): Backslope, shoulder
Landform position (three-dimensional): Upper third of mountainflank
Down-slope shape: Convex, linear
Across-slope shape: Convex, concave
Hydric soil rating: No

PtB—Pulehu cobbly clay loam, 3 to 7 percent slopes

Map Unit Setting

National map unit symbol: hqbp
Elevation: 0 to 300 feet
Mean annual precipitation: 10 to 35 inches
Mean annual air temperature: 73 to 75 degrees F
Frost-free period: 365 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Pulehu and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Pulehu

Setting

Landform: Alluvial fans
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope, tread
Down-slope shape: Linear
Across-slope shape: Concave
Parent material: Alluvium

Typical profile

H1 - 0 to 21 inches: cobbly clay loam
H2 - 21 to 60 inches: silty clay loam

Properties and qualities

Slope: 3 to 7 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: NoneOccasional
Frequency of ponding: None
Available water supply, 0 to 60 inches: Moderate (about 7.5 inches)

Interpretive groups

Land capability classification (irrigated): 2e
Land capability classification (nonirrigated): 4s
Hydrologic Soil Group: B
Ecological site: R158XY002HI - Isohyperthermic Torric Naturalized Grassland
Hydric soil rating: No

rRK—Rock land

Map Unit Setting

National map unit symbol: hqcq
Elevation: 0 to 6,000 feet
Mean annual precipitation: 15 to 60 inches
Mean annual air temperature: 57 to 75 degrees F
Frost-free period: 365 days
Farmland classification: Not prime farmland

Map Unit Composition

Rock land and similar soils: 55 percent
Rock outcrop: 45 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Rock Land

Setting

Landform: Pahoehoe lava flows
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Mountainflank, side slope, riser, rise
Down-slope shape: Linear
Across-slope shape: Concave
Parent material: Basalt

Typical profile

H1 - 0 to 4 inches: silty clay loam
H2 - 4 to 8 inches: silty clay
H3 - 8 to 20 inches: bedrock

Properties and qualities

Slope: 0 to 70 percent
Depth to restrictive feature: 4 to 10 inches to lithic bedrock
Drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Very low (about 1.1 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: D
Hydric soil rating: No

Description of Rock Outcrop

Typical profile

H1 - 0 to 60 inches: bedrock

Properties and qualities

Slope: 10 to 70 percent
Depth to restrictive feature: 0 inches to lithic bedrock
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Available water supply, 0 to 60 inches: Very low (about 0.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8s

rRO—Rock outcrop

Map Unit Setting

National map unit symbol: hqcr
Elevation: 0 to 10,000 feet
Mean annual precipitation: 10 to 175 inches
Mean annual air temperature: 45 to 75 degrees F
Frost-free period: 365 days
Farmland classification: Not prime farmland

Map Unit Composition

Rock outcrop: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Rock Outcrop

Typical profile

H1 - 0 to 60 inches: bedrock

Properties and qualities

Slope: 5 to 99 percent
Depth to restrictive feature: 0 inches to lithic bedrock
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Available water supply, 0 to 60 inches: Very low (about 0.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8s
Hydric soil rating: No

rRS—Rough broken and stony land

Map Unit Setting

National map unit symbol: hqct
Elevation: 0 to 4,000 feet
Mean annual precipitation: 20 to 200 inches
Mean annual air temperature: 61 to 73 degrees F
Frost-free period: 365 days
Farmland classification: Not prime farmland

Map Unit Composition

Rough broken and stony land: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Rough Broken And Stony Land

Setting

Landform: Gulches
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Mountainflank
Down-slope shape: Linear
Across-slope shape: Concave
Parent material: Alluvium & colluvium

Typical profile

H1 - 0 to 8 inches: very stony silty clay
H2 - 8 to 18 inches: silty clay
H3 - 18 to 60 inches: bedrock

Properties and qualities

Slope: 40 to 70 percent
Depth to restrictive feature: 12 to 55 inches to paralithic bedrock
Drainage class: Well drained
Runoff class: Very high

Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Available water supply, 0 to 60 inches: Very low (about 2.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydric soil rating: No

rRT—Rough mountainous land

Map Unit Setting

National map unit symbol: hqcv
Elevation: 0 to 6,000 feet
Mean annual precipitation: 70 to 400 inches
Mean annual air temperature: 57 to 72 degrees F
Frost-free period: 365 days
Farmland classification: Not prime farmland

Map Unit Composition

Rough mountainous land and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Rough Mountainous Land

Setting

Landform: Gulches
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Mountainflank, side slope, rise
Down-slope shape: Linear
Across-slope shape: Convex
Parent material: Alluvium and colluvium

Typical profile

H1 - 0 to 5 inches: silty clay loam
H2 - 5 to 25 inches: very cobbly clay loam
H3 - 25 to 29 inches: bedrock

Properties and qualities

Slope: 50 to 99 percent
Depth to restrictive feature: 20 to 40 inches to paralithic bedrock
Drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Low (about 3.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8e

Hydrologic Soil Group: B
Hydric soil rating: No

rSM—Stony alluvial land

Map Unit Setting

National map unit symbol: hqcw
Elevation: 0 to 1,000 feet
Mean annual precipitation: 10 to 50 inches
Mean annual air temperature: 72 to 75 degrees F
Frost-free period: 365 days
Farmland classification: Not prime farmland

Map Unit Composition

Stony alluvial land and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Stony Alluvial Land

Setting

Landform: Alluvial fans
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Rise
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Alluvium

Typical profile

H1 - 0 to 10 inches: extremely stony clay loam
H2 - 10 to 60 inches: bouldery silty clay loam

Properties and qualities

Slope: 3 to 15 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: About 6 to 12 inches
Frequency of flooding: Frequent
Frequency of ponding: None
Available water supply, 0 to 60 inches: Low (about 3.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: A/D
Hydric soil rating: No

References

American Association of State Highway and Transportation Officials (AASHTO). 2004. Standard specifications for transportation materials and methods of sampling and testing. 24th edition.

American Society for Testing and Materials (ASTM). 2005. Standard classification of soils for engineering purposes. ASTM Standard D2487-00.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deep-water habitats of the United States. U.S. Fish and Wildlife Service FWS/OBS-79/31.

Federal Register. July 13, 1994. Changes in hydric soils of the United States.

Federal Register. September 18, 2002. Hydric soils of the United States.

Hurt, G.W., and L.M. Vasilas, editors. Version 6.0, 2006. Field indicators of hydric soils in the United States.

National Research Council. 1995. Wetlands: Characteristics and boundaries.

Soil Survey Division Staff. 1993. Soil survey manual. Soil Conservation Service. U.S. Department of Agriculture Handbook 18. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_054262

Soil Survey Staff. 1999. Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys. 2nd edition. Natural Resources Conservation Service, U.S. Department of Agriculture Handbook 436. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053577

Soil Survey Staff. 2010. Keys to soil taxonomy. 11th edition. U.S. Department of Agriculture, Natural Resources Conservation Service. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053580

Tiner, R.W., Jr. 1985. Wetlands of Delaware. U.S. Fish and Wildlife Service and Delaware Department of Natural Resources and Environmental Control, Wetlands Section.

United States Army Corps of Engineers, Environmental Laboratory. 1987. Corps of Engineers wetlands delineation manual. Waterways Experiment Station Technical Report Y-87-1.

United States Department of Agriculture, Natural Resources Conservation Service. National forestry manual. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/home/?cid=nrcs142p2_053374

United States Department of Agriculture, Natural Resources Conservation Service. National range and pasture handbook. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/landuse/rangepasture/?cid=stelprdb1043084

United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/scientists/?cid=nrcs142p2_054242

United States Department of Agriculture, Natural Resources Conservation Service. 2006. Land resource regions and major land resource areas of the United States, the Caribbean, and the Pacific Basin. U.S. Department of Agriculture Handbook 296. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053624

United States Department of Agriculture, Soil Conservation Service. 1961. Land capability classification. U.S. Department of Agriculture Handbook 210. http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_052290.pdf

Appendix B. MEC Head Cut Monitoring Report
From January of 2021

POHAKEA WATERSHED / MAALAEA BAY
MAUI COUNTY, HAWAII

HEAD CUT MONITORING MAUKA OF HONOAPIILANI HIGHWAY
JANUARY 2021 REPORT

Prepared for:

MAUI NUI MARINE RESOURCE COUNCIL

January 25th, 2021

Prepared by:

MAUI ENVIRONMENTAL CONSULTING

Maui Environmental Consulting, LLC
PO Box 790568
Paia, HI 96779 • 808-866-6919

Emily R. Johnson
Field Ecologist

Michael J. Reyes
Senior Ecologist/Principal

1.0 INTRODUCTION

At the request of Maui Nui Marine Resource Council (MNMRC) (Client), Maui Environmental Consulting, LLC (MEC) installed simple erosion monitoring infrastructure at four previously identified stream locations where severe head cutting has been observed. MEC monitors and records loss of soils at each location after rain events have caused streams to flow. Head cut data collection will assist in quantifying the amount of sediment and other pollutants entering Ma'alaea Bay during stormwater events. MEC monitored soil loss associated with head cutting on January 20th, 2021 after significant rainfall was produced during the stormwater event that occurred on January 18th, 2021. MEC will continue to monitor these locations after large storm events (Project).

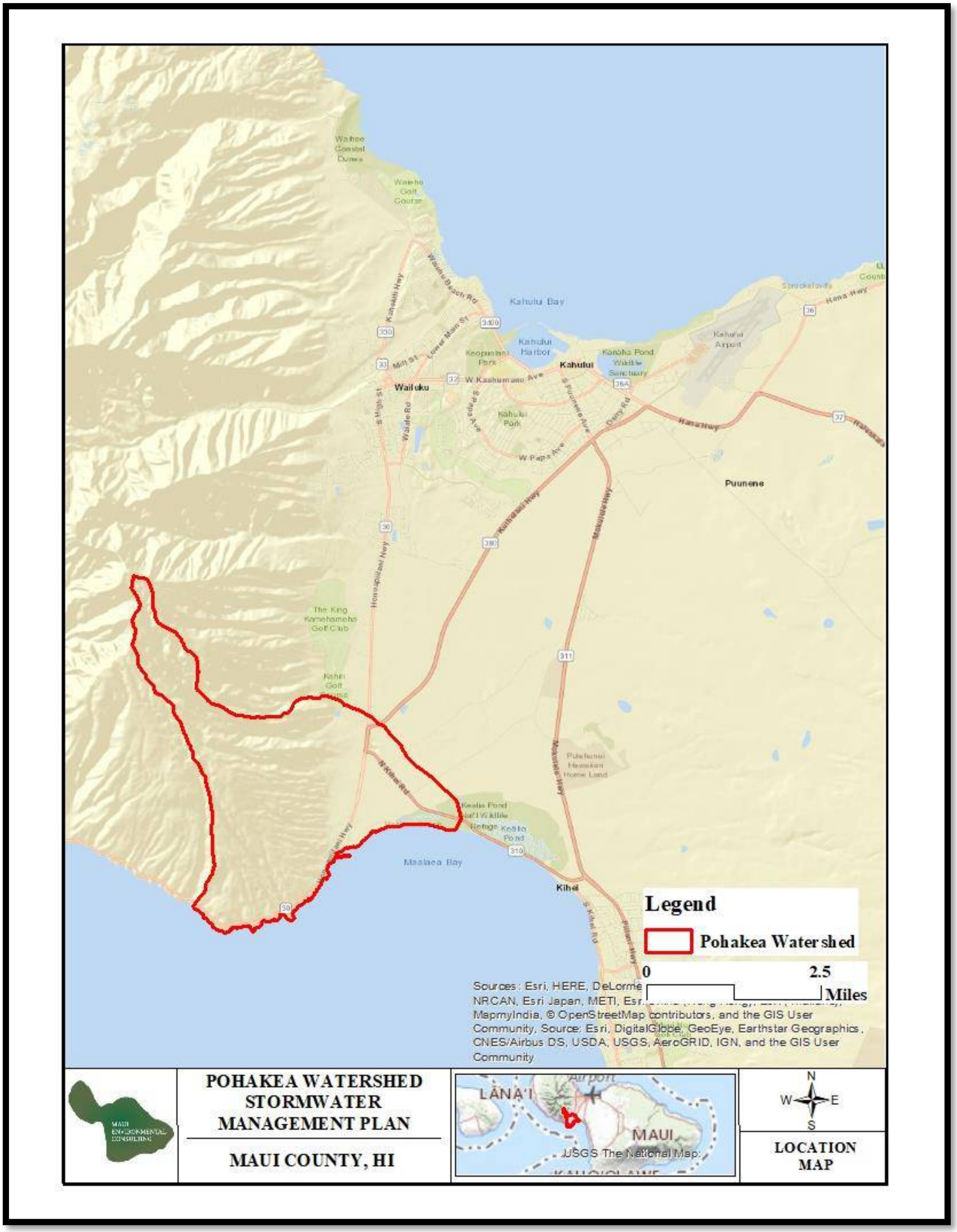
2.0 BACKGROUND

Pohakea Watershed begins at approximately 4,600 feet at the summit of Hanaula within the West Maui Mountains. Along the coast, this watershed stretches from Kealia Pond and continues west past McGregor's Point to the eastern ridge of Manawainui Gulch. The makai portions of the watershed are approximately located between mile markers 4.5 and 9.25 along Honoapiʻilani Highway (or from just west of Papawai Point to just north of the intersection of Honoapi'ilani and Kuihelani Highways). Pohakea extends east to approximately mile marker 1.5 along North Kihei Road and the western edge of Kealia Pond. The entire area is part of the West Maui Mountains land formation and discharges into the western portion of Maʻalaea Bay (Location Map).

In 2018, while canvassing the Pohakea Watershed for sources of land-based pollution, MEC observed four locations exhibiting substantial loss of sediment along the upstream side of Honoapiilani Highway. At these locations stream flow is directed underneath the highway through box drains and culverts. The constriction point created by these culverts has led to extensive head cutting within the stream channel and loss of many tons of sediment material during times when the streams flow. Head cuts occur when stream force is directed downward due to a constriction of flow (in this case a road culvert), and creates a sheer bluff or cliff known as the knickpoint. The head cutting observed was 'active' in that more stream channel incision, loss of floodplain connectivity, and loss of sediment at an exponential rate will continue and worsen as the knickpoint migrates further upstream each time the stream flows.

2.1 Streams and Stormwater Conveyances

Of the four head cut locations observed, two are associated with Maalaea Gulch and two are associated with unnamed stormwater conveyances. Maalaea gulch begins at approximately 1,800 feet, flowing east towards Honoapiʻilani Highway. Historically, the stream flowed under the highway near the northern portion of the Maalaea Triangle. Today, due to agricultural impacts, the stream flows south of its original path, flowing under the highway near the middle of the Maalaea Triangle. In addition to the two locations associated with Maʻalaea gulch, two smaller stormwater conveyances exhibit substantial head cutting where they enter culverts running under Honoapiilani Highway. One is associated with the Spencer property and the other is on State land (Head Cut Monitoring Sites Map).


Kahului Bay
Kahului
Wailuku
Puunene
Maalaea Bay
Kihei
Legend
Pohakea Watershed
0
2.5
Miles
Sources: Esri, HERE, DeLorme, NRCAN, Esri Japan, METI, Esri ... Mapmyindia, © OpenStreetMap contributors, and the GIS User Community, Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
POHAKEA WATERSHED
STORMWATER
MANAGEMENT PLAN
MAUI COUNTY, HI
LĀNA'I
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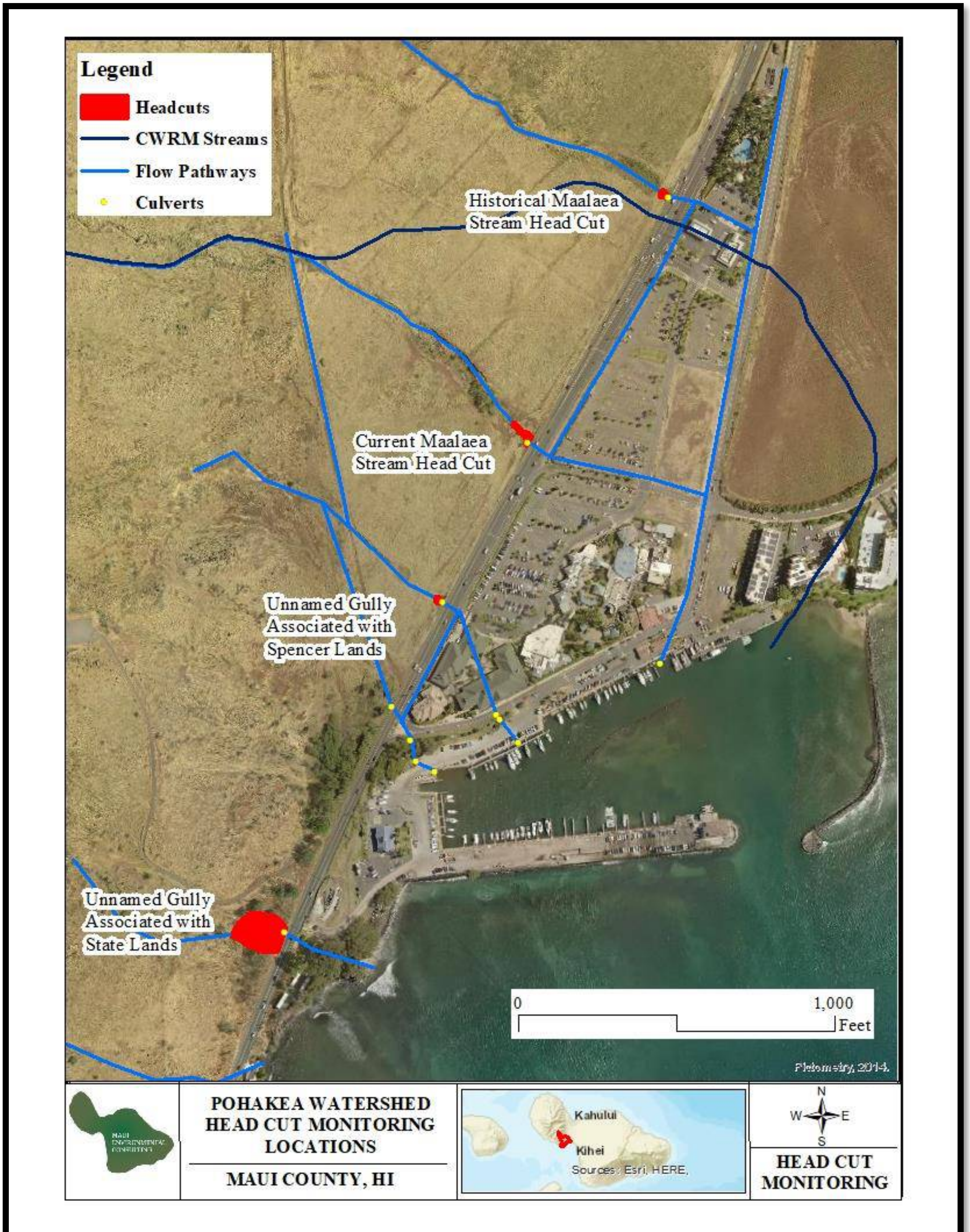
Legend
Headcuts
CWRM Streams
Flow Pathways
Culverts
Historical Maalaea Stream Head Cut
Current Maalaea Stream Head Cut
Unnamed Gully Associated with Spencer Lands
Unnamed Gully Associated with State Lands
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Feet
POHAKEA WATERSHED HEAD CUT MONITORING LOCATIONS
MAUI COUNTY, HI
Kahului
Kihei
Sources: Esri, HERE,
N
W
E
S
HEAD CUT MONITORING

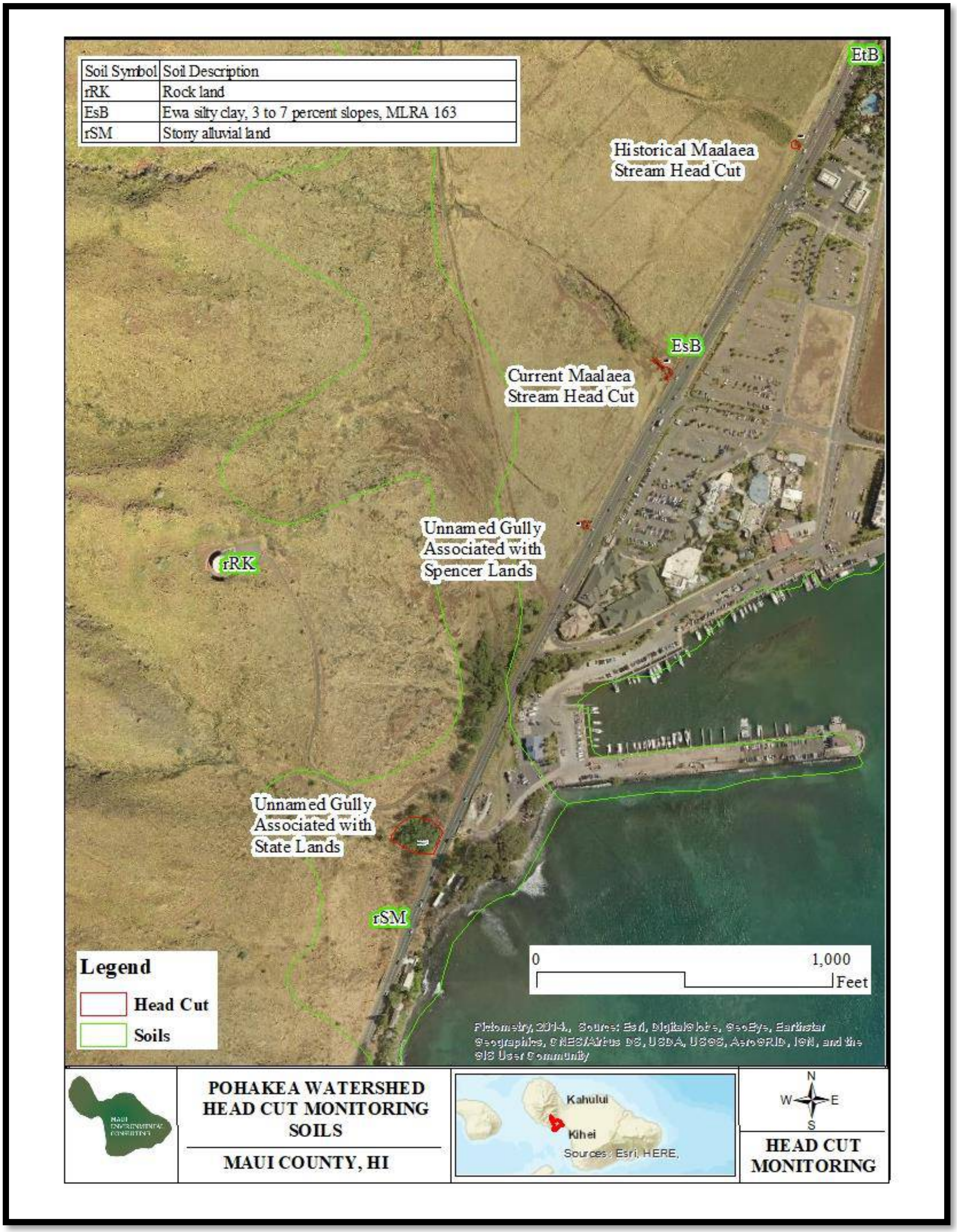
2.2 Soil Descriptions

Based on the USDA/NRCS Soil Survey for Maui County, three soil types are mapped within the Project (Soils Map). In addition, the center of the reservoir is mapped as Water Greater than 40 Acres. Neither of the soil types listed are classified as hydric according to the *NRCS Web Soil Survey*. Listed below are the soil types (including the Water classification) found within the Project boundary and a general description of their characteristics.

2.2.1 *EsB—Ewa silty clay, 3 to 7 percent slopes, MLRA 163–* This soil type in found at elevations from 0 to 320 feet in areas with a mean annual precipitation of 17 to 25 inches. It is typically associated with alluvial fans and has a foot slope landform position. The parent material is basic igneous rock. The typical surface profile is silty clay from the surface to a depth of 13 inches. From 13 to 60 inches, this becomes silty clay loam. Depth to a restrictive feature and the water table is more than 80 inches and is this soil type is considered well drained. The runoff class designation is Medium. There is no frequency of ponding or flooding and this soil type is not considered hydric according to the *NRCS Web Soil Survey*.

2.2.2 *rRK-Rock land –* This soil type in found at elevations from 0 to 6,000 feet in areas with a mean annual precipitation of 15 to 60 inches. It has a backslope slope landform position and is associated with pahoehoe lava flows. The parent material is basalt. The typical surface profile is silty clay loam from the surface to a depth of four inches. From four to eight inches, it is silty clay. Below eight inches to a depth of 20 inches, bedrock exists. Depth to a restrictive feature, in this case lithic bedrock, occurs in four to ten inches. Depth to the water table is greater than 80 inches. This soil type is considered Well Drained. The runoff class designation is Very High. There is no frequency of ponding or flooding and this soil type is not considered hydric according to the NRCS Web Soil Survey.

2.2.3 *rSM—Stony alluvial land–* This soil type in found at elevations from 0 to 1,000 feet in areas with a mean annual precipitation of 10 to 50 inches. It is typically associated with alluvial fans and has a foot slope landform position. The parent material is alluvium. The typical surface profile is extremely stony clay loam from the surface to a depth of ten inches and boulder silty clay loam from ten inches to 60 inches. Depth to a restrictive feature is more than 80 inches. Depth to the water table is approximately six to 12 inches. This soil type is considered well drained. The runoff class designation is Medium. Frequency of flooding is Frequent and there is no frequency of ponding. This soil type is not considered hydric according to the NRCS Web Soil Survey.


Soil Symbol | Soil Description
rRK | Rock land
EsB | Ewa silty clay, 3 to 7 percent slopes, MLRA 163
rSM | Stony alluvial land
EtB
Historical Maalaea Stream Head Cut
EsB
Current Maalaea Stream Head Cut
Unnamed Gully Associated with Spencer Lands
rRK
Unnamed Gully Associated with State Lands
rSM
Legend
Head Cut
Soils
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1,000
Feet
POHAKEA WATERSHED
HEAD CUT MONITORING
SOILS
MAUI COUNTY, HI
Kahului
Kihei
Sources: Esri, HERE,
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MONITORING

3.0 METHODOLOGY

3.1 Installation of Head Cut Monitoring Infrastructure

In July of 2020, MEC drove 10-inch galvanized-steel spike nails into the ground at the upper extent of head cuts observed at four stream locations within the Pohakea Watershed. Two additional nails were driven into the ground at one-foot increments from the current edge of the head cut for a total of three nails (three feet) per array within each of the four monitoring locations. By measuring the amount of soil lost between nails, and the depth of the head cut observed, MEC aims to quantify the approximate amount of soil loss during stormwater events.

3.2 October 2020 Head Cut Monitoring

In October of 2020, MEC staff canvassed the four streams to review the head cut monitoring infrastructure. Pictures were taken of any obvious changes to the soil pin arrays. Any evidence of knickpoint cleaving or loss of soil pins at the edge of head cuts was photographed and measured using a standard tape measurer. In addition, evident of erosion from sheet flow, evidenced by exposed soil pins was also recorded.

3.3 January 2021 Head Cut Monitoring

On January 18th, 2021 a storm event occurred with enough rain to cause flow within the gullies and gulches associated with the Pohakea Watershed. MEC staff canvassed the four streams to review the head cut monitoring infrastructure on January 20th, 2021. Pictures were taken of any obvious changes to the soil pin arrays. Any evidence of knickpoint cleaving or loss of soil pins at the edge of head cuts was photographed and measured using a standard tape measurer. In addition, evidence of erosion from sheet flow was also recorded.

3.4 Soil Loss Calculations

The head cut monitoring infrastructure consists of soil pin arrays made up of three 10-inch galvanized nails. These arrays have been placed around the perimeter of each head cut at the four locations identified by this study. This monitoring infrastructure is intended to offer general approximations of soil loss at each monitoring station. These approximations are based on various assumptions. A key assumption built into the soil loss calculation is that one cubic foot of soil weighs approximately 75 pounds. The calculations included as results in this study are therefore meant to be approximations based on the assumptions employed in the soil loss calculations.

A tape measurer was used to measure the height of the soil pin above the soil surface. For each soil array, three pins are separated by a distance of one foot. When the first pin in the array depicts soil loss but the second and third pin remain flush against the soil surface, we assume that one square foot or less of soil surface area has been lost at each array.

For the purposes of this study the loss is assumed to be one square foot of soil loss until the second soil pin in the array also begins to show evidence of soil loss. Generally, one cubic foot of dry loose soil weighs approximately 75 pounds. Therefore, one cubic inch of this same soil weighs approximately 0.043 pounds (there are 1728 cubic inches in a cubic foot). Assuming one square foot of surface area soil loss (144 square inches), we calculate the volume of soil lost by multiplying the area or soil loss by the depth from the top of the soil pin to the current surface of the soil. Finally, to determine weight of soil lost, we multiply the volume by the weight of the soil.

4.0 RESULTS

The following section provides information on the January 2021 conditions observed at the four head cut monitoring locations. These locations were chosen based on severe head cutting observed during field work conducted in 2018 in association with the Pohakea Stormwater Management Plan. MEC staff took 204 photographs while recording current conditions at these locations during the January monitoring event. Additional pictures not included in the photo document have been shared with Maui Nui Marine Resource Council via Dropbox. Head cut monitoring stations were titled:

1. Historic Maalaea Gulch Head Cut Monitoring Station
2. Current Maalaea Gulch Head Cut Monitoring Station
3. Spencer Lands Head Cut Monitoring Station
4. State Lands Head Cut Monitoring Station

The results from this study are broken down over four individual diagrams and photo-documents. Each photo-document contains pictures of respective head cuts and monitoring pins and is proceeded by diagram depicting each site. Future head cut monitoring events and reports will also include any loss of soil monitoring pins along with an approximation of the amount of soil lost. Results of the January 2021 monitoring event are presented below.

4.1 Historic Maalaea Head Cut Monitoring Station

According to the State of Hawaii Department of Land and Natural Resources, Commission on Water Resource Management (CWRM) Hawaii Stream Assessment database, the natural stream channel of Maalaea Gulch has been altered due to legacy agricultural operations associated with the area. The stream used to flow east past both Honoapiilani Highway and Maalaea Road in the northern portion of where Maalaea Triangle exists today before turning south and discharging into Maalaea Harbor where the Maalaea Yacht Marina Condos now stand (Head Cut Monitoring Sites Map). Today, this stormwater conveyance is more akin to a ditch, with an old detention basin located mauka of the highway and just above the location of the head cutting.

The original head cut wall was approximately 50 feet in length and formed a half circle. Eleven arrays consisting of three nails spaced in one-foot increments were placed every five feet along the top of the wall. The depth of the head cutting was fairly uniform at six and a half feet deep.

At the time of the October 2020 monitoring event extremely dry conditions were observed. Plants located in the old detention basin just mauka of the head cut were dry and dying. During the January 2021 monitoring event, this detention basin was full of water, likely causing anaerobic soil conditions that further stressed the existing plants. Rocks are still being piled up within the culvert by homeless individuals living under Honoapiilani Highway.

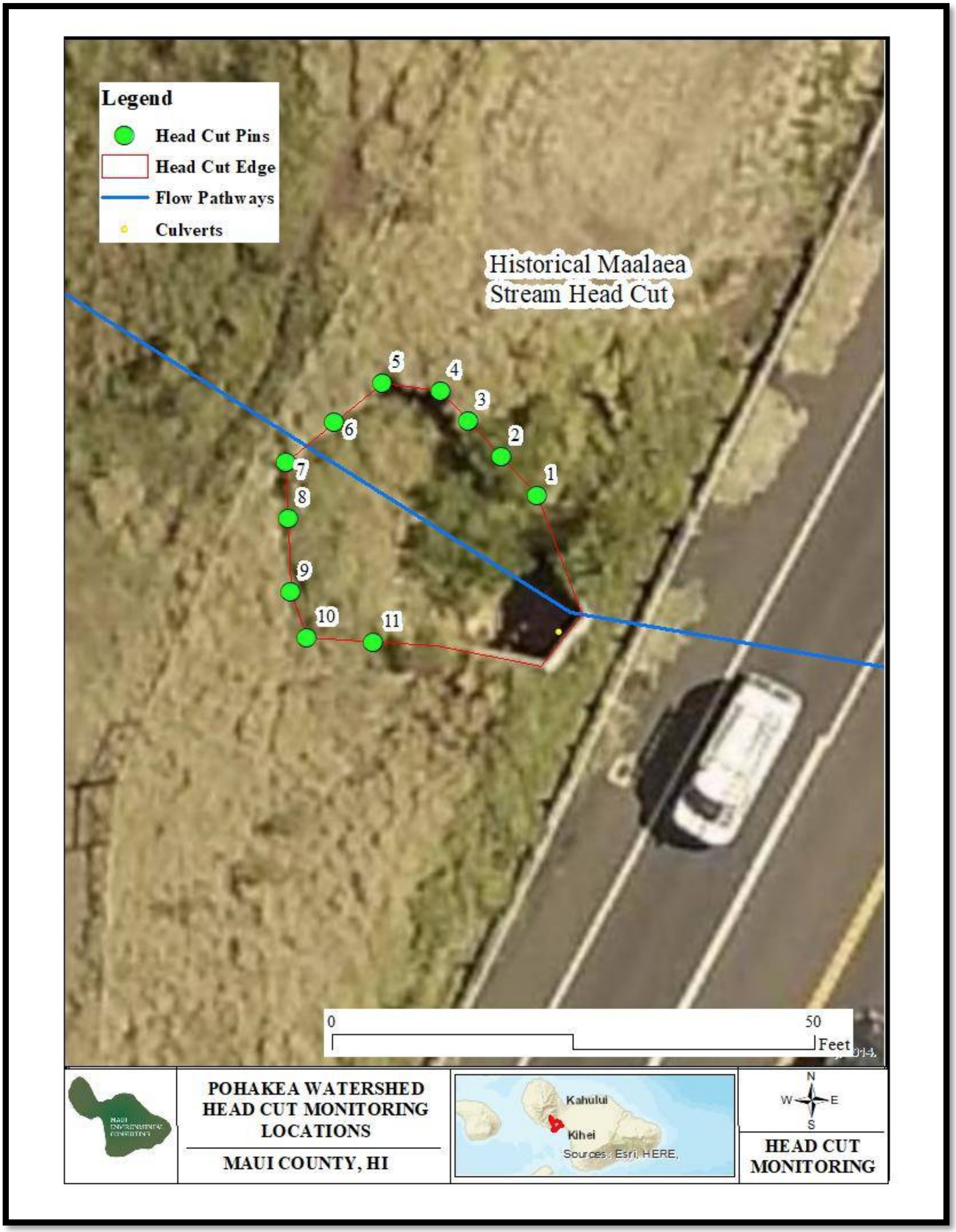
During the January 2021 monitoring event significant soil loss was observed, especially at the knickpoint located at the top of the head cut. As depicted by the images, several soil pins were dislodged, and three array locations (5, 7, 9) had one nail missing. For each of these nails, MEC staff assumed one square foot of soil surface area was lost. In addition, severe erosion associated with array #6 caused the loss of all three nails, indicating at least three-square feet of soil surface area lost from this portion of the head cut. Due to soil loss at this location, it is highly likely that during a future storm event with similar rainfall, head cutting will undermine the detention basin and cause significant flooding and erosion.

Multiplied by the averaged wall height of the original head cut (6.5 feet), there was an estimated total of 5,795.72 pounds of soil lost within the Historical Ma'alaea Head Cut due to the January 18th, 2021 stormwater event. Table 1 below depicts the amount of soil lost based on observations made during the January 2021 monitoring event.

Table 1. January 2021 Historical Maalaea Soil Loss by Array

Array	Surface Area of Soil Loss (square inches)	Depth of Soil Loss (inches)	Weight of One Square Inch of Soil (0.043 pounds)	Pounds of Soil Lost
5	144	78	0.043	482.98
6	1,296	78	0.043	4,346.78
7	144	78	0.043	482.98
9	144	78	0.043	482.98

Total Pounds of Soil Lost- 5,795.72


Legend
Head Cut Pins
Head Cut Edge
Flow Pathways
Culverts
Historical Maalaea
Stream Head Cut
1
2
3
4
5
6
7
8
9
10
11
0
50
Feet
POHAKEA WATERSHED
HEAD CUT MONITORING
LOCATIONS
MAUI COUNTY, HI
Kahului
Kihei
Sources: Esri, HERE,
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MONITORING

Historic Maalaea Head Cut Monitoring Station – January 2021

Wrack lines and sediment deposits at culvert entrance

Evidence of sediment laden stormwater

Location of array #6 with all three soil pins missing

Exposed soil pin at array #9

Vegetation comparison:

July 2020

January 2021

4.2 Current Maalaea Head Cut Monitoring Station

Maalaea Gulch currently flows south of its original pathway. Just mauka of where this stormwater conveyance flows under Honoapiilani Highway, a large and deeply incised head cut has formed. The head cut is much more severe than others observed within Pohakea Watershed. Shear vertical walls have formed along the stream channel

Taking into account both banks, the head cut wall is approximately 170 feet in length. Average wall height is 16 feet. In total 46 monitoring arrays were installed. Of these, 43 are located at the edge of the head cut and three additional arrays were installed at the lip of a ledge that exists at the upper extent of the head cut. Each monitoring array consists of three nails spaced in one-foot increments. The arrays are spaced every 5 feet along the top of the head cut wall.

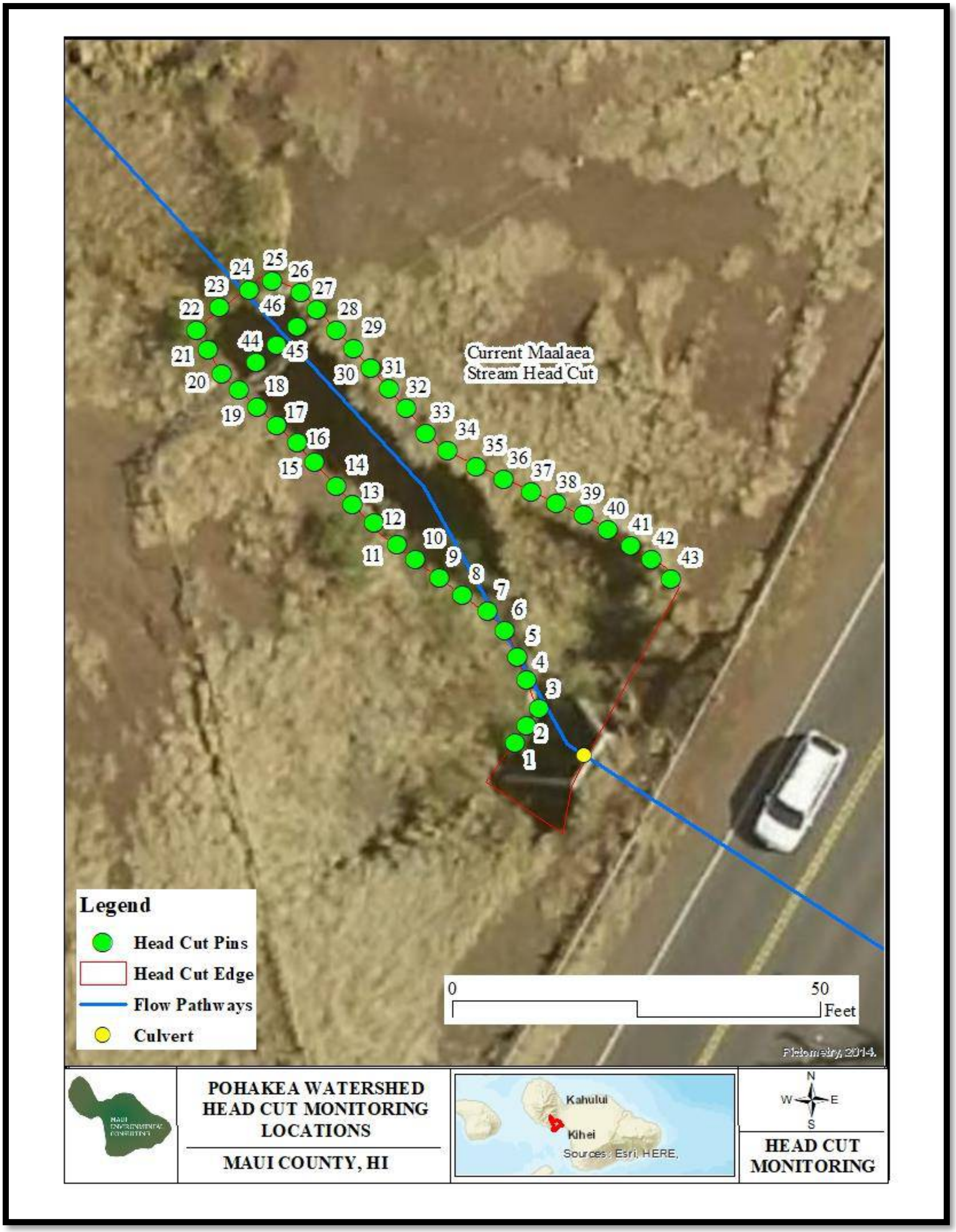
At the time of the baseline monitoring, a homeless encampment was observed within the culvert associated with this head cut. Large piles of debris were piled both outside the culvert within the head cut as well as within the culvert itself. The amount of the debris observed was cause for concern as the culvert was completely clogged with rubbish. MEC notified MNMRC of the situation. Amy Hodges from MNMRC then contact Maui Department of Transportation and the rubbish has since been removed. MEC will continue to record any observations of trash being placed in stormwater conveyance and culverts associated with Pohakea Watershed. At the time of the January 2021 monitoring event, the culvert continued to be free of rubbish except for a couple of small items of debris at the entrance to the culvert. Branches remain piled up within the head cut and may potentially clog the culvert during future stormwater events.

Evidence of severe head cutting was observed during the January 2021 monitoring event at the Current Maalaea Head Cut monitoring station. Significant soil loss was observed, especially at the knickpoint located at the top of the head cut. As illustrated in the images, many soil pins were dislodged, and four arrays (20, 22, 23, and 45) were completely gone, with all three nails missing. This indicates at least three-square feet of soil surface area were lost from each of these portions of the head cut. There were two array locations (21 and 46) that had two nails missing, indicating at least two square feet of soil surface lost at these arrays. Lastly, there were five array locations (19, 26, 32, 42, and 44) that had one soil pin missing, indicating at least one square foot of soil surface loss at these locations within the head cut. Combined with the averaged depth of the original head cut (16 feet), there was an estimated total of 58,254.33 pounds of soil lost within the Current Ma’alaea Head Cut due to the January 18th, 2021 stormwater event. Table 2 below depicts the amount of soil lost based on observations made during the January 2021 monitoring event.

Table 2. January 2021 Current Maalaea Soil Loss by Array

Array	Surface Area of Soil Loss (square inches)	Depth of Soil Loss (inches)	Weight of One Square Inch of Soil (0.043 pounds)	Pounds of Soil Lost
19	144	192	0.043	1,188.86
20	1,296	192	0.043	10,699.78
21	576	192	0.043	4, 755.46
22	1,296	192	0.043	10,699.78
23	1,296	192	0.043	10,699.78
26	144	192	0.043	1,188.86
32	144	192	0.043	1,188.86
42	144	192	0.043	1,188.86
44	144	192	0.043	1,188.86
45	1,296	192	0.043	10,699.78
46	576	192	0.043	4, 755.46

Total Pounds of Soil Lost- 58,254.33


Current Maalaea Stream Head Cut
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46
Legend
Head Cut Pins
Head Cut Edge
Flow Pathways
Culvert
0
50
Feet
Pictometry, 2014.
POHAKEA WATERSHED HEAD CUT MONITORING LOCATIONS
MAUI COUNTY, HI
Kahului
Kihei
Sources: Esri, HERE,
N
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E
S
HEAD CUT MONITORING

Current Maalaea Head Cut Monitoring Station

Soil and debris captured at bollards just mauka of the box culvert

Significant soil loss within head cut

October 2020 Extent of Head Cut

January 2021 Extend of Head Cut

4.3 Spencer Lands Head Cut Monitoring Station

This stormwater conveyance is more akin to a ditch, with an old detention basin located approximately 100 feet mauka of the location of the head cutting. This head cut is similar in size to the Historic Maalaea Gulch Head Cut.

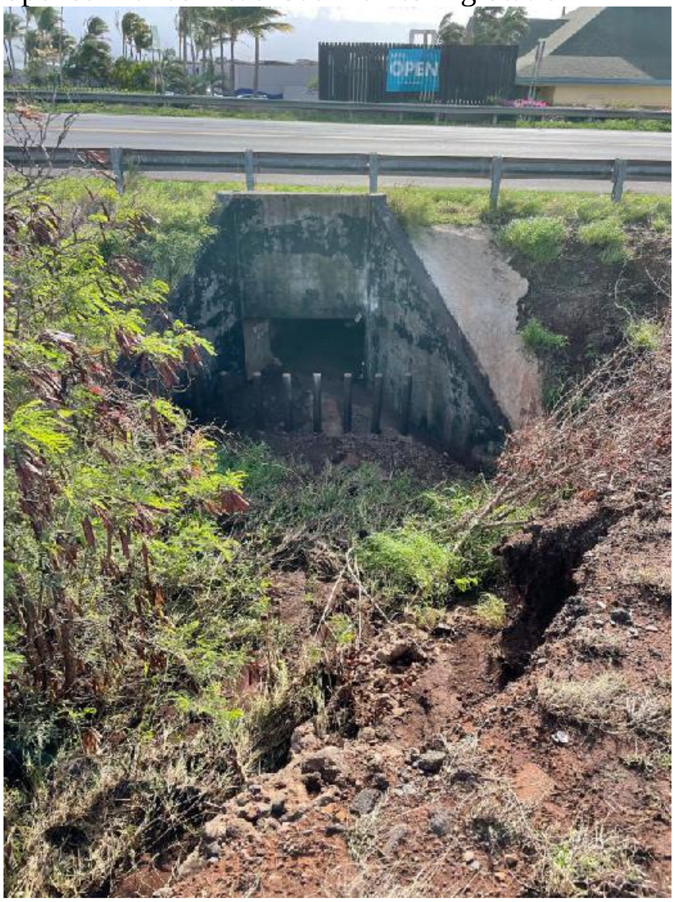
The head cut wall is approximately 50 feet in length and forms a half circle. Twelve arrays consisting of three nails spaced in one-foot increments were placed every five feet along the top of the wall. The depth of the head cutting was fairly uniform at six and a half feet deep.

During the October 2020 monitoring event, large amounts of rubbish were observed to be stockpiled inside the culvert. This rubbish is due to an ongoing homeless encampment occurring in the stormwater infrastructure under Honoapiilani Highway. During the January 2021 monitoring event it was noted that the rubbish has since been removed.

While some evidence of sheet flow erosion was observed during the October 2020 monitoring event, no erosion or soil lost was observed during the January 2021 event at the Spencer Lands head cut monitoring station. This lack of new evidence of erosion after a large storm event suggests the original soil lost was due to wind erosion and not caused by surface water sheet flow.


10
11
12
9
8
7
6
5
4
3
2
1
Unnamed Gully Associated with Spencer Lands
Legend
Head Cut Pins
Head Cut Edge
Flow Pathways
Culvert
0
30
Feet
Pictometry, 2014.
POHAKEA WATERSHED HEAD CUT MONITORING LOCATIONS
MAUI COUNTY, HI
Kahului
Kihei
Sources: Esri, HERE,
N
W
E
S
HEAD CUT MONITORING

Spencer Lands Head Cut Monitoring Station

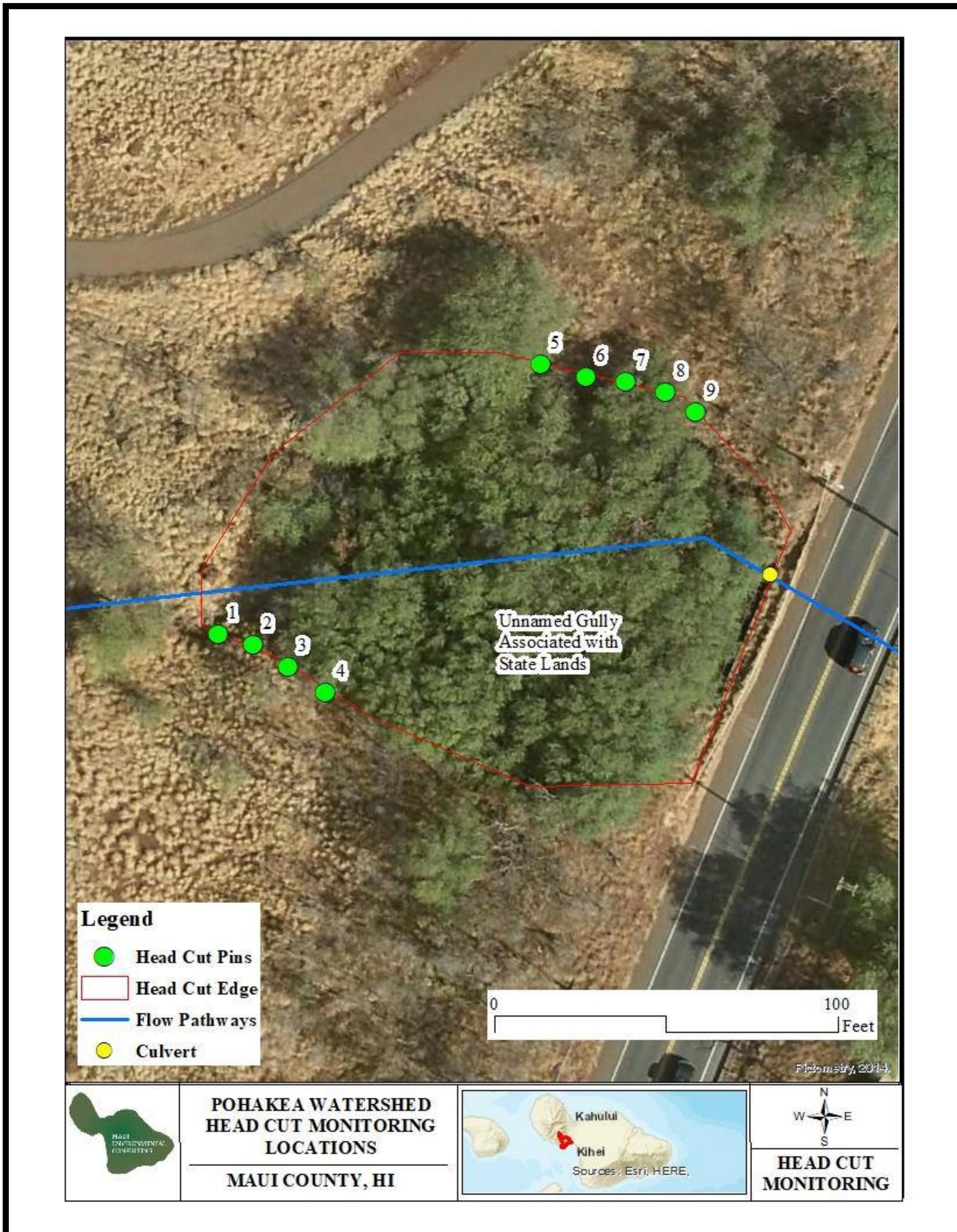


4.4 State Lands Head Cut Monitoring Station

While much larger than the other head cuts, this site is associated with a small unnamed gully located on State lands. The gully flows into the bowl-shaped head cut and then flows under Honoapiilani Highway before discharging into Maalaea Bay just south of the break wall of Maalaea Harbor. Sections of this head cut appear to have been armored in the past. Today, two sections remain unprotected. Monitoring arrays were therefore limited to these sections of the head cut.

The entire perimeter of the head cut area is quite large with a length of approximately 360 feet. The two sections where head cutting appears to be recent were much smaller. Four arrays were spaced five feet apart on the southern wall of the head cut and five arrays were placed on the northern wall. Each array consists of three nails evenly spaced one foot apart.

While evidence of flow was observed within the site, no indication of further head cutting or sheet flow erosion was observed during the January 2021 monitoring events at the State Lands head cut monitoring station.


5
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4
Unnamed Gully Associated with State Lands
Legend
Head Cut Pins
Head Cut Edge
Flow Pathways
Culvert
0
100
Feet
Pictometry, 2014.
POHAKEA WATERSHED HEAD CUT MONITORING LOCATIONS
MAUI COUNTY, HI
Kahului
Kihei
Sources: Esri, HERE,
N
W
E
S
HEAD CUT MONITORING

Unnamed Gully Associated with State Lands Head Cut Monitoring Station

5.0 DISSCUSSION

MEC canvassed all four head cut monitoring stations for evidence of soil loss during the January 2021 field event. These stormwater conveyances flowed in response to a storm that occurred on January 18th, 2021. Head cutting and the associated soil loss was significant at two of the four monitoring stations.

MEC estimates at least 5,800 pounds of soil became loose and entered into the stream channel and storm water infrastructure associated with the Historic Maalaea Head Cut Monitoring Station. The knickpoint of this head cut is dangerously close to undermining a detention basin associated with legacy agricultural operations immediately mauka of the Department of Transportation right-of-way fence. If the knickpoint of the head cut continues in this manner, it will likely undermine the detention basin while the basin is full of water and may cause significant flood damage.

The Current Maalaea Head Cut Monitoring Station exhibited severe soil loss. MEC estimates over 58,000 pounds of soil has eroded away and entered the stream bed and/or storm water infrastructure. This monitoring station experiences the worst erosion by far of the four stations being monitored and should be considered a top priority for future bank stabilization efforts. MEC will conduct a final head cut monitoring event in the Spring of 2021.

Due to the substantial and ongoing losses of sediment observed at head cuts just mauka of the highway, head cut stabilization is a priority recommendation for preventing sediment loss within the project area. Head cut stabilization is accomplished by either 1) excavating the actively eroding knickpoint (cliff) and incised stream banks to substantially reduce the slope, or 2) by filling in the incised channel below the knickpoint having the same result.

Both these methods serve to reduce stream flow velocity which prevents further scouring and erosion, however filling in the channel is not possible in these cases due to the presence of the highway just below the head cuts. Along the newly reshaped stream channel slope, boulders are used to create riffle pools which further reduce stream flow velocity and allow one pool to fill up before spilling into the next. Head cut stabilization and restoration is greatly enhanced by including native plants to further prevent erosion and maintain the new channel shape.

All four head cut sites described in this report are candidates for repair. The Pohakea Watershed is characterized by long periods with little to no rain punctuated by substantial and damaging stormwater flows. Any head cut stabilization or stream channel reshaping must be engineered to handle these high flow events. As mentioned earlier, a review of aerial imagery suggests that at least two of the sites, Historic Maalaea Gulch and the Unnamed Gully on Spencer land, have unmaintained detention basins that may assist with controlling stormwater in the future.

Appendix C. MEC Māʻalaea Triangle LID Report

MA‘ALAEA TRIANGLE
HONOAPIILANI HIGHWAY
MAUI COUNTY, HAWAII

LOW IMPACT DEVELOPMENT
RESEARCH, EVALUATION, AND DESIGN

Prepared for:

MAUI NUI MARINE
RESOURCE COUNCIL

December 28th, 2021

Prepared by:

Maui Environmental Consulting, LLC
PO Box 790568
Paia, HI 96779 • 808-866-6919

Katie Woodbury
Ecologist

Michael J. Reyes
Senior Ecologist/Principal

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FIGURES

APPENDICES

1.0 INTRODUCTION AND PURPOSE

At the request of Maui Nui Marine Resource Council (MNMRC), Maui Environmental Consulting, LLC (MEC) conducted Low Impact Development (LID) research, evaluation, and design services for the Maʻalaea Triangle parking lot located in the urban corridor of the Pohakea watershed. In addition, MEC worked with CDF Engineering and Goodfellow Bros. to evaluate several options for reducing stormwater scouring in the head cuts just mauka of Honoapiilani Highway (Project). Specifically, MEC met with MNMRC and Maʻalaea Triangle stakeholders on October 29th and November 30th, 2021, to identify pollutants of concern, develop performance standards, identify regulatory entities, and design and rank candidate LID projects.

2.0 PROJECT SITE DESCRIPTION AND CURRENT CONDITIONS

Pohakea Watershed begins at approximately 4,600 feet at the summit of Hanaula within the West Maui Mountains. Along the coast, this watershed stretches from Kealia Pond and continues west past McGregor's Point to the eastern ridge of Manawainui Gulch. The makai portions of the watershed are approximately located between mile markers 4.5 and 9.25 along Honoapiʻilani Highway (or from just west of Papawai Point to just north of the intersection of Honoapiʻilani and Kuihelani Highways). Pohakea extends east to approximately mile marker 1.5 along North Kihei Road and the western edge of Kealia Pond. The entire area is part of the Mauna Kahālāwai land formation and discharges into the western portion of Maʻalaea Bay

Within the urban corridor of the Pohakea Watershed, the parking lots that service the Maʻalaea Triangle represent approximately 276,000 square feet of impervious surface. This area is a potential source of stormwater runoff. Currently, stormwater entering storm drains receives no treatment before discharging directly into the harbor. Runoff from parking lots has the potential to contain sediment as well as petrochemicals, heavy metals, trash, and other pollutants associated with urban runoff.

2.1 Soils

Based on the USDA/NRCS Soil Survey for Maui County (Version 15, October 3rd, 2017), 19 soil types are mapped within the Pohakea Watershed. The Maʻalaea Triangle sits upon Ewa Silty Clay (Soils Map). Listed below are the soil types near the Project and general descriptions of their characteristics.

Table 1. Soils Near Maʻalaea Triangle

Soil Symbol	Soil Name	Mean Annual Precipitation (inches)	Elevation (feet)	Slope (percent)	Drainage Class	Runoff Class	Frequency of Flooding
EsB	Ewa Silty Clay	15 to 30	0 to 150	3 to 7	Well Drained	Medium	None

Soil Symbol	Soil Name	Mean Annual Precipitation (inches)	Elevation (feet)	Slope (percent)	Drainage Class	Runoff Class	Frequency of Flooding
EtB	Ewa Cobbly Silty Clay	15 to 30	0 to 150	3 to 7	Well Drained	Medium	None
KMW	Kealia Silt Loam	10 to 41	0 to 260	0 to 1	Poorly Drained	Negligible	Frequent
PsA	Pulehu Clay Loam	10 to 50	0 to 300	0 to 3	Well Drained	Low	Rare
PtA	Pulehu Cobbly Clay Loam	10 to 35	0 to 300	0 to 3	Well Drained	Low	Occasional
rRK	Rock Land	15 to 60	0 to 6,000	0 to 70	Well Drained	Very High	None
rSM	Stony Alluvial Land	10 to 50	0 to 1,000	3 to 15	Well Drained	Medium	Frequent

(EsB) – Ewa Silty Clay, 3 To 7 Percent Slopes– This soil type in found at elevations from 0 to 150 feet in areas with a mean annual precipitation of 15 to 30 inches. It is considered prime farmland when irrigated. It has a convex foot slope landform position. The typical surface profile is silty clay from the surface to a depth of 18 inches. From 18 inches to 60 inches, the soil is silty clay loam. Depth to a restrictive feature and the water table is more than 80 inches and is this soil type is considered well drained. The runoff class designation is Medium. There is no frequency of ponding or flooding and this soil type is not considered hydric according to the *NRCS Web Soil Survey*.

(EtB) – Ewa Cobbly Silty Clay, 3 To 7 Percent Slopes– This soil type in found at elevations from 0 to 150 feet in areas with a mean annual precipitation of 15 to 30 inches. It is considered prime farmland when irrigated. It has a convex foot slope landform position. Parent material is basic igneous rocks. The typical surface profile is cobly silty clay from the surface to a depth of 18 inches. From 18 inches to 60 inches, the soil is silty clay loam. Depth to a restrictive feature and the water table is more than 80 inches and is this soil type is considered well drained. The runoff class designation is Medium. There is no frequency of ponding or flooding and this soil type is not considered hydric according to the *NRCS Web Soil Survey*.

(KMW) - Kealia Silt Loam, Frequent Ponding, 0 To 1 Percent Slopes, MLRA 163– This soil type in found at elevations from 0 to 260 feet in areas with a mean annual precipitation of 10 to 41 inches. It is not considered prime farmland. This soil type is typically associated with salt marshes and tidal flats. Parent material is alluvium over beach sand. The typical surface profile is silt loam from the surface to a depth of 3 inches. From 3 inches to 27 inches, the soil is loam. From 27 inches to 64 inches it is fine sandy loam. Depth to a restrictive feature is more than 80 inches but water is typoically encountered within 12 to 42 inches. This soil type is considered poorly drained. The runoff class designation is Negligible. There frequency of ponding and flooding is listed as Frequent. This soil type is considered hydric according to the *NRCS Web Soil Survey*.

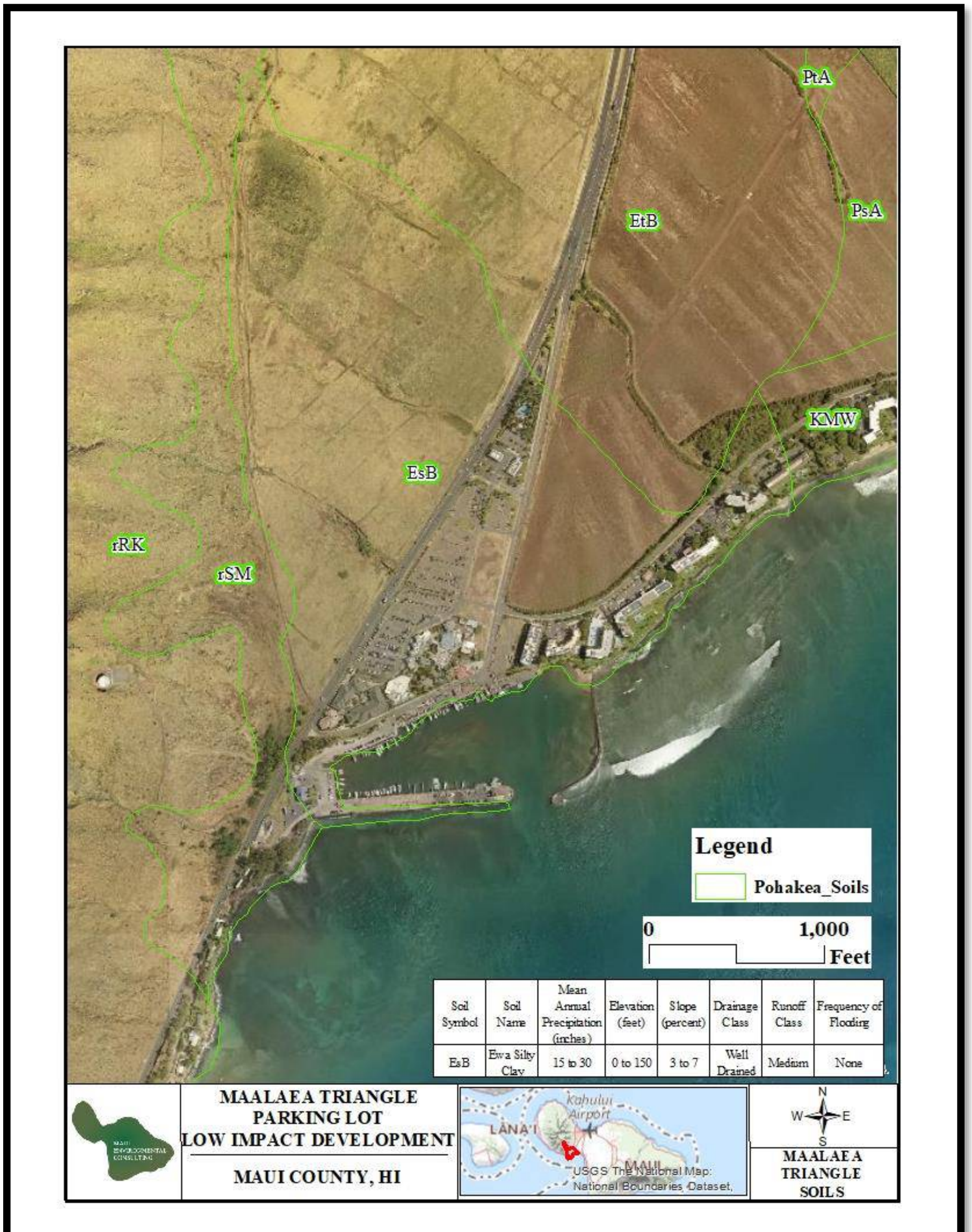
(PsA) - Pulehu Clay Loam, 0 To 3 Percent Slopes , MLRA 163– This soil type in found at elevations from 0 to 300 feet in areas with a mean annual precipitation of 10 to 50 inches. It is considered prime farmland if irrigated. This soil type is typically associated with alluvial fans, floodplains, and stream terraces. Parent material is alluvium derived from igneous rock. The typical surface profile is clay loam from the surface to a depth of 21 inches, loam from 21 inches to 33 inches, loamy sand from 33 inches to 37 inches, fine sandy loam from 37 inches to 47 inches, and silt loam from 47 inches to 60 inches. Depth to a restrictive feature and the water table is more than 80 inches. This soil type is considered Well Drained. The runoff class designation is Low. The frequency of flooding is considered Rare and there is no frequency of ponding. This soil type is not considered hydric according to the *NRCS Web Soil Survey*.

(PtA) - Pulehu Cobbly Clay Loam, 0 To 3 Percent Slopes– This soil type in found at elevations from 0 to 300 feet in areas with a mean annual precipitation of 10 to 35 inches. It is considered prime farmland if irrigated. This soil type is typically associated with alluvial fans, with parent material being composed of alluvium. The typical surface profile is cobbly clay loam from the surface to a depth of 21 inches. From 21 inches to 60 inches, the soil is silty clay loam. Depth to a restrictive feature and the water table is more than 80 inches. This soil type is considered Well Drained. The runoff class designation is Low. The frequency of flooding is listed as Occasional. There is no frequency of ponding. This soil type is not considered hydric according to the *NRCS Web Soil Survey*.

(rRK) Rock Land - This soil type in found at elevations from 0 to 6,000 feet in areas with a mean annual precipitation of 15 to 60 inches. It has a linear pahoehoe lava flow landform position and the parent material is basalt. The typical surface profile is silty clay loam from the surface to a depth of four inches. From four to eight inches is comprised of silty clay. From eight inches to 20 inches, it is bedrock. Slope for this soil type is highly variable from 0 to 70 percent. Depth to the restrictive feature of lithic bedrock occurs between four and 10 inches. Depth to the water table is more than 80 inches. This soil type is considered well drained. The runoff class designation is Very High. There is no frequency of ponding or flooding and this soil type is not considered hydric according to the *NRCS Web Soil Survey*.

(rSM) - Stony Alluvial Land– This soil type in found at elevations from 0 to 1000 feet in areas with a mean annual precipitation of 10 to 50 inches. It is not considered prime farmland. This soil type is typically associated with alluvial fans, with parent material being composed of alluvium. The typical surface profile is extremely stony clay loam from the surface to a depth of 10 inches. From 10 inches to 60 inches, the soil is boulder silty clay loam. Depth to a restrictive feature is more than 80 inches but water is typoically encountered within 6 to 12 inches. This soil type is considered well drained. The runoff class designation is Medium. There frequency of flooding is listed as Frequent. There is no frequency of ponding. This soil type is not considered hydric according to the *NRCS Web Soil Survey*.

Figure 1. Maʻalaea Triangle Soils



Soil Symbol	Soil Name	Mean Annual Precipitation (inches)	Elevation (feet)	Slope (percent)	Drainage Class	Runoff Class	Frequency of Flooding
EsB	Ewa Silty Clay	15 to 30	0 to 150	3 to 7	Well Drained	Medium	None

2.2 Maʻalaea Rainfall

Period-of-record rainfall data was analyzed from the Waikapu 390 rain gauge located at 20.8536 degrees latitude and -156.5088 degrees longitude. The period-of-record began 16 August 1916 and continues through present day. While this rain gauge is the nearest monitoring device at only four miles due north of the project, this data set represents a wetter microclimate than that of the Maʻalaea Triangle (Figure 2). Additional rainfall data was reviewed from GIS genereated isohyets. Data used to generate Figure 3 was pulled from the State of Hawaiʻi, Office of Planning Geographic Information System Data Portal.

To capture recent rainfall trends associated with the Maʻalaea Triangle, the last five years (2017-2021) of rainfall data from the Waikapu 390 station was analyzed. The median and maximum rainfall was recorded for each month within the five-year dataset. As mentioned above, the location of this rain gauge receives more precipitation than the location of the Maʻalaea Triangle. Based on the isohyets provided, the Project receives less than 15 inches of annual rainfall while the median rainfall over the five year period at Waikapu 390 was 23.94 inches. Knowing that this rain gauge is in a wetter location than the Project, designing LID projects to accomodate rainfall events recorded at Waikapu 390 produces conservative estimations when designing infrastructure to accommodate these stormwater capacities.

Table 2. Waikapu 390 Rainfall by Month from 2017 to 2021

Year	Monthly Rainfall												Totals
	January	February	March	April	May	June	July	August	September	October	November	December	
2017	5.77	4.28	4.55	No Data	1.30	0.33	0.77	0.31	0.24	3.86	3.14	10.83	35.38
2018	0.05	8.92	2.19	4.89	1.85	0.05	0.67	1.34	4.36	2.11	2.73	1.29	30.45
2019	2.56	6.49	0.75	No Data	1.24	0.00	0.08	0.44	0.01	0.29	0.28	0.61	12.75
2020	1.37	2.95	1.89	1.60	0.85	0.00	0.01	0.01	0.21	0.36	0.09	0.00	9.34
2021	5.61	1.75	4.51	2.03	0.07	0.02	0.00	0.24	0.02	0.12	0.42	9.15	23.94
Monthly Median Rainfall	2.56	4.28	2.19	2.03	1.24	0.02	0.08	0.31	0.21	0.36	0.42	1.29	23.94
Monthly Maximum Rainfall	5.77	8.92	4.55	4.89	1.85	0.33	0.77	1.34	4.36	3.86	3	10.83	35.38

2.3 Ma'alaea Triangle Parking Lot Current Conditions

MEC staff utilized land surveying grade Global Positioning Satellite (GPS) technology to capture the locations and elevations of storm drains, curbs, planters, slope, and other features within the Maʻalaea Triangle parking lot. This equipment is generally accurate to one one-hundreth of a foot or approximately an eighth of an inch. Data was then imported in ArcGIS and maps were generated to depict current conditions. Figures 4-9 show the locations and size of permeable and impermeable surfaces, locations of storm drains, and the flow direction of stormwater within the parking lot. This information was used to determine what LID projects could be implemented with minimal changes to the current conditions located at the Project site. Determining the slope of the parking lot was of particular importance is determining how stormwater could be captured by proposed projects.

Figure 2. Waikapu Rain Gauge

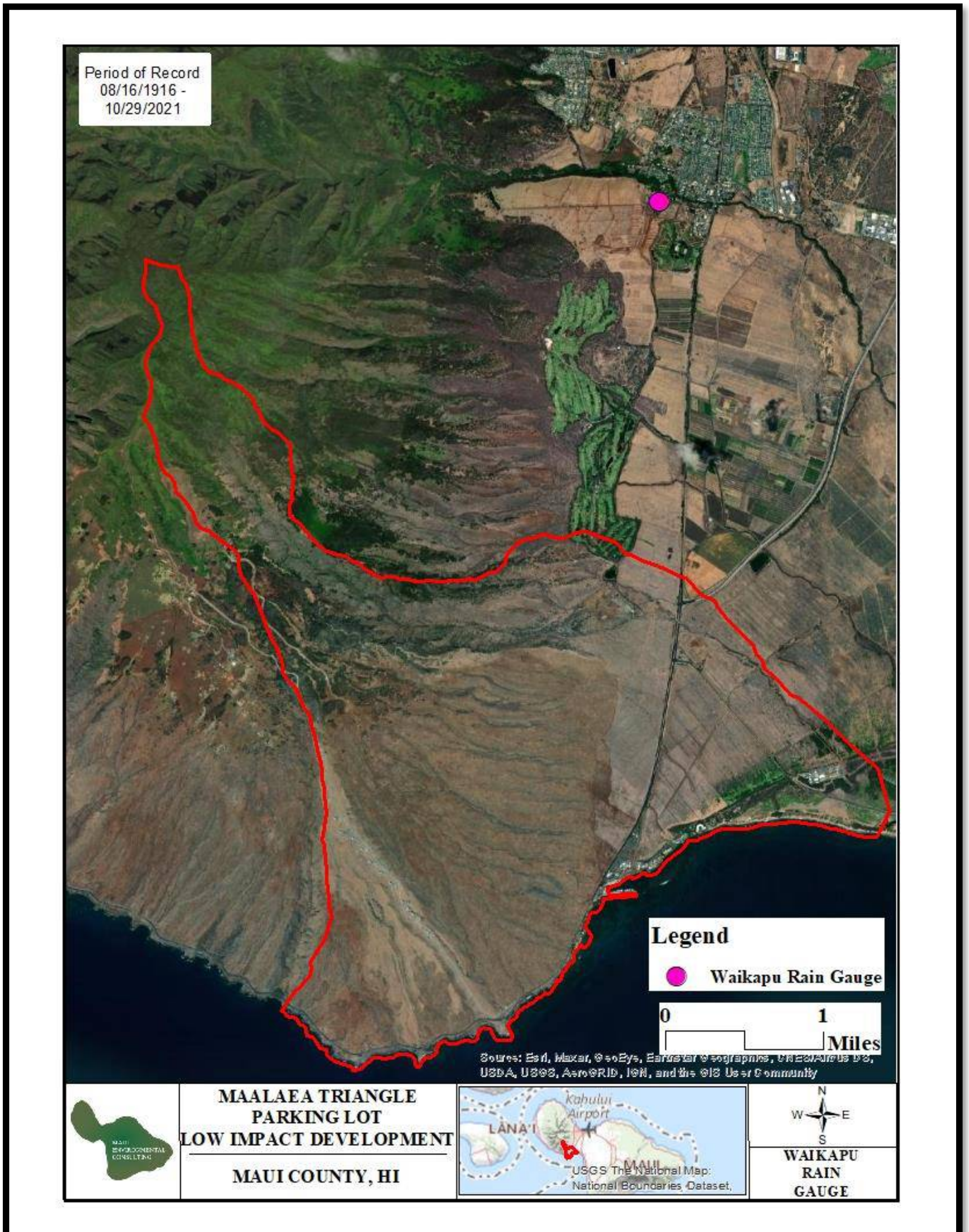


Figure 3. Rainfall Isohyets for Maʻalaea Triangle

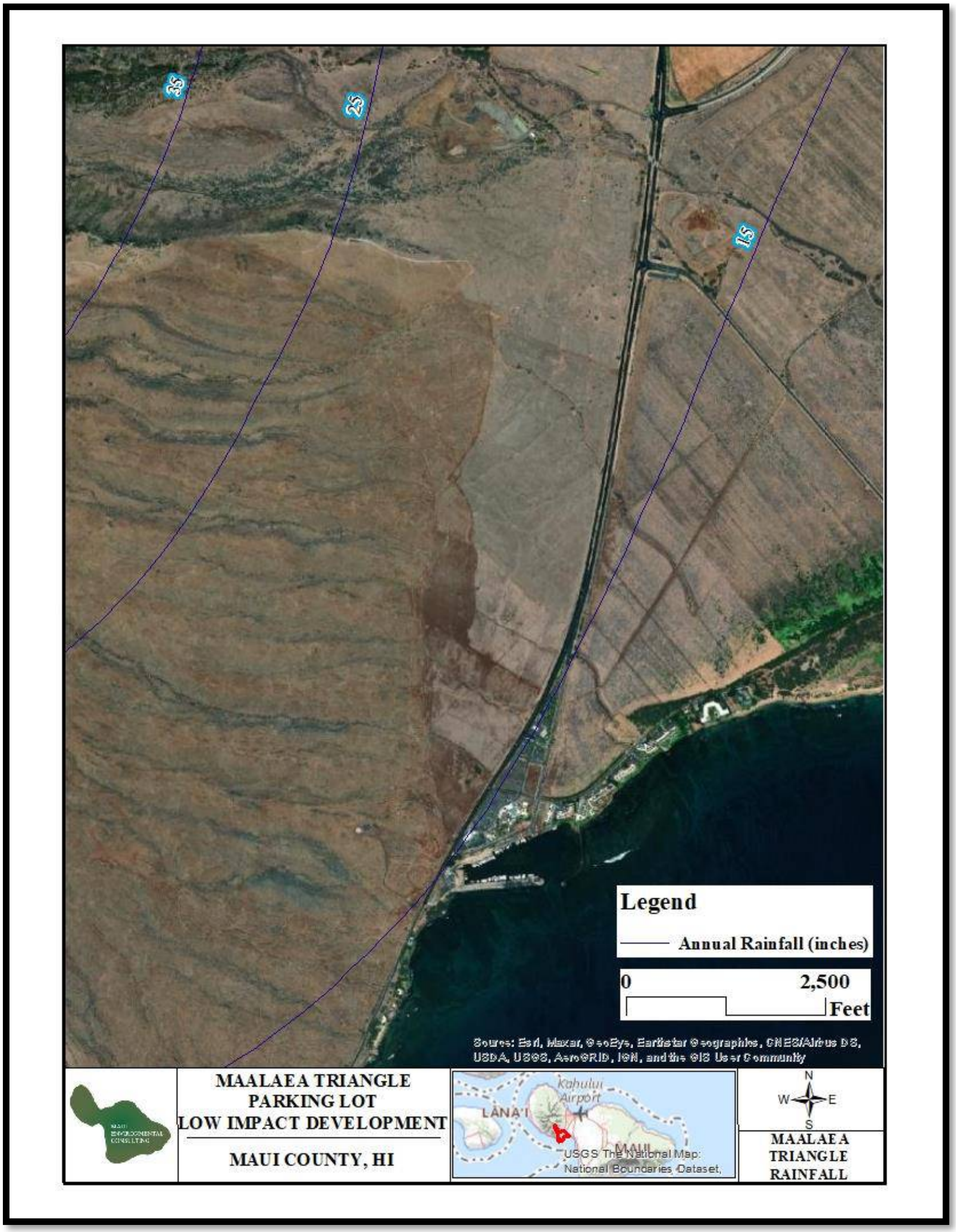


Figure 4. Impermeable Surfaces at Maʻalaea Triangle

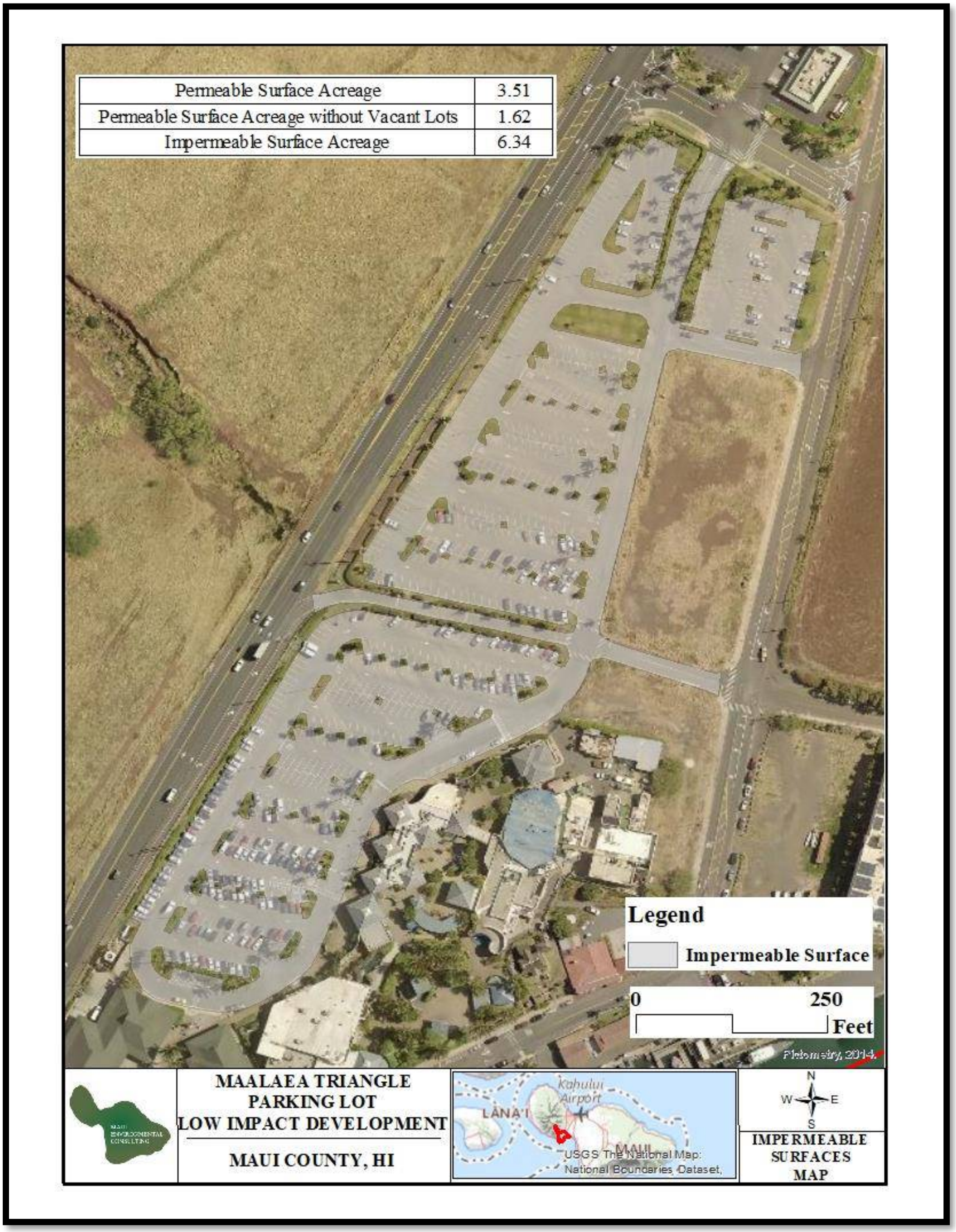


Figure 5. Permeable Surfaces at Ma‘alaea Triangle

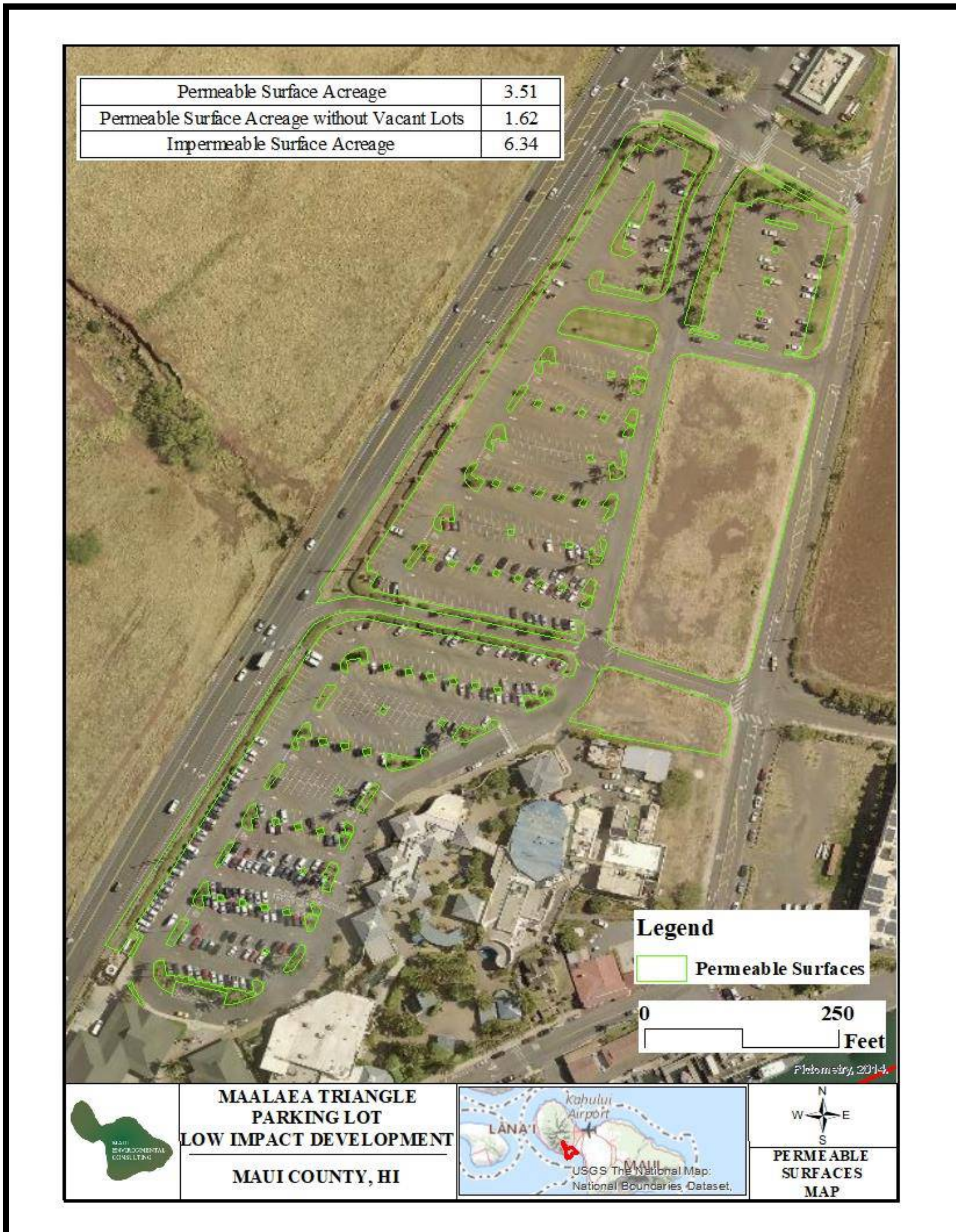


Figure 6. Storm Drains at Ma'alaea Triangle

Figure 7. Flow Directions at Maʻalaea Triangle (1 of 3)

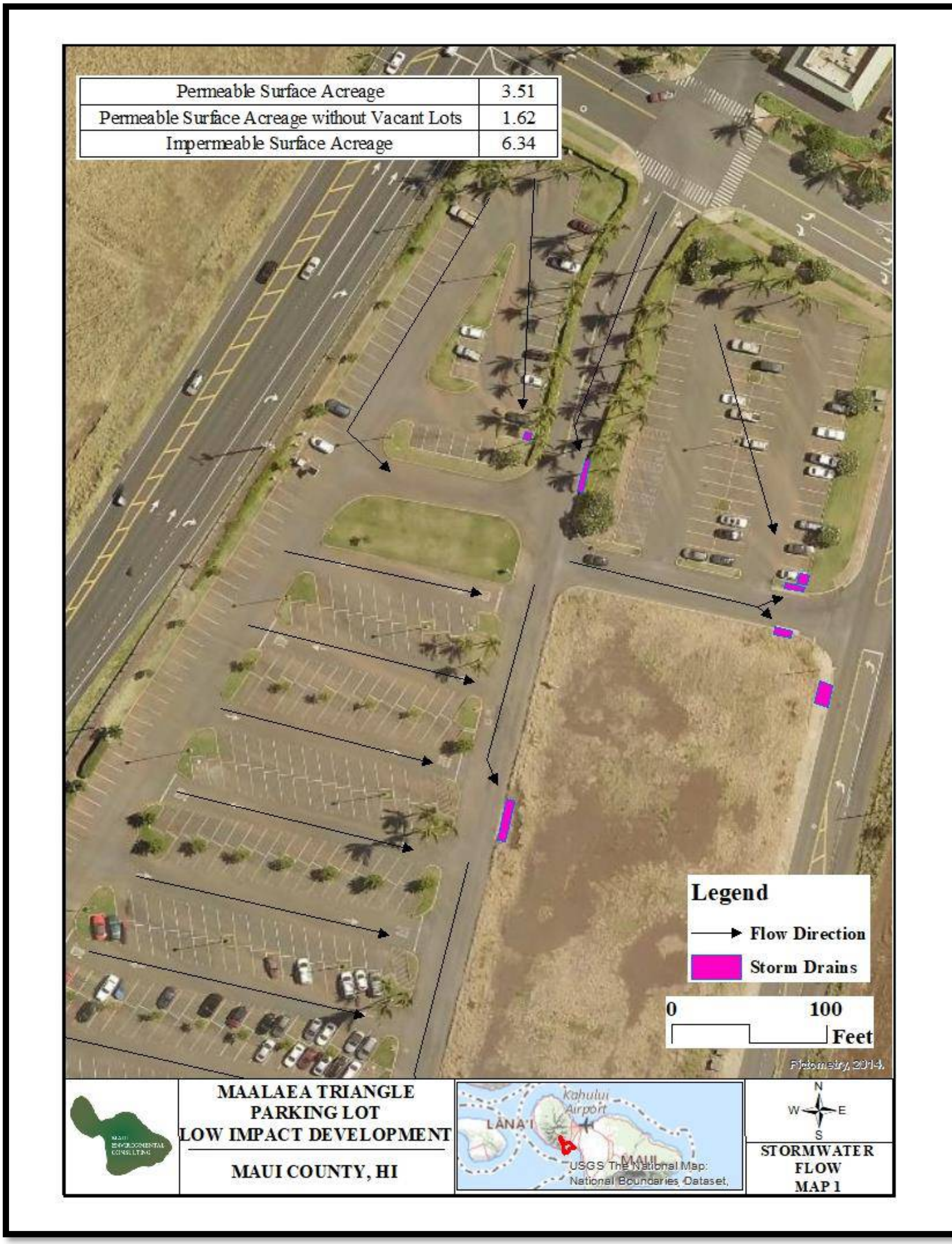


Figure 8. Flow Directions at Ma'alaea Triangle (2 of 3)

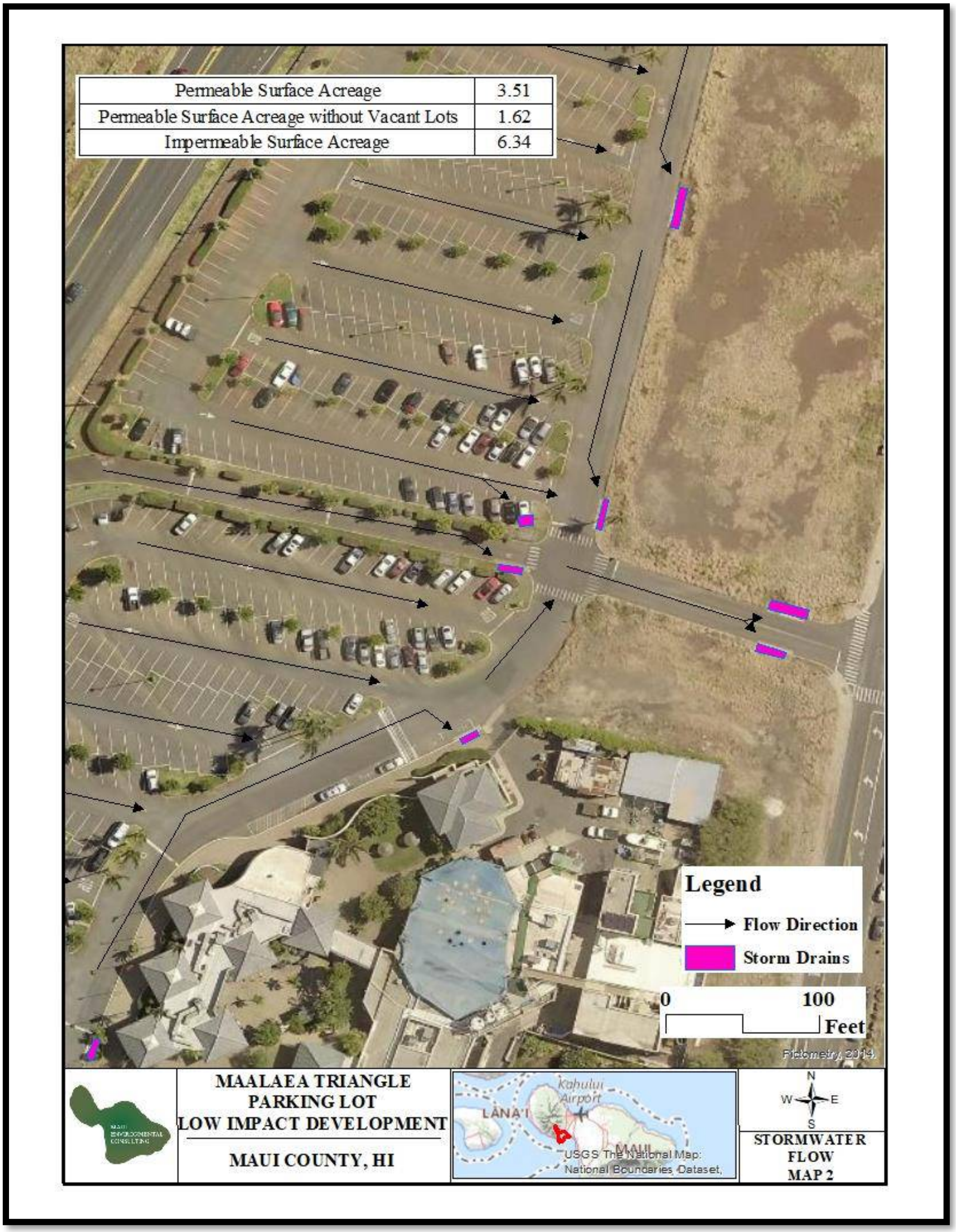
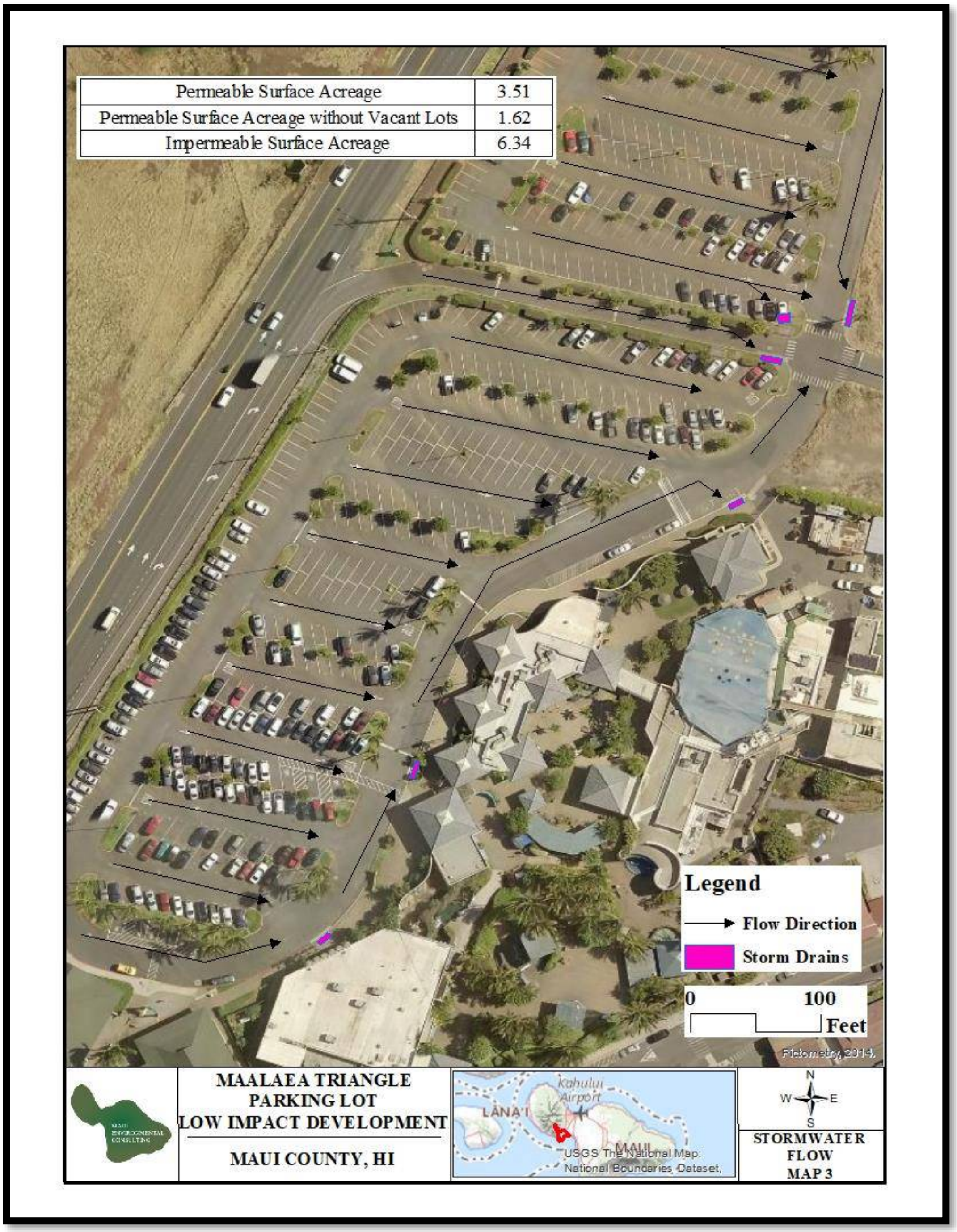


Figure 9. Flow Directions at Maʻalaea Triangle (3 of 3)



3.0 LOW IMPACT DESIGN

Low Impact Design is a method of designing and developing infrastructure that captures and filters stormwater before it leaves a designated site. LID has the potential to capture and clean stormwater before it enters coastal waters. In addition, LID can trap stormwater so that it doesn't enter septic systems, storm drains, or other infrastructure prone to flooding. LID can also provide economic benefits, including reduced maintenance costs, free irrigation, improved aesthetics, reduced flooding, and green marketability.

Things to consider with LID implementation include rainfall, slope, soil type, and land use. When developing LID, it is important to identify the pollutants of concern, the types and number of Best Management Practices (BMPs) to be implemented, their size, location, and any maintenance required. LID incorporates green infrastructure such as rain gardens, infiltration basins, bioretention, constructed wetlands, vegetated swales, permeable pavement, green roofs, and cisterns.

Within the Maʻalaea Triangle, locations suitable for curb cuts and biofiltration are areas where the grade of the planted area contained within the curbs could be lowered by digging out and hauling away the existing soil (ideally to a maximum depth of four feet if possible), backfilling with a suitable compost topsoil mix at a lower grade than the surrounding pavement, and planting the area with native plants, allowing stormwater running off the parking lot to enter the planted area and infiltrate into the ground. Irrigation infrastructure is already in place for most of these sites.

4.0 POLLUTANTS OF CONCERN AND TREATMENT OBJECTIVES

MEC reviewed water quality parameters of concern and water quality impairments associated with the urban corridor of the Pohakea watershed. In addition to this desktop exercise, MEC staff utilized professional surveying equipment to record the locations of landscaping planters, curbs, storm drains, and impermeable surfaces.

To better understand the pollutants of concern, MEC held an initial stakeholder meeting on October 29th, 2021 with Amy Hodges from MNMRC, Tapani Vuori from the Maui Ocean Center, Robin Knox form Save the Wetlands Hui, Travis Liggett of Reef Power, Shelby Serra of the Pacific Whale Foundation, and Robert Vafaie of the Maʻalaea Harbor Shops. The group identified pollutants associated with cars, namely oil and grease and toxic metals such as cadmium, as being major pollutants of concern. Solid waste was also discussed with an emphasis placed on vegetative debris contributing to nutrient loading within the harbor. Additional topics related to solid waste included wind pickup and dispersion, the prevalence of COVID-19 masks and other loose items in vehicles as additional sources or rubbish. Lastly, stormwater was discussed as a general pollutant of concern in that it currently leaves the parking lot through storm drains and enters Maʻalaea Harbor, potentially transferring sediment, rubbish, and other pollutants from the parking lot.

To determine the volume of stormwater generated at the Maʻalaea Triangle, MEC used one inch of rain as a baseline in calculations. Using ArcGIS, impermeable surface withing the parking lot was determined to be approximately 276,211 feet. One inch of rain was converted to feet and multiplied by the impermeable surface area to generate the volume of this area in cubic feet. There are 7.48 gallons of water contained in one cubic foot, resulting in a total of 171,482.74 gallons of stormwater being generated from one inch of rain within the parking lot.

Table 3. Approximate Stormwater Generated from 1" of Rainfall

Stormwater Generated from One Inch of Rainfall	
Impermeable Surface in Square Feet	276,211.00
One Inch of Rain Converted to Feet	0.08
Volume in Cubic Feet	22,925.50
7.48 Gallons of Water per Cubic Foot	7.48
Total Gallons of Stormwater from 1 Inch of Rainfall	171,482.74

Knowing the current conditions within the Project, as well as the approximate amount of stormwater generated from one inch of rain, the stakeholder group was able to identify performance standards for the Maʻalaea Triangle parking lot. The main performance standard was to capture all stormwater onsite before it discharges into storm drains leading to the harbor. Other performance standards included capturing oil, grease, and metals that may be generated by the parking lot, minimizing use of irrigation water, utilizing native plants in landscaping, reducing solid waste pollution, and educating the public on the importance of stormwater, and pollution reduction measures.

Specific BMPs of interest to acheive these performance standards included permeable pavement, curbcuts, bioswales, landscaping with drought tolerant native plants, and speed bumps doubling as water bars to slow and redirect stormwater. These performance standards are discussed in detail below.

5.0 PERFORMANCE STANDARDS

A second stakeholder meeting was held on November 30th, 2021, to identify performance standards. The main performance standard identified by the group was to capture and retain on-site all stormwater so that it does not discharge into storm drains and end up in Maʻalaea Harbor. To better understand what these rainfall events looked like, we calculated the 5-year median monthly rainfall (0.81 inches) and the median wet season monthly rainfall (1.89 inches) over the five year period. Because both numbers are relatively small, the highest monthly median and maximum rainfall events over the last five years (2017 to 2021) were also analyzed. The highest monthly median rainfall (4.28 inches) was observed in February of 2017. This proved to be a very wet year in that the maximum monthly rainfall event occurred in December of 2017 (followed closely by December of 2021).

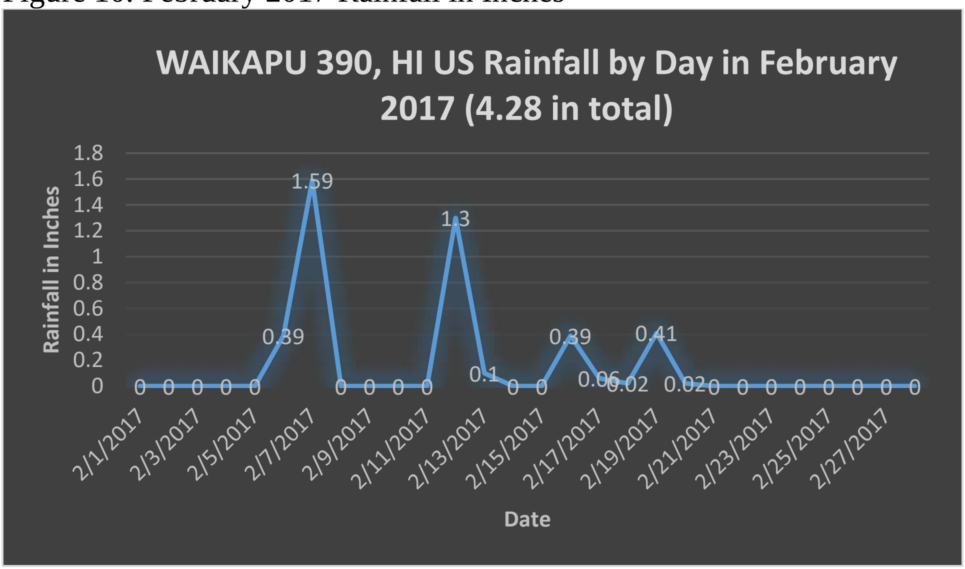
Table 4. Largest Median Monthly Rainfall and Maximum Monthly Rainfall

Year	Monthly Rainfall												Totals
	January	February	March	April	May	June	July	August	September	October	November	December	
2017	5.77	4.28	4.55	No Data	1.30	0.33	0.77	0.31	0.24	3.86	3.14	10.83	35.38
2018	0.05	8.92	2.19	4.89	1.85	0.05	0.67	1.34	4.36	2.11	2.73	1.29	30.45
2019	2.56	6.49	0.75	No Data	1.24	0.00	0.08	0.44	0.01	0.29	0.28	0.61	12.75
2020	1.37	2.95	1.89	1.60	0.85	0.00	0.01	0.01	0.21	0.36	0.09	0.00	9.34
2021	5.61	1.75	4.51	2.03	0.07	0.02	0.00	0.24	0.02	0.12	0.42	9.15	23.94
Monthly Median Rainfall	2.56	4.28*	2.19	2.03	1.24	0.02	0.08	0.31	0.21	0.36	0.42	1.29	23.94
Monthly Maximum Rainfall	5.77	8.92	4.55	4.89	1.85	0.33	0.77	1.34	4.36	3.86	3	10.83ǂ	35.38

*Largest monthly median rainfall event observed over five year period
ǂMaximim monthly rainfall event observed over five year period

Breaking down these monthly rainfalls into daily events, we are able to determine what stormwater volumes would be produced during these storm events and what LID infrastructure would be needed to capture these volumes. Using the largest monthly median rainfall value observed over the last five years, which was 4.28 inches for the month of February 2017, daily rainfall events were as follows; a storm produced 1.98 inches of rain between February 5th and 7th, 2017, a second storm event on February 12th dropped another 1.4 inches, and from February 17th through the 21st, an additional 0.9 iches of rain was observed.

Figure 10. February 2017 Rainfall in Inches



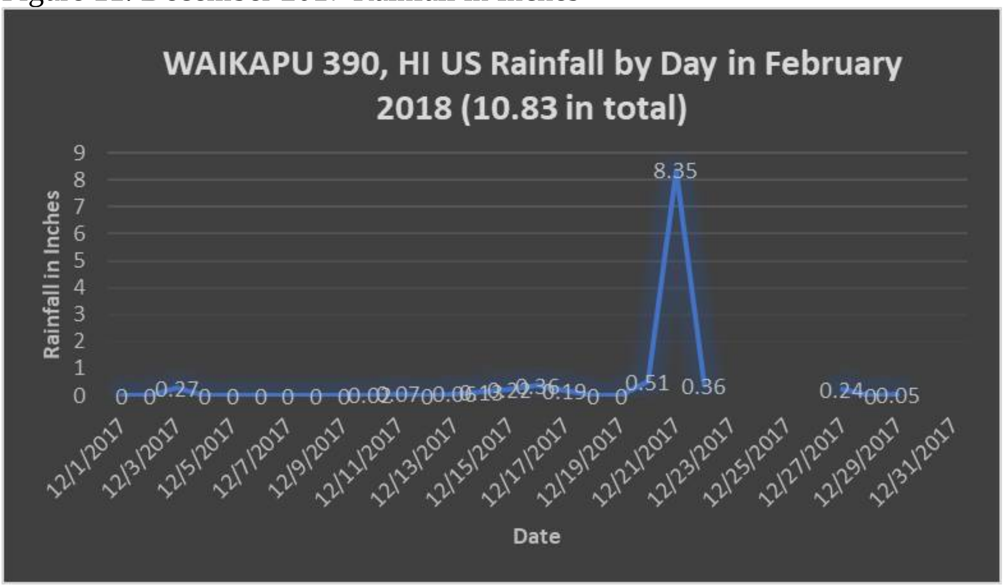
Using this information, we calculated the volume of stormwater that would need to be captured onsite using LID infrastructure so that no water was discharged into Ma‘alaea Harbor. To do this, we used the same formula as before and multiplied the known impermeable surface area by 1.98 inches of rainfall to generate a volume of stormwater in cubic feet. We know one cubic foot contains 7.48 gallons of water. Therefore, the February 7th, 2017 storm event generated approximately 340,900 gallons of stormwater within the Ma‘alaea Triangle parking lot. It should be noted that this calculation does not take into account time and treats the entire storm as a single event happening instantly.

Table 5. Stormwater Generated from February 7^{th}, 2017, Storm Event

Stormwater Generated from 1.98 Inches of Rainfall	
Impermeable Surface in Square Feet	276,211.00
1.98 Inches of Rain Converted to Feet (1.98/12)	0.17
Volume in Cubic Feet	45,574.82
7.48 Gallons of Water per Cubic Foot	7.48
Total Gallons of Stormwater from 1.98 Inches of Rainfall	340,899.62

Looking at the maximum monthly rainfall observed over the last five years (December 2017) and breaking it down into daily rainfall events, it becomes clear that a large storm event occurred between December 20th, 2017 and continued through the 22nd. According to the Waikapu 390 rain gauge, 9.22 inches of rain was observed during this time.

Figure 11. December 2017 Rainfall in Inches



Using this stormwater event, approximately 1,587,420 gallons of stormwater would be produced by the impermeable surfaces associated with the Maʻalaea Triangle. It should be noted that this rainfall event is an outlier. For example, the recent December 5th storm event only produced 5.7 inches of rain at the Waikapu 390 rain gauge and would therefore generate 981,380 gallons of stormwater within the Project.

Figure 6. Stormwater Generated from December 21st, 2017, Storm Event

Stormwater Generated from 9.22 Inches of Rainfall	
Impermeable Surface in Square Feet	276,211.00
9.22 Inches of Rain Converted to Feet	0.77
Volume in Cubic Feet	212,222.12
7.48 Gallons of Water per Cubic Foot	7.48
Total Gallons of Stormwater from 9.22 Inches of Rainfall	1,587,421.45

6.0 CANDIDATE LOW IMPACT DEVELOPMENT BMPS

6.1 Bioswales

Bioswales are a constructed depression planted with native vegetation that allows stormwater from impermeable surfaces such as roofs, driveways, and parking lots to collect, briefly store and then infiltrate into the groundwater.

Because of the existing landscaping planters already distributed throughout the parking lot, it was determined that converting these areas to bioswales was a high value candidate project. Using ArcGIS, it was determined that approximately 1.62 acres of permeable surface exists within the Project. Unfortunately, due to topography, much of this area is located on the uphill portion of the parking lot and will not perform well as a bioswale location. Removing any permeable surfaces where stormwater cannot easily be diverted using gravity or speed bumps repurposed as water bars, approximately 40,715 square feet of permeable surface remains for potential conversion to bioswales.

For bioretention, storage is allocated to ponded water on the surface, water stored within the pores of soil/compost media, and water stored within the voids of coral stone and/or gravel layers. The following formula was used to determine the approximate volume of stormwater captured by 40,715 square feet of bioretention (Horsley Witten, 2014).

Pv = Vsp + Vs + Vg

Where;

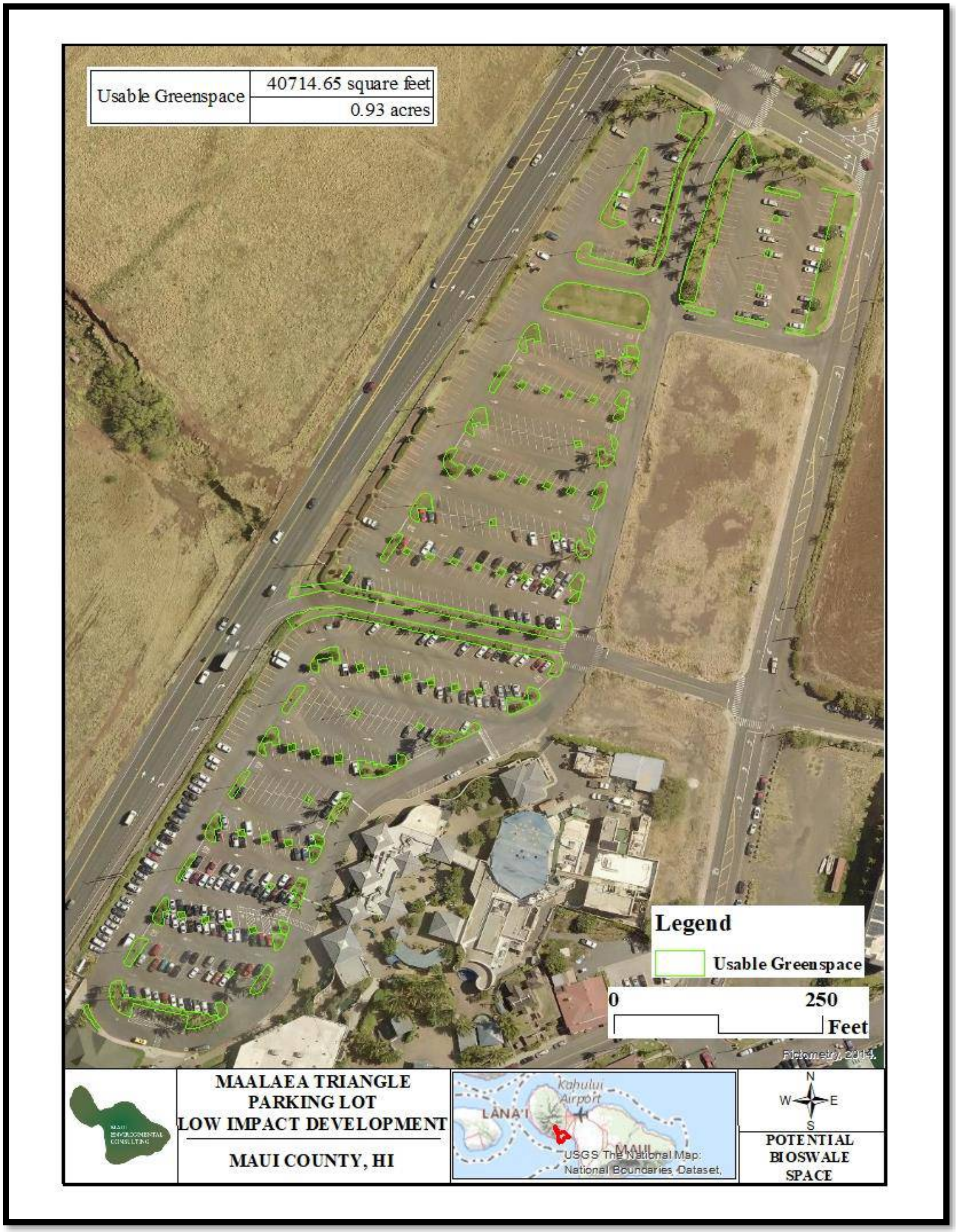
Pv = Volume of stormwater captured
Vsp = Surface ponding volume (we assumed one foot) x 1.0
Vs = Storage volume of soil/compost x 0.25
Vg = Storage volume of gravel and/or stone/coral layer x 0.40

Using this formula, approximately 354,668 gallons of stormwater can be captured if the available planters and greenways associated with the Maʻalaea Triangle parking lot are converted to bioswales.

Table 7. Total Stormwater Volume Captured by Conversion of Planters to Bioswales

Vsp	
Bioswale Surface in Square Feet	40,714.65
One foot of surface ponding	1.00
Volume in Cubic Feet	40,714.65
Vs	
1.5 Inches of soil/compost	0.125
Volume in Cubic Feet	5,089.33
Multiply by 0.25	1,272.33
Vg	
4 inches of soil media barrier (sand and stone)	0.33
Volume in Cubic Feet	13,571.55
Multiply by 0.4	5,428.62
Pv	47,415.60
7.48 gallons per cubic foot	
Stormwater captured in gallons	354,668.71

Figure 12. Potential Bioswale Locations



Comparing this volume with the stormwater generated from the February 2017 event, it becomes clear that this LID infrastructure alone would be able to completely capture approximately two inches of rainfall occurring during a storm event without any of this water leaving the parking lot and being discharged through storm drains into Maʻalaea Harbor. To put this in perspective, a review of the period-of-record data (1916-Present) reveals that of the 21,145 days where rainfall data was recorded, only 123 days had rainfall amounts above two inches. This equates to rainfall at the Waikapu 390 rainfall gauge being under two inches 99.42 percent of the time since August of 1916. Essentially, transitioning the available planters to bioswales would capture and retain stormwater onsite for all but the largest storm events (all but 0.58 percent of all recorded storm events) occurring at the Maʻalaea Triangle parking lot.

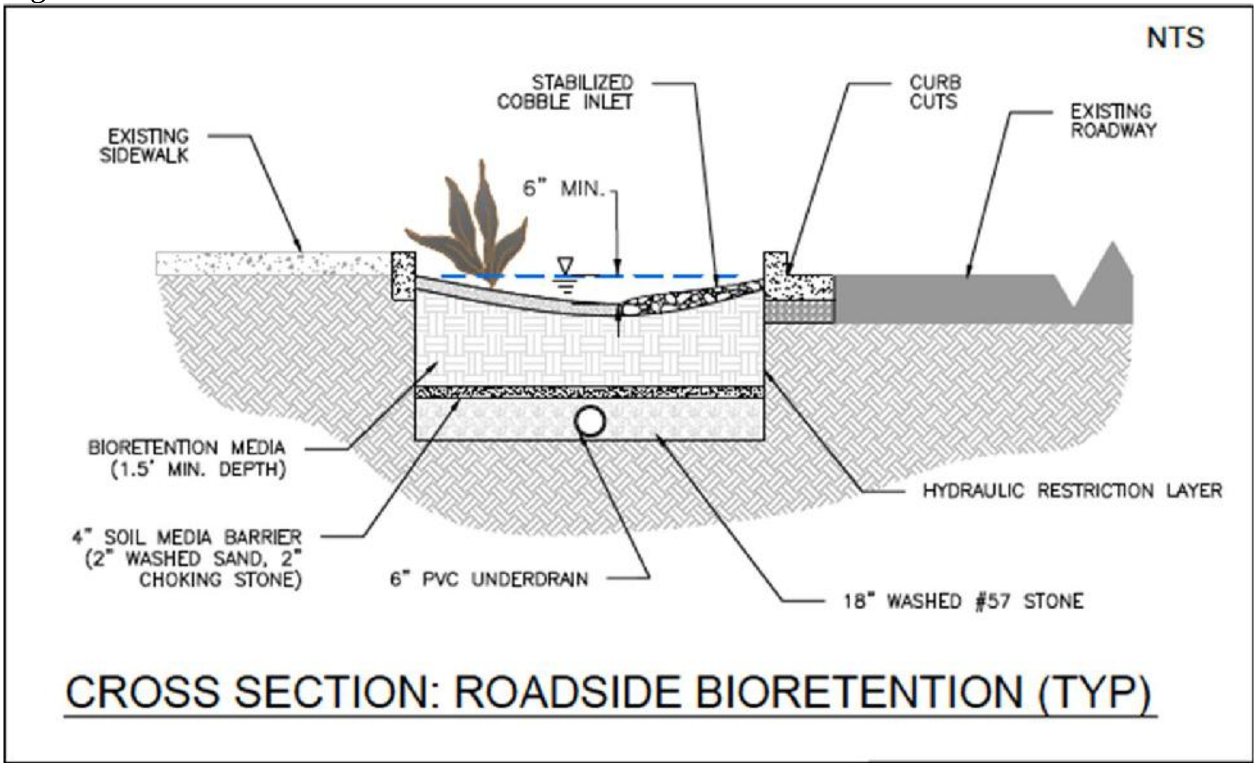
These bioswales would also provide an opportunity to plant drought tolerant dryland native forest plants. These plants, coupled with the LID green infrastructure, would provide an educational experience for visitors to the Maʻalaea Triangle. Additionally, these plants require less irrigation than traditional landscaping and may provide a cost savings opportunity. Currently, irrigation costs are low although there have been documented leaks that caused irrigation costs to rise significantly. From November of 2020 to October of 2021, the total water bill for the Project was $556.80. Unfortunately, $227 of this cost came from the month of August 2021, when damage to the irrigation system occurred. Typically, monthly water bills would be approximately $30. With native draught tolerant plant species placed in bioswales, irrigation costs could potentially be eliminated entirely.

Table 8. List of Drought Tolerant Plants with Costs

Hawaiian Name	Scientific Name	Cost
ʻAʻaliʻi	*Dodonaea viscosa*	$ 2.75
ʻIlima	*Sida fallax*	$ 3.00
Wiliwili	*Erythrina sandwicensis*	$ 4.00
ʻOhe makai	*Polyscias sandwicensis*	$ 3.25
Naio	*Myoporum sandwicense*	$ 3.50
Alaheʻe	*Psydrax odorata*	$ 4.00
Koaiʻa	*Acacia koaia*	$ 3.25
Chaff flower	*achyranthes splendes var. splendens*	$ 2.25
ʻĀweoweo	*Chenopodium oahuensis*	$ 2.85
Āwikiwiki	*Canavalia pubescens*	$ 3.50
Maʻo hau hele	*Hibiscus brackenridgei*	$ 3.25

Bioswales also offer the opportunity to utilize biochar. Biochar is black carbon produced from organic biomass by way of pyrolysis. This process involves the devolatilization of organic material, leaving the carbon char behind. This char can capture pollutants such as heavy metals and can provide a substrate for nitrogen fixing bacteria and other beneficial microbes. Biochar also plays an important role in carbon sequestration. In the following diagram, biochar could be used as an amendment to the bioretention media displayed.

Figure 13. Cross Section of a Bioswale

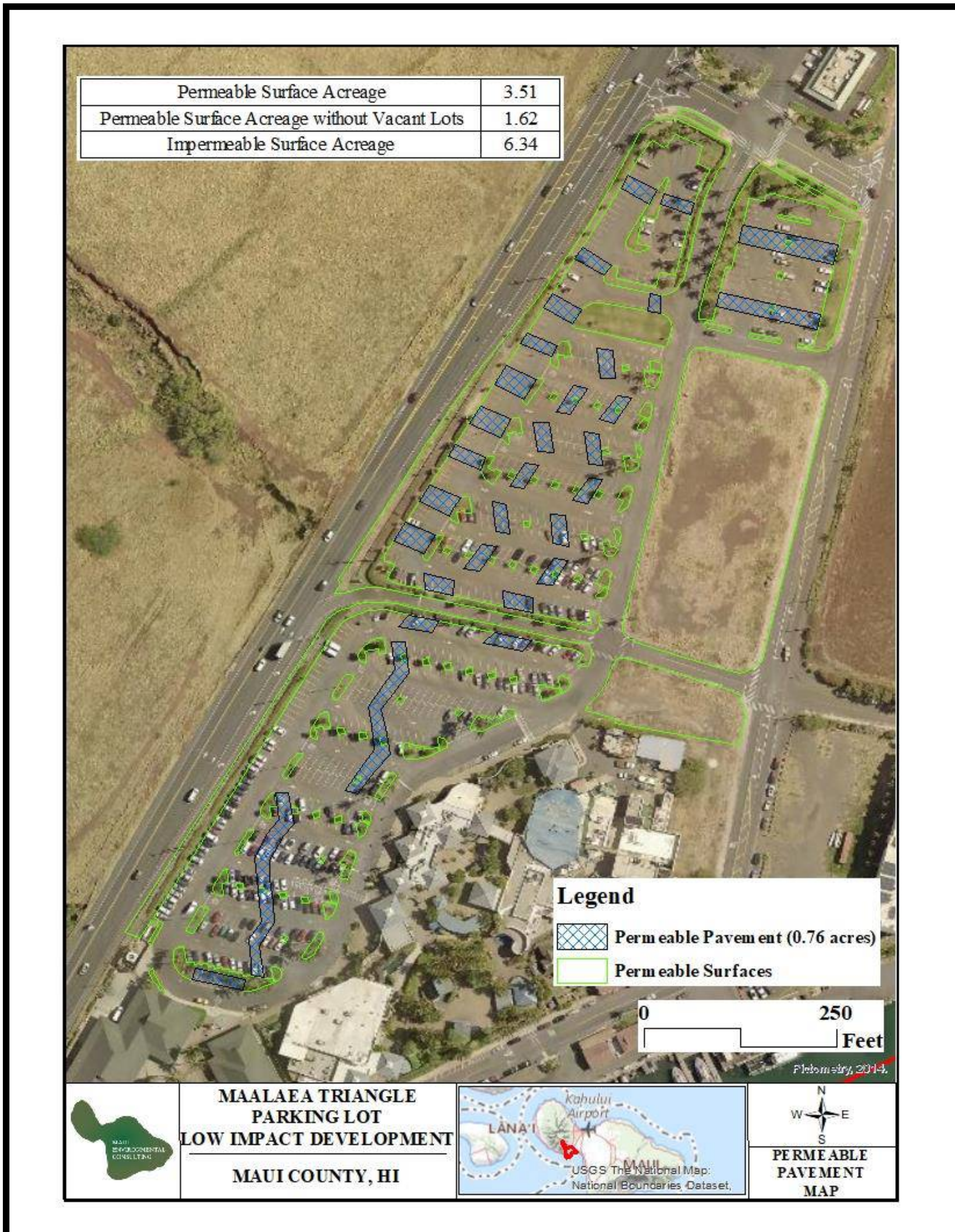


6.2 Permeable Pavers

During the second stakeholder meeting permeable pavement was discussed as an additional LID project to be considered at the Maʻalaea Triangle. This type of pavement has an infiltration rate as high as 250 inches per hour per square inch. Unfortunately, this permeability is limited by the infiltration rates of the substrate it is built upon. During stakeholder discussions, questions regarding maintenance and functionality arose. Scenarios were presented where up to half the Maʻalaea Triangle were converted to permeable pavement. Costs have been quoted at approximately $25 a square foot or $1,089,000 per acre. The approximate cost to retrofit the entire parking lot with permeable pavement would therefore cost approximately $6,904,260.00.

Like bioswales, storage from permeable pavement is allocated to ponded water on the surface, water stored within the porous pavement or in between pavers depending on the method employed, the pores of soil/compost media, water stored within the voids of coral stone and/or gravel layers, and water stored within the pores associated with a sand filter layer.

Figure 14. Example Map Depicting Permeable Pavement Spread Throughout the Ma‘alaea Triangle to Reduce Cost



The following formula was used to determine the approximate volume of stormwater captured by one square foot of permeable pavement and is meant to guide management strategies when determining the amount of pavement that should be installed to augment stormwater management not being met using bioswales alone (Horsley Witten, 2014).

Pv = Va+ Vb + Vc + Ve + Vf

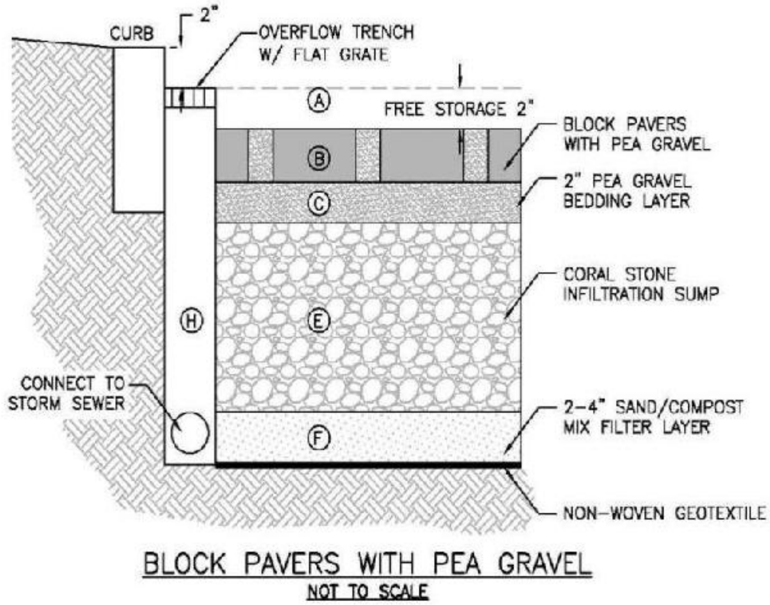
Where;
Pv = Volume of stormwater captured
Va = Surface ponding volume (we assumed two inches) x 1.0
Vb = Surface ponding volume x surface open void space (0.1)
Vc = Storage volume of pea gravel x 0.25
Ve = Storage volume of gravel or coral stone reservoir layer x .4 (no underdrain)
Vf = Storage volume of sand layer x 0.25

Using this formula, approximately 11.06 gallons of stormwater can be captured for every square foot of the Ma‘alaea Triangle parking lot a converted to permeable pavers. This number has many assumptions built into it including the type of pavers used and the depths and types of substrates utilized. Actual volumes of stormwater captured will be specific to the type of system installed. These calculations are meant as an approximation to show the utility of permeable pavement.

Table 9. Stormwater Volume Captured per Square Foot of Permeable Pavement

Va	
Permeable Pavement Surface in Square Feet	1.000
Two Inches of surface ponding (.166 feet)	0.166
Volume in Cubic Feet	0.166
Vb	
Surface layer volume x 0.1	
Volume in Cubic Feet	0.017
Vc	
2 inches of pea gravel	0.333
Volume in Cubic Feet	0.166
Multiply by 0.4	0.066
Ve	
12 inches of gravel	1.000
Multiply by 0.4	0.400
Vf	
4 inches of sand	0.333
Multiply by 0.25	0.830
Pv	1.479
7.48 gallons per cubic foot	
Stormwater captured in gallons per square foot of permeable paver	11.06

Figure 15. Cross Section of Permeable Pavement



6.3 Water Bars

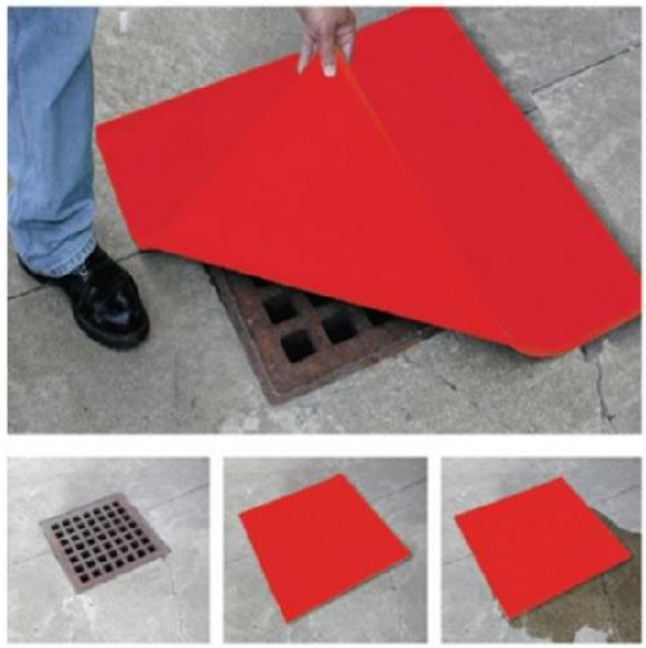
Water bars should be utilized to divert stormwater towards bioswales. These water bars can serve a dual purpose as speed bumps, providing both stormwater management and an added safety component to the parking lot. Various aftermarket models exist and can be installed at the same time planters are retrofitted as bioswales. Twelve-foot-long speed bumps are approximately $200 and can be easily installed to direct flow towards bioswales and away from storm drains.

Figure 16. Speed Bumps Serve Dual Purpose as Water Bars

6.4 Storm Drain BMPs

To address vegetative debris, rubbish, and other solid waste from entering the storm drain infrastructure, various filters can be placed at the opening of storm drains. There is a maintenance component associated with using these BMPs. The landscaping company in charge of maintenance at the Ma'alaea Triangle should be engaged to discuss the utilization of these BMPs.

Figure 17. Storm Drain BMPs



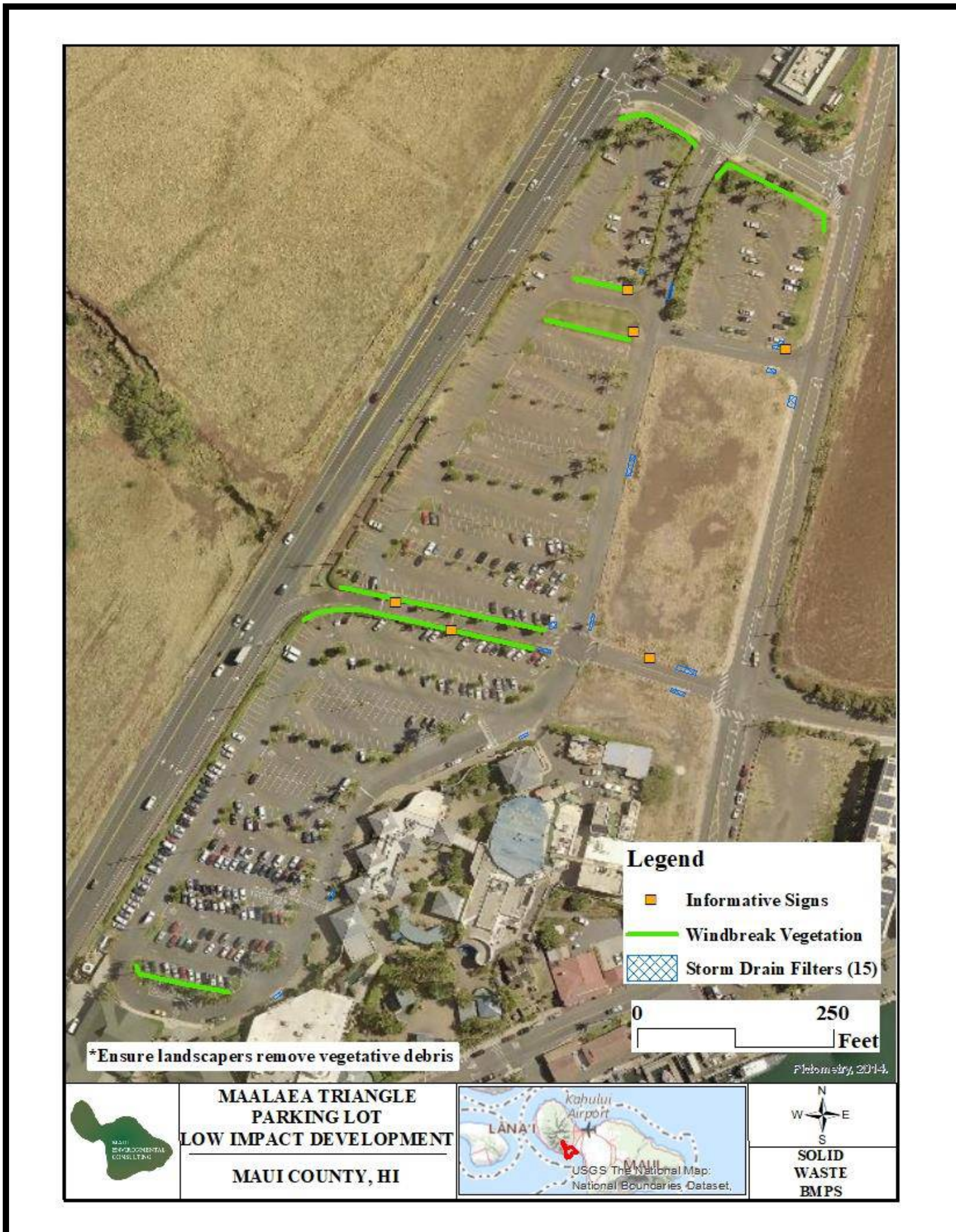
6.5 Wind Break Vegetation

To further assist in the reduction of solid waste being dispersed within the Ma'alaea Triangle parking lot, native dryland forest plants can be utilized to provide wind breaks. During stakeholder meetings, when discussing solid waste pollution, wind was identified as a major contributor to unintended litter. Often, visitors open their doors upon arriving at the parking lot, not realizing how windy conditions will be. Any loose papers, masks, or unsecured rubbish is easily picked up and swept away by heavy winds. Wind break vegetation can slow air currents while providing green space, educational opportunities, and native habitat.

6.6 Informative Signs

Informative signs should be utilized to convey information to the public on the importance of the Pohakea Watershed and Ma'alaea Harbor and Ma'alaea Bay. In addition, these signs can educate people on the LID infrastructure in place to manage stormwater, teach them about native dryland forest plants, and provide a medium for green marketability.

Figure 18. Sign, Wind Break Vegetation, and Storm Drain BMPs



7.0 Permitting Requirements

Based on stakeholder discussions held on October 29th and November 30th, 2021, retrofitting existing landscaping planters to become bioswales was identified as the ideal solution for stormwater management within the Maʻalaea Triangle parking lot. This LID infrastructure would require less disruption than repaving the entire parking lot with permeable pavement and will provide a substantial amount of stormwater retention. Therefore, permitting requirements were primarily considered for retrofitting the parking lot with bioswales.

Costs to complete this work were provided by Fukumoto Engineering. In their Scope of Work (Appendix A) they expect both a Special Management Area (SMA) Permit and a Grading and Grubbing Permit will be required for this work. Due to the size of any associated earth work, and due to the current use of the parking lot, they do not foresee the need for drainage plans or archeological work.

8.0 HEAD CUTS

MEC has been working separately on the head cutting occurring mauka of Honoapiʻilani Highway. In addition to documenting the extent of the head cutting and soil loss that has been occurring during storm events, MEC has met with Goodfellows Bros. and CDF Engineering to determine methods to stop this erosion from continuing to happen.

Options for protecting the existing channel from further erosion include the following options:

1. Channel protection using boulders, cobble stones, and filter fabric
2. Rock lined inlets and outlets
3. Culverts to eliminate change in water course
4. Rock check dams
5. Concrete lined ditches
6. Rolled erosion control product-channel
7. ShoreMax channel protection
8. Energy Dissipaters

CDF Engineering and Goodfellow Bros. will provide detailed analysis of the head cutting mitigation options. Appendix B depicts the various methods being proposed to anchor soils in place and fix the head cutting issue.

9.0 SUMMARY AND DISCUSSION

The Maʻalaea Triangle parking lot is located just makai of Honoapiʻilani Highway within the urban corridor of the Pohakea watershed. This area is known to be extremely dry. The mountains associated with this watershed have a high runoff potential, resulting in catastrophic flooding when storm events do occur. While these events are rare, they have the potential to drastically affect water quality within Maʻalaea Harbor and Maʻalaea Bay.

Working with MNMRC, MEC met with Tapani Vuori from the Maui Ocean Center, Robin Know from Save the Wetlands Hui, Travis Liggett of Reef Power, Shelby Serra of the Pacific Whale Foundation, and Robert Vafaie of the Maʻalaea Harbor Shops on October 29th and November 30th, 2021. The purpose of these meeting was to identify pollutants of concern and to develop performance standards, including the identification of suitable LID infrastructure for the parking lot.

A GPS survey of the Project and a review of period-of-record rainfall data from the Waikapu 390 rain gauge helped to classify the amount of stormwater generated at the Maʻalaea Triangle parking lot. It should be noted that this rain gauge is in a wetter location than the parking lot and all stormwater calculations based on this dataset should be considered conservative. Regardless, catastrophic flooding associated with rare storm events have been documented at the Maʻalaea Triangle and within the greater Pohakea watershed.

During stakeholder discussions, pollutants of concern were identified. These included oil and grease, heavy metals, vegetative debris, rubbish, sediment, and stormwater more generally. Performance standards were discussed, and LID infrastructure sized to capture and retain all stormwater on-site was identified as an ideal outcome. After reviewing the current conditions of the parking lot, several LID projects were considered. These included bioswales, permeable pavement, water bars, drought tolerant vegetation, wind breaks, storm drain filters, and informative signs.

Because the parking lot already has landscaping planters that could easily be retrofitted as bioswales, this LID infrastructure was identified as the best option. Based on the modeled stormwater retention outlined above, bioretention can likely capture and treat 99.42 percent of all rainfall events that have occurred at the Waikapu 390 rain gauge four miles north of the Maʻalaea Triangle parking lot for the period-of-record beginning in August of 1916. A quote for bioswale design and permitting has been provided by Fukumoto Engineering as Appendix A to this report.

Permeable pavement was considered as an additional LID project worth pursuing. During stakeholder meetings, concerns regarding maintenance and effectiveness of permeable pavement were voiced. Due to the large surface area of the parking lot, and a cost of $25 a square foot for the installation of permeable pavement, this LID infrastructure was determined to be of less interest than bioswales within the Maʻalaea Triangle.

Other BMPs including stormwater drain filters, drought tolerant plants, informative signs, native plant wind breaks, and speed bumps acting as water bars to divert stormwater towards bioswales were all considered easy solutions to stormwater management. In addition to providing stormwater mitigation, many of these projects provide sustainability, wind relief, green space beautification, and educational opportunities for visitors to the Maʻalaea Triangle.

Several options to mitigate head cutting occurring just mauka of Honoapiʻilani Highway have been provided. CDF Engineering and Goodfellow Bros. have been working to identify the best strategy for addressing the continued erosion occuring at these locations. A drawing of the eight proposed mitigation strategies has been provided as Appendix B.

10.0 RESOURCES

2015a. Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Web Soil Survey. Available at: http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm. Accessed May 9, 2017.

2015b. Hydric Soils State Lists, Hydric Soils of Hawaiʻi. Available at: https://www.nrcs.usda.gov/wps/PA_NRCSConsumption/download?cid=stelprdb1248596&ext=xlsx.

U.S. Department of Agriculture (USDA)/Natural Resource Conservation Service (NRCS) Soil Survey of Islands of Kauai, Oahu, Maui, Molokai, and Lanai, State of Hawaiʻi. 1972.

U.S. Geological Survey (USGS) Topographic Quadrangle Maps. Online resources available from http://topomaps.usgs.gov/.

U.S. Fish and Wildlife Survey (FWS). National Wetland Inventory (NWI). Online resources available from http://www.fws.gov/wetlands/Data/Mapper.html

Stormwater Management in Pacific and Caribbean Islands: A Practitioners Guild to Implementing LID – prepared by the Horsley Witten Group Inc. February 2014.

Stormwater Management the Natural Way: Low Impact Design and Development – An Overview for the Accommodations Industry in Hawaii – Prepared by the Coral Reef Alliance

Appendix A.
Fukumoto Engineering, Inc.
Bioswale Construction Design and Permitting

FUKUMOTO ENGINEERING, INC.
Civil Engineering & Land Surveying Consultants

Ronald M. Fukumoto, PE, LS
Michael E. Silva, PE, LS, LEED AP
1721 Wili Pa Loop, Suite 203
Wailuku, Hawaii 96793
Phone: (808) 242-8611
Email: office@femaui.com
Website: www.femaui.com

January 7, 2022

Mr. Michael Reyes (VIA EMAIL)
Maui Environmental Consulting, LLC
P.O. Box 790568
Paia, Hawaii 96779

Dear Michael:

Subject: **BIOSWALE IMPROVEMENTS AT MAALAEA TRIANGLE**
Tax Map Keys (2) 3-6-008:001, 002, 004, 005, and 006
Maalaea, Maui, Hawaii

We are sending you this letter to submit our proposal for professional consulting services for the subject project. We want to thank you for emailing and discussing the project requirements.

BACKGROUND

The project site is a parking lot in Maalaea on Maui, Hawaii. The parking lot serves the business at the Maalaea Triangle that include Maui Ocean Center and the Maui Harbor Shops. The site is bordered by Honoapiilani Highway to the west, Kapoli Street to the north, and Maalaea Road to the east and south. The parking lot area is approximately 11 acres.

Low Impact Development (LID) improvements will be made at the parking lot at Maalaea Triangle. Bioswales or other LID improvements will be installed in the existing greenspace to improve water quality, rainwater reuse, and groundwater recharge. The available existing greenspace is estimated to be approximately 0.93 acre.

SCOPE OF SERVICES

The work includes the following land surveying phase, construction documents phase, permitting phase, bidding phase, and construction administration phase.

A. LAND SURVEYING PHASE

This item involves consultation, collecting and reviewing reference information, visiting the site, performing a field survey, and preparing a topographic map.

1. Consultation: Correspond and coordinate with you.

2. Research: Collect and review reference construction drawings, maps, and reports.

3. Site Visits: Visit the site with you and owner to discuss the project approach.

4. Field Survey: Establish survey control stations and perform limited topographic survey. Perform aerial survey to collect aerial photo data.

5. Map Preparation: Prepare topographic map of the project areas based on aerial survey data at a scale of 1 inch = 40 feet or other suitable scale. The map will show high-resolution aerial image, elevation contours, approximate location of underground utility lines, lot lines, public right-of-way, roadway centerline, and survey control stations. Submit PDF and DWG files.

B. CONSTRUCTION DOCUMENTS PHASE

This item involves preparing construction documents including construction drawings, project manual, and drainage assessments.

1. Consultation: Correspond and coordinate with you.

2. Construction Drawings: Prepare construction drawings including the following estimated number of additional 24" x 36" sheets.

Sheet Title	No. of Sheets
a. Title Sheet	1
b. Construction Notes	1
c. Erosion Control Best Management Practices Plan	1
d. Roadway Plan and Profile (1"=40')	2
e. Drainage and Miscellaneous Details	1
Total No. of Sheets	6

3. Client Review: Submit pre-final documents to you via email and review documents with you. Incorporate your comments, if any, into documents.

4. Agency Review and Approvals: Prepare grading permit. Submit documents to County Development Services Administration for review. Incorporate agency comments into documents and resubmit for approval.

5. Special Management Area Assessment: Prepare draft application documents and submit to you for review. Incorporate your comments into application and submit application to Department of Planning (DOP) for review. The intent of the SMA Assessment is to seek an SMA Minor Permit. The improvements may be classified as a “development” but the valuation will be less than $500,000. Incorporate comments into documents and resubmit for approval. Client will provide check for permit review fee.

C. BIDDING PHASE

This item involves assisting you with bidding.

1. Consultation: Coordinate with you and bidders.

2. Addenda: If required, prepare addenda to interpret, clarify, or expand the bidding documents.

D. CONSTRUCTION ADMINISTRATION PHASE

This item involves monitoring construction so that the constructed improvements comply with the intent of the construction documents. This item also involves assisting you with administering the construction contract.

1. Consultation: Meet and coordinate with you and Contractor. Assist you with conducting a pre-construction conference with Contractor.

2. Clarifications and Changes: Provide interpretations and clarifications of the contract documents. Review change proposals and make recommendations to you.

3. Inspection: Conduct a pre-final inspection to determine if the work is substantially complete and a final inspection to determine if the completed work is acceptable. Submit written reports and recommendations to you.

CLARIFICATIONS & EXCLUSIONS

A. This work does not include soils engineering services, site electrical engineering services, site structural engineering services, or landscape architectural services. This work also does not include archaeological monitoring or reporting services during the construction phase.

B. This work is not anticipated to exceed 1 acre of ground disturbance. An NPDES permit is not anticipated. A minor grading permit is anticipated which does not require SHPD review. NPDES and SHPD reviews are excluded.

CLIENT'S & OWNER'S RESPONSIBILITIES

A. Provide us with reference information for the project including maps, reports, and other information.

B. Perform daily construction management services.

FEES

Client shall pay the lump sum amounts and reimbursable expenses noted on the attached breakdown.

TIME OF PERFORMANCE

We will perform the services as broken down below after receiving the notice to proceed and the required information. The time of performance does not include your or governmental agency review time.

Work Item	Completion Time
Land Surveying	30 days
Construction Documents	30 days
Permitting	30 days

If this proposal meets your requirements, we would like to incorporate the enclosed General Conditions into a consulting services agreement, and would appreciate a written acceptance and notice to proceed. This letter may be used as the acceptance and notice to proceed by filling in the information below, signing, and sending the signed copy to our office.

Thank you for the opportunity to submit this proposal for professional consulting services. We look forward to your acceptance of this proposal and working with you.

Sincerely,

Michael E. Silva, PE, LS, LEED AP
Vice President

Enclosures

ACCEPTANCE & NOTICE TO PROCEED:

____________________ Name (please print)	____________________ Title (please print)
____________________ Signature	____________________ Date (please print)
____________________ Mailing Address (please print)	____________________ Telephone (please print)
____________________ City, State, Zip Code (please print)	____________________ E-mail (please print)

Fee Estimate for Maui Environmental Consultants
Bioswale Improvements at Maalaea Triangle
Maalaea, Maui, Hawaii

1/7/2022

	Activities		Project Manager $225/hr.	Project Engineer $160/hr.	Senior Technician $125/hr.	Admin Asst $80/hr.	Survey Crew $160/hr.	Fees	Expenses	Total
			Estimated Hours							
A	LAND SURVEYING PHASE									
1	Consultation		2	1	-	-	-	610	20	630
2	Research		1	2	4	1	-	1,125	10	1,135
3	Site Visit		2	-	-	1	-	530	30	560
4	Field Survey	2	1	2	4	-	16	3,605	100	3,705
5	Map Preparation	2	1	2	24	-	-	3,545	525	4,070
	Subtotal Hours		7	7	32	2	16			
	Subtotal Charges		$ 1,575	$ 1,120	$ 4,000	$ 160	$ 2,560	$ 9,415	$ 685	$ 10,100
B	CONSTRUCTION DOCUMENTS PHASE									
1	Consultation		4	2	-	2	-	1,380	55	1,435
2	Construction Drawings	6	6	30	36	-	-	10,650	60	10,710
3	Client Review		2	4	6	2	-	2,000	35	2,035
4	Agency Review and Approvals	6	3	9	18	-	-	4,365	60	4,425
5	SMA Assessment		6	12	10	8	-	5,160	35	5,195
	Subtotal Hours		21	57	70	12	-			
	Subtotal Charges		$ 4,725	$ 9,120	$ 8,750	$ 960	$ -	$ 23,555	$ 245	$ 23,800
C	BIDDING PHASE									
1	Consultation		1	2	-	1	-	625	30	655
2	Addenda		1	2	2	-	-	795	50	845
	Subtotal Hours		2	4	2	1	-			
	Subtotal Charges		$ 450	$ 640	$ 250	$ 80	$ -	$ 1,420	$ 80	$ 1,500
D	CONSTRUCTION ADMINISTRATION PHASE									
1	Consultation		1	4	-	1	-	945	15	960
2	Clarifications and Changes		1	2	4	-	-	1,045	10	1,055
3	Inspection and Follow-up	1	1	4	-	1	-	945	40	985
	Subtotal Hours		3	10	4	2	-			
	Subtotal Charges		$ 675	$ 1,600	$ 500	$ 160	$ -	$ 2,935	$ 65	$ 3,000
	TOTAL HOURS		33	78	108	17	16			
	TOTAL CHARGES		$ 7,425	$ 12,480	$ 13,500	$ 1,360	$ 2,560	$ 37,325	$ 1,075	$ 38,400

GENERAL CONDITIONS

SECTION 1 - BASIC SERVICES OF ENGINEER

1.1 After written authorization to proceed, ENGINEER will perform the professional services as stated in the proposal letter.

SECTION 2 - ADDITIONAL SERVICES

2.1 If authorized in writing by CLIENT, Additional Services related to the Project will be performed by ENGINEER for an additional fee.

SECTION 3 - PAYMENTS TO ENGINEER

3.1 For Basic Services. CLIENT will pay ENGINEER for all services as stated in the proposal letter.

3.2 For Additional Services. CLIENT will pay for all Additional Services rendered under Section 2 on the basis agreed to in writing.

3.3 Reimbursable Expenses. In addition to the payments provided for in paragraphs 3.1 and 3.2, CLIENT will pay ENGINEER for reimbursable expenses incurred. An administration charge of 15% will be added to all reimbursable expenses. Reimbursable Expenses mean the actual expenses incurred by ENGINEER directly or indirectly in connection with the Project, such as expenses for: transportation; reproduction of reports, drawings, and other Project related items.

3.4 Times of Payment. ENGINEER will submit invoices for Basic and Additional Services rendered and for Reimbursable Expenses incurred from time to time, but no more frequently than every two weeks. Invoices will be based upon ENGINEER's estimate of the proportion of the total services actually completed at the time of billing. Invoices will be due and payable within thirty (30) calendar days of the invoice date.

3.5 If CLIENT fails to make payments to ENGINEER, such failure will be considered substantial nonperformance and cause for termination or, at ENGINEER's option, cause for suspension of services. If ENGINEER elects to suspend services, ENGINEER will give seven days written notice to CLIENT. In the event of a suspension of services, ENGINEER will have no liability to and will be indemnified by CLIENT for delay or damage caused because of such suspension of services. Before resuming services, ENGINEER will be paid all sums due for services, expenses and charges.

3.6 CLIENT will promptly review ENGINEER's invoice upon receipt and will notify ENGINEER of any dispute or any portion of invoice within ten days of receipt. Any dispute identified thereafter will not be a basis to withhold any payment.

3.7 In the event CLIENT disputes any portion of an invoice, CLIENT will pay all undisputed portions of invoice.

3.8 CLIENT will not withhold any payment or portion thereof as an offset to any current or prospective claim. CLIENT may only withhold payment as to those specific services CLIENT claims were improperly performed.

3.9 Any and all of CLIENT'S rights in ENGINEER's work product including reports, plans, and specifications will be contingent upon full, complete, and timely payment of all fees, costs, and expenses due to ENGINEER. In the event of any non-payment or delayed payment, ENGINEER will be entitled to immediate return of all its work product.

SECTION 4 - GENERAL CONSIDERATIONS

4.1 All documents prepared or furnished by ENGINEER are instruments of service and ENGINEER will retain ownership and property interest therein. CLIENT may make and retain copies for information and reference; however, such documents are not intended or represented to be suitable for reuse by CLIENT or others.

4.2 The obligation to provide further services under this Agreement may be terminated by either party upon thirty (30) calendar days' written notice in the event of substantial failure by the other party to perform in accordance with the terms hereof through no fault of the terminating party. In the event of any termination, ENGINEER will be paid for all services rendered and reimbursable expenses incurred to the date of termination and, in addition, all reimbursable expenses directly attributable to termination.

4.3 CLIENT and ENGINEER each is hereby bound and the partners, successors, executors, administrators and legal representatives of CLIENT and ENGINEER (and to the extent permitted by paragraph 4.4 the assigns of CLIENT and ENGINEER) are hereby bound to the other party and to the partners, successors, executors, administrators and legal representatives (and said assigns) of such other party, in respect of all covenants, agreements and obligations of this Agreement.

4.4 Neither CLIENT nor ENGINEER will assign or sublet or transfer any rights or interest (including, but without limitation, moneys that may become due or moneys that are due) without the written consent of the other, except to the extent that any assignment, subletting or transfer is mandated by law or the effect of this limitation may be restricted by law. Unless specifically stated to the contrary in any written consent to an assignment, no assignment will release or discharge the assignor from any duty or responsibility. Nothing contained in this paragraph will prevent ENGINEER from employing independent professional associates and consultants as ENGINEER to assist in the performance of services hereunder.

4.5 ENGINEER will not be responsible for the acts or omissions of the CLIENT, the Contractor and Subcontractors, and their respective agents or employees, or any other persons or entities performing work on the Project who are not under the direct control or authority of ENGINEER.

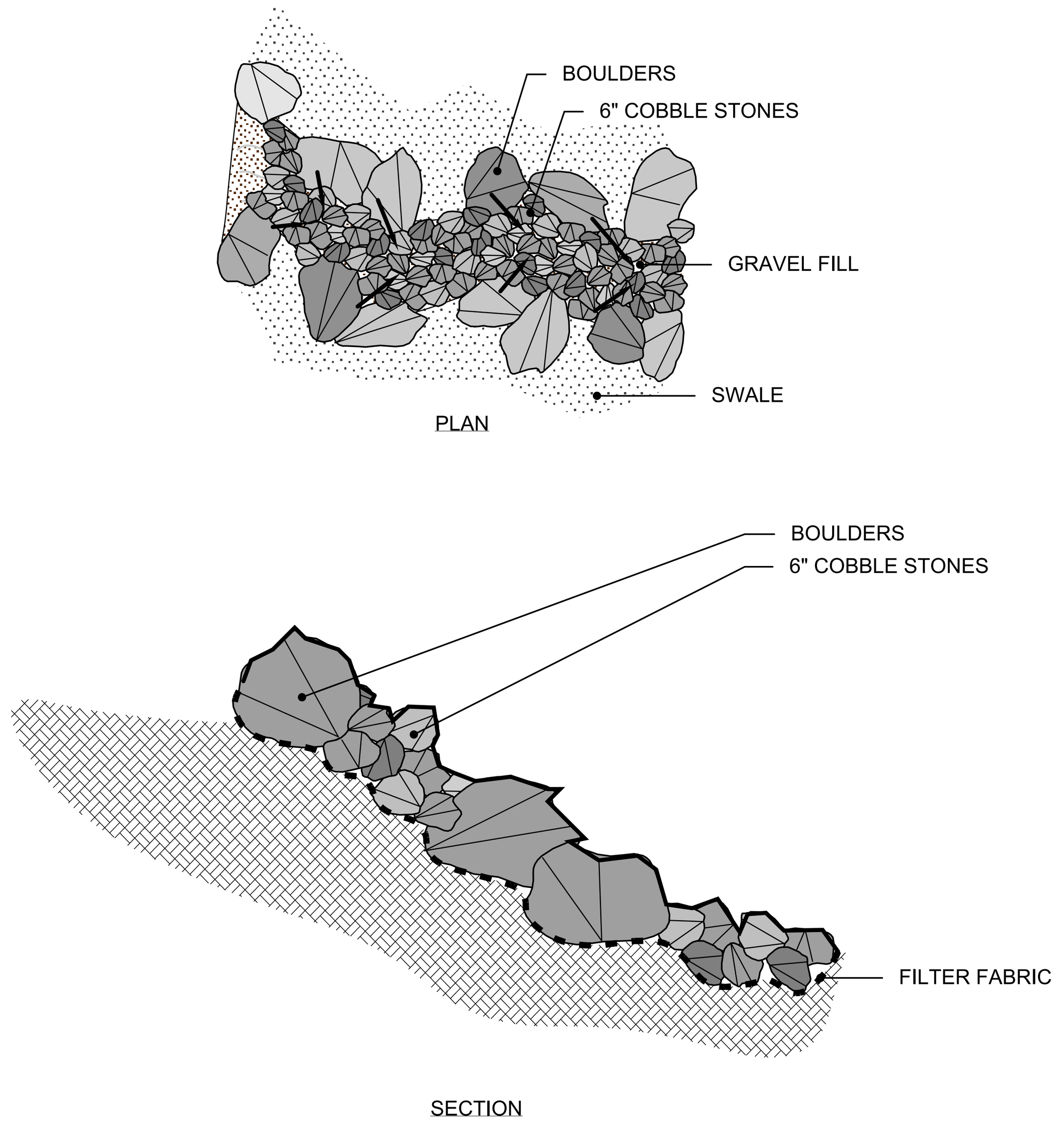
4.6 RISK ALLOCATION. CLIENT AND ENGINEER HAVE DISCUSSED THE RISKS, REWARDS AND BENEFITS OF THE PROJECT AND THE ENGINEER'S TOTAL FEE FOR SERVICES. THE RISKS HAVE BEEN ALLOCATED SUCH THAT THE CLIENT AGREES THAT TO THE FULLEST EXTENT PERMITTED BY LAW, ENGINEER'S TOTAL LIABILITY TO CLIENT FOR ANY AND ALL INJURIES, CLAIMS, LOSSES, EXPENSES, DAMAGES OR CLAIMS EXPENSES FROM ANY CAUSE OR CAUSES, WILL NOT EXCEED THE TOTAL AMOUNT OF $ **50,000** . SUCH CAUSES INCLUDE BUT ARE NOT LIMITED TO ENGINEER'S NEGLIGENCE, ERRORS, OMISSIONS, STRICT LIABILITY, BREACH OF CONTRACT OR BREACH OF WARRANTY.

4.7 ENGINEER'S services will be provided consistent with and limited to the standard of care applicable to such services, which is that ENGINEER will provide its services consistent with the professional skill and care ordinarily provided by consultants practicing in the same or similar locality under the same or similar circumstances. Such standard of care is not a warranty or guarantee. Accordingly, CLIENT should prepare and plan for clarifications and modifications which may impact both the cost and schedule of the Project.

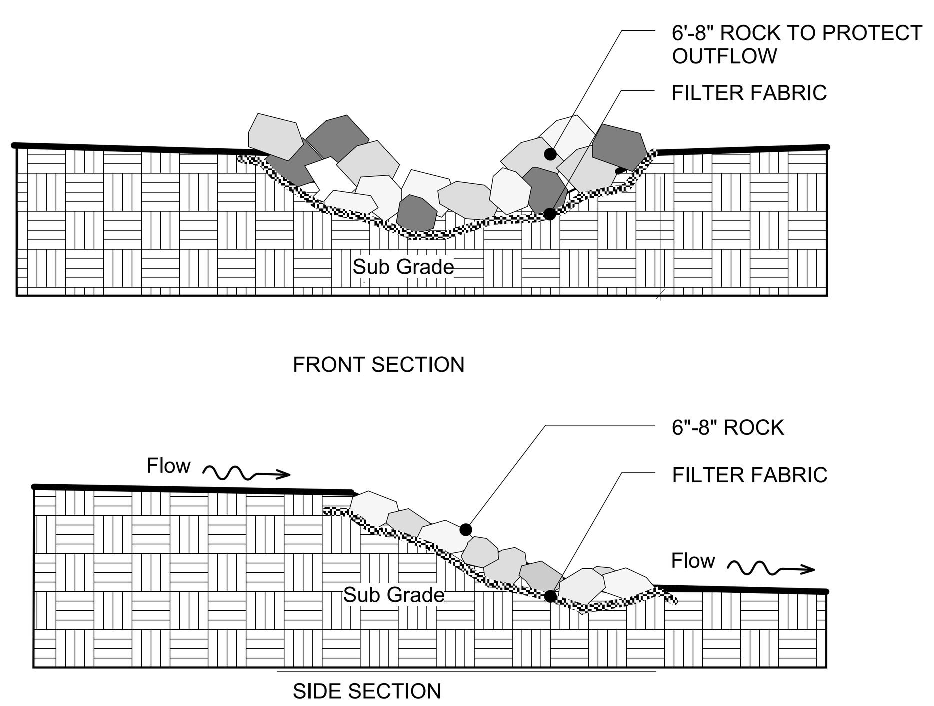
4.8 These General Conditions together with the proposal letter constitute the entire Agreement between CLIENT and ENGINEER and supersede all prior written or oral understandings. This Agreement may only be amended, supplemented, modified or cancelled by a duly executed written instrument. All of ENGINEER's actions and communications relative to the Project will be subject to this Agreement.

Appendix B.

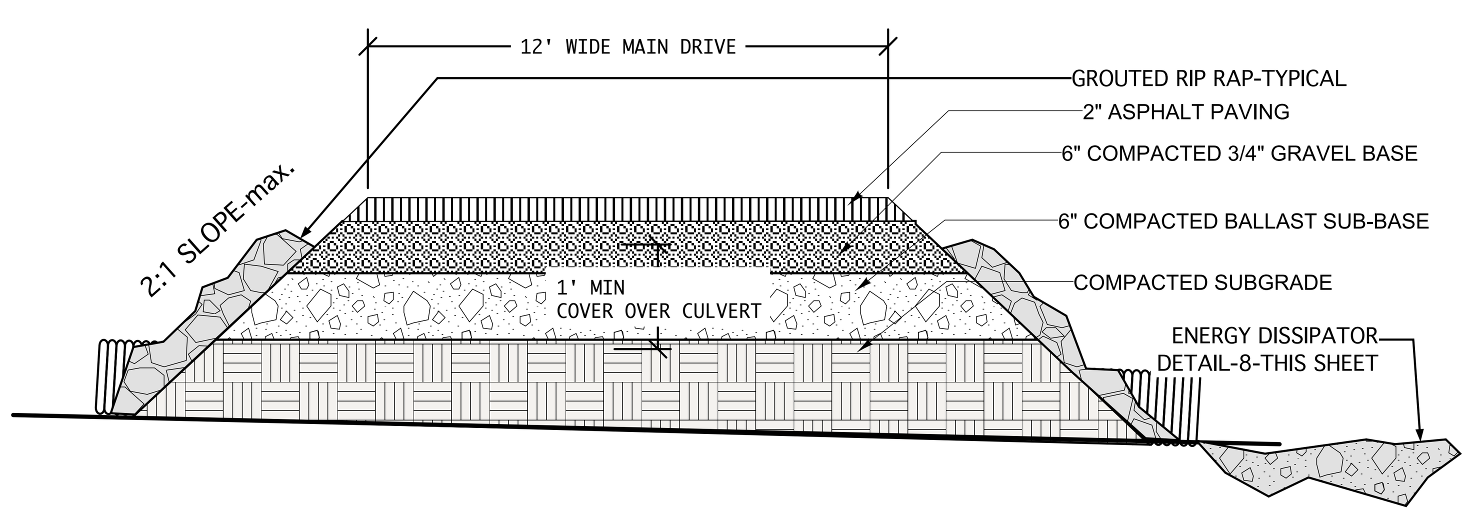
Head Cut Mitigation Strategies



1 Channel Protection
NOT TO SCALE

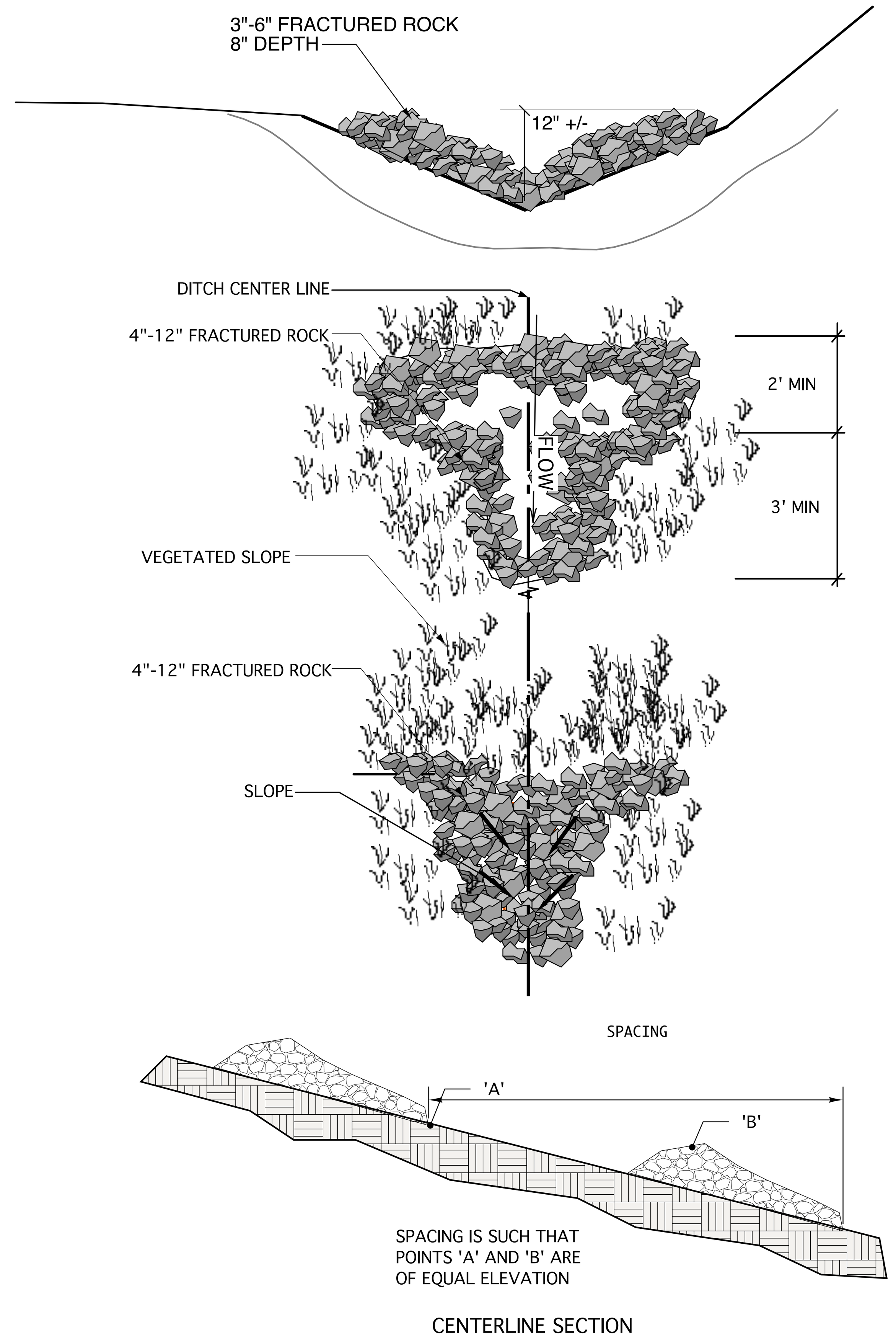


2 Rock Lined Inlet/Outlet
NOT TO SCALE

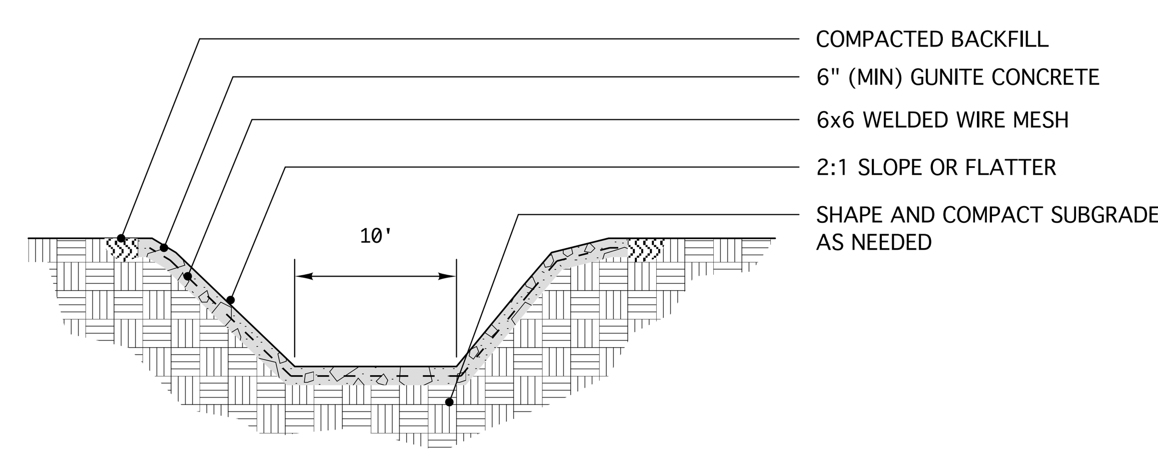


NOTE:
1. INSTALL CULVERTS SO THAT NO CHANGE IS WATER COURSE OCCURES AT INLET NOR OUTLET.
2. COMPACT CULVERT SUBGRADE-MAX 6" LIFT
3. COMPACT SIDEWALL FILL OF CULVERT -MAX 8" LIFT- MIN OF ONE CULVERT DIAMETER EACH SIDE

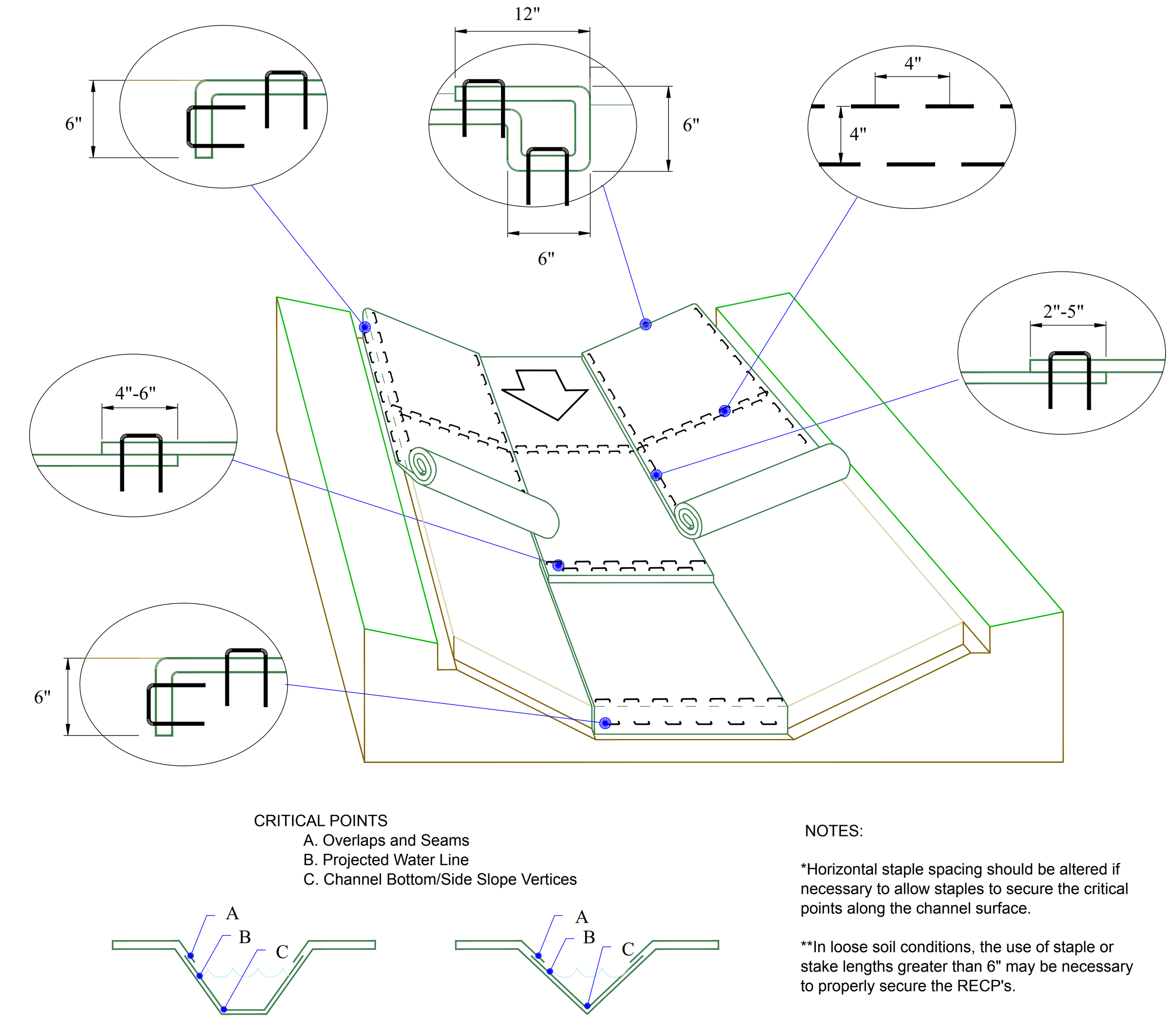
3 Culvert
NOT TO SCALE



4 Rock Check Dam
NOT TO SCALE



5 Concrete Lined Ditch
NOT TO SCALE



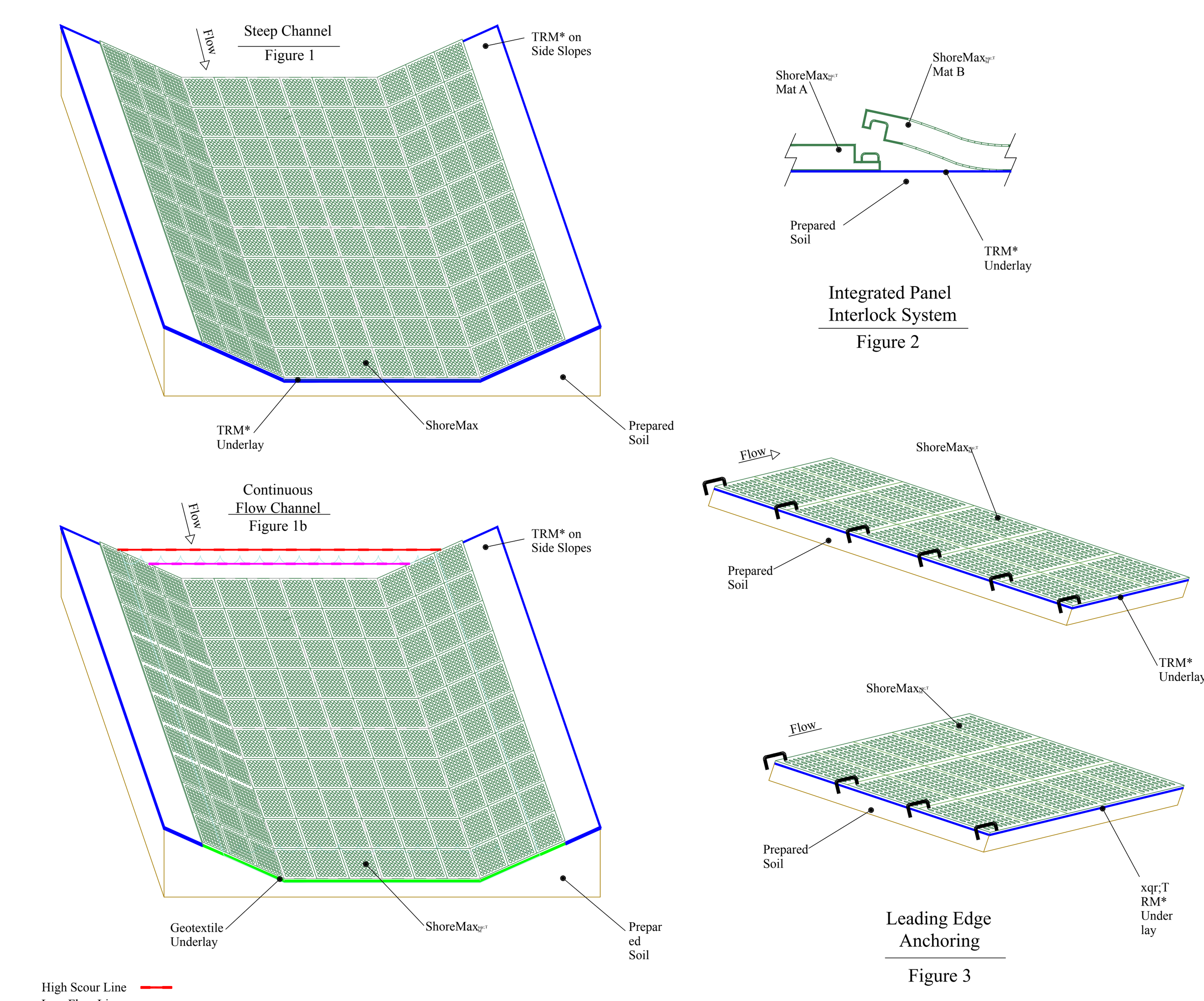
NOTES:

*Horizontal staple spacing should be altered if necessary to allow staples to secure the critical points along the channel surface.

**In loose soil conditions, the use of staple or stake lengths greater than 6" may be necessary to properly secure the RECP's.

1. Prepare soil before installing rolled erosion control products (RECPs), including any necessary application of lime, fertilizer, and seed.
2. Begin at the top of the channel by anchoring the RECPs in a 6" deep X 6" wide trench with approximately 12" of RECPs extended beyond the up-slope portion of the trench. Use ShoreMax mat at the channel/culvert outlet as supplemental scour protection as needed. Anchor the RECPs with a row of staples/stakes approximately 12" apart in the bottom of the trench. Backfill and compact the trench after stapling. Apply seed to the compacted soil and fold the remaining 12" portion of RECPs back over the seed and compacted soil. Secure RECPs over compacted soil with a row of staples/stakes spaced approximately 12" apart across the width of the RECPs.
3. Roll center RECPs in direction of water flow in bottom of channel. RECPs will unroll with appropriate side against the soil surface. All RECPs must be securely fastened to soil surface by placing staples/stakes in appropriate locations as shown in the staple pattern guide.
4. Place consecutive RECPs end-over-end (Shingle style) with a 4"-6" overlap. Use a double row of staples staggered 4" apart and 4" on center to secure RECPs.
5. Full length edge of RECPs at top of side slopes must be anchored with a row of staples/stakes approximately 12" apart in a 6" deep X 6" wide trench. Backfill and compact the trench after stapling.
6. Adjacent RECPs must be overlapped approximately 2"-5" (Depending on RECPs type) and stapled.
7. In high flow channel applications a staple check slot is recommended at 30 to 40 foot intervals. Use a double row of staples staggered 4" apart and 4" on center over entire width of the channel.
8. The terminal end of the RECPs must be anchored with a row of staples/stakes approximately 12" apart in a 6" deep X 6" wide trench. Backfill and compact the trench after stapling.

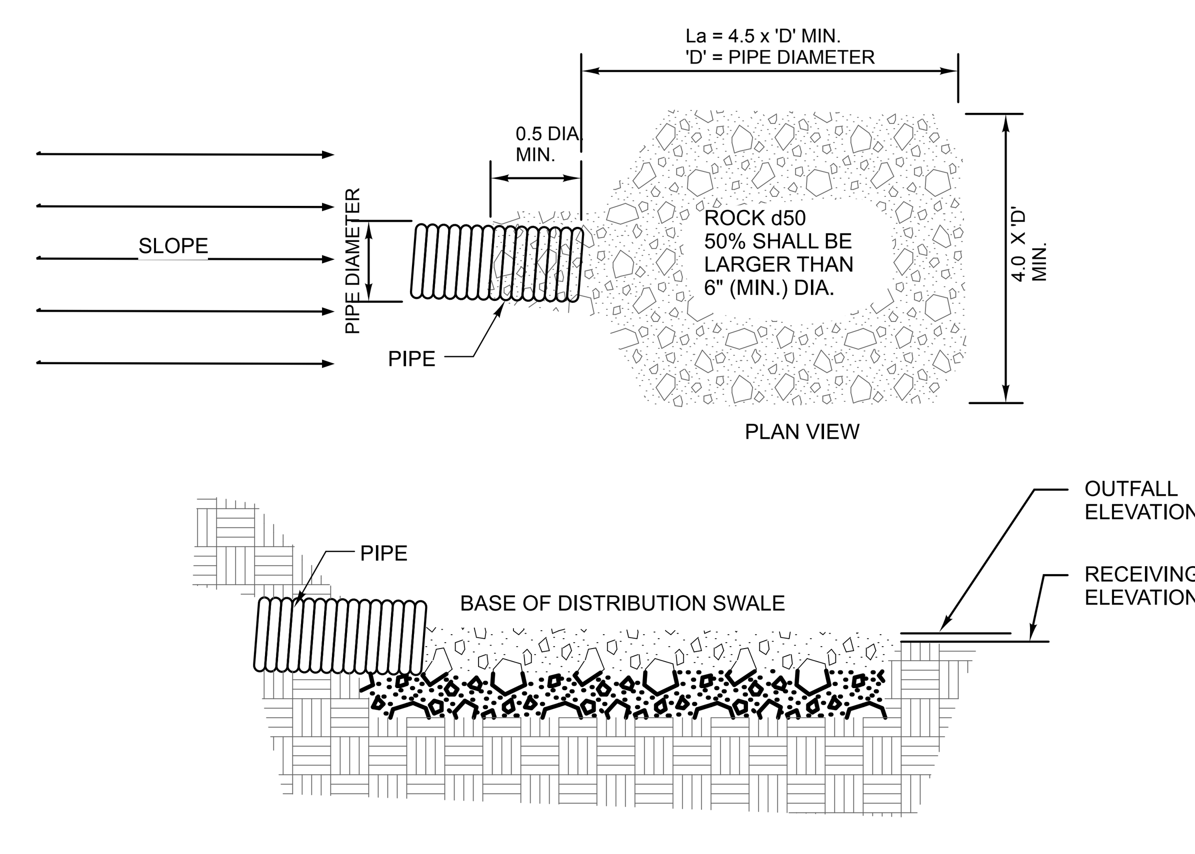
6 Rolled Erosion Control Product-Channel
NOT TO SCALE



* ShoreMax mats can be installed over a variety of underlayments including: sod, turf reinforcement mats (TRMs), geotextiles, and in some cases erosion control blankets (ECBs).

1. Prepare soil before installing erosion control products, including any necessary application of lime, fertilizer, and seed (when installing TRM or ECB underlayment).
2. Install turf reinforcement mat (TRM) over prepared soils according to manufacturer's recommendations.
3. Place ShoreMax mat in the bottom of the channel over the installed TRM (figure 1). The ShoreMax mat should be installed up to the appropriate elevation on the side slope as determined by the engineer. When using multiple panels, connect the panels using the Integrated Panel Interlock System (figure 2). ShoreMax mat can be laid in either direction.
4. For channels carrying continuous water flows, an appropriate geotextile should be placed under the ShoreMax mat for submerged applications (figure 1b).
5. Place staples/anchors in the appropriate pattern. Perimeter staples can be shared between two adjacent panels. In soft or highly erodible soils, percussion earth anchors may be required. View ShoreMax Anchoring Guide, for additional details.
6. At beginning of channel and areas where significant concentrated flows are directed onto the ShoreMax mat, place 1 staple/pin per linear foot along the leading edge of the ShoreMax system, resulting in 1 staple/pin on each corner and gridline (figure 3).

7 ShoreMax, Channel Protection
NOT TO SCALE



NOTE:
1. "La" = LENGTH OF APRON. DISTANCE 'La' SHALL BE OF SUFFICIENT LENGTH TO DISSIPATE ENERGY.
2. APRON SHALL BE SET AT A ZERO GRADE AND ALIGNED STRAIGHT.
3. FILTER MATERIAL SHALL BE FILTER FABRIC OR 6" THICK (MIN.) GRADED GRAVEL LAYER.

8 Energy Dissipator
NOT TO SCALE