Southwest Maui Watershed Management Plan

Maui County, HI
Draft Report 2017

Prepared For:
Hawaii Department of Health
Clean Water Branch and
The U.S. Environmental Protection Agency

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Thompson Ranch
Ulupalakua Ranch
Leeward Haleakala Watershed Restoration Partnership
Whole Foods

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1.0 INTRODUCTION AND PURPOSE

The Southwest Maui Watershed Plan (SMWP) was developed to include the 49,688-acre planning area designated by the State of Hawaii as the Hapapa, Wailea, and Moʻoloa watersheds. The planning area extends from near the summit of Haleakala down to coastal areas, with 11 major drainage basins discharging to the Kihei, Wailea, and Makena coastlines (Figure 1). The entire coastline of the planning area is part of the Hawaiian Islands Humpback Whale National Marine Sanctuary. The upcountry areas are primarily forests, farms, and ranch lands, and the coastal areas are developed resort, urban, and residential areas. Long term rainfall averages range from 10 inches per year near the Kihei coastline to 40 inches per year at 9,400 feet elevation near the summit of Haleakala. The three watersheds in the planning area encompass diverse habitat types utilized by a significant number of threatened and endangered species, including alpine, dryland forest, scrub and shrub, grasslands, coastal and elevated wetlands, ephemeral streams, estuaries, dune systems, tidal pools, rocky shorelines, and coral reefs.

1.1 The Hapapa, Wailea, and Moʻoloa Watersheds

The watersheds include some of the nation's fastest growing population areas, increasing an average of 3.3% per year upcountry and 10% per year in the coastal areas. There is a trend of increased impervious surface and habitat loss due to development. The County of Maui Planning Department (COM Planning) reported that there are at total of ~11,610 acres of planned development projects within the Southwest Maui planning area, which more than doubles the existing impervious surface area (existing development area totals ~4,194 acres). Some of these projects are already completed or are currently being completed; these projects total 196 acres. Planned/Committed projects total 8,445 acres, Planned/Designated projects total 961 acres, and Planned/Proposed projects total 2,010 acres. Most of the potable water for this area is imported from the wet Kahalawai, Iao Watershed, in which water allocations are currently being regulated.

The DOH Integrated Water Quality Report to the EPA and Congress pursuant to Clean Water Act Section 303(d) indicates that more than 26 coastal waterbodies are impaired and not meeting state and federal water quality standards. Total Maximum Daily Load studies to determine needed pollutant load reductions are mandated for more than 74 waterbody/pollutant combinations within the planning area, but none are listed as high priority for state program funding. Of the 33 waterbodies assessed, more than 28 lack adequate data for assessment (Figure 2).

The primary source and most problematic pollutant is sediment carried by storm water runoff. Weather patterns are seasonal and erratic, bringing large rain events which erode land and streambanks. These storm waters overload coastal wetlands causing flooding in the urban area near the shore. State standards for water quality are not being met for many sites along the southwest Maui coastline.

Figure 1. Southwest Maui Watersheds

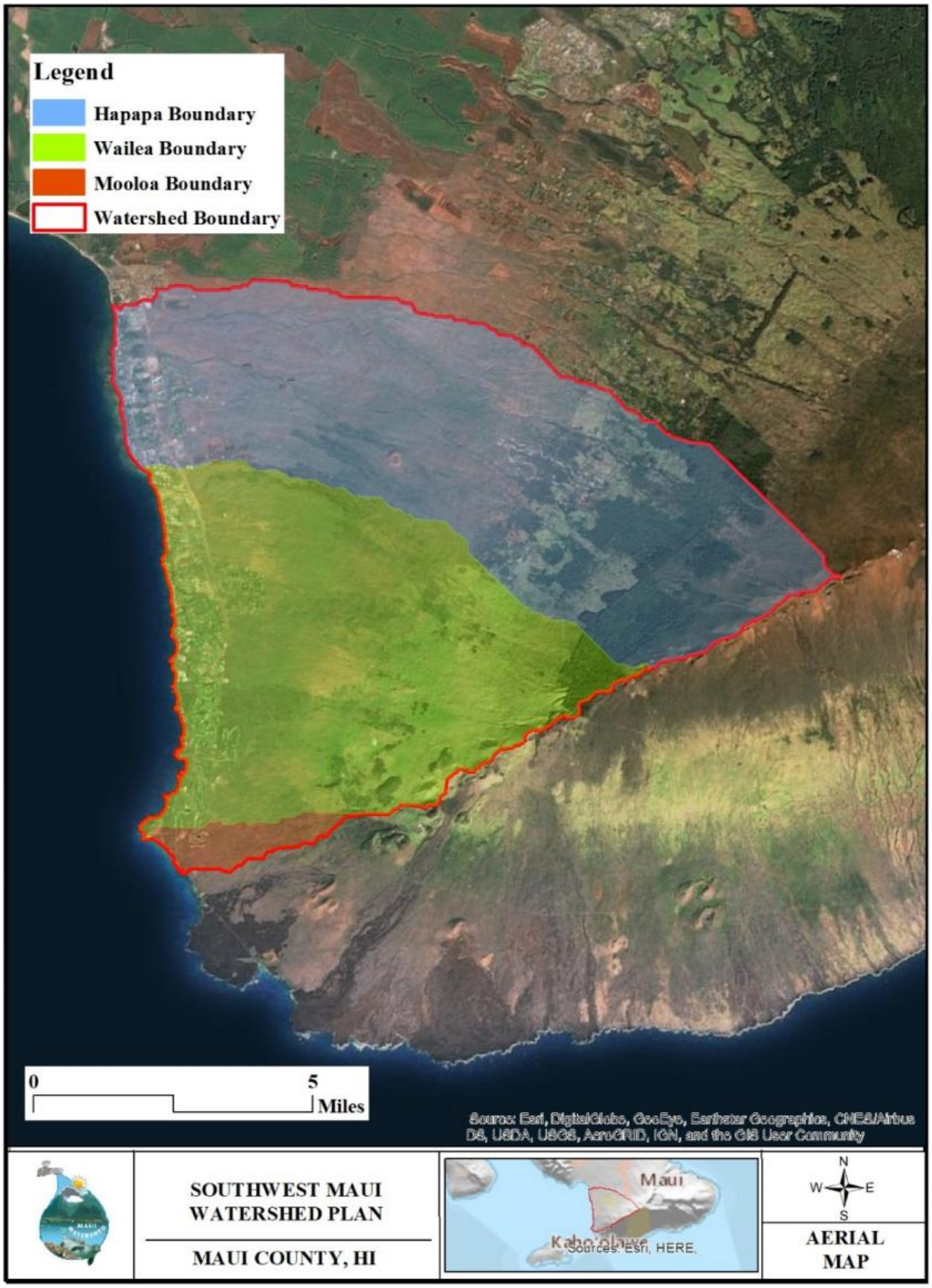

Figure 2. Impaired Waters in the Southwest Maui Watershed Plan

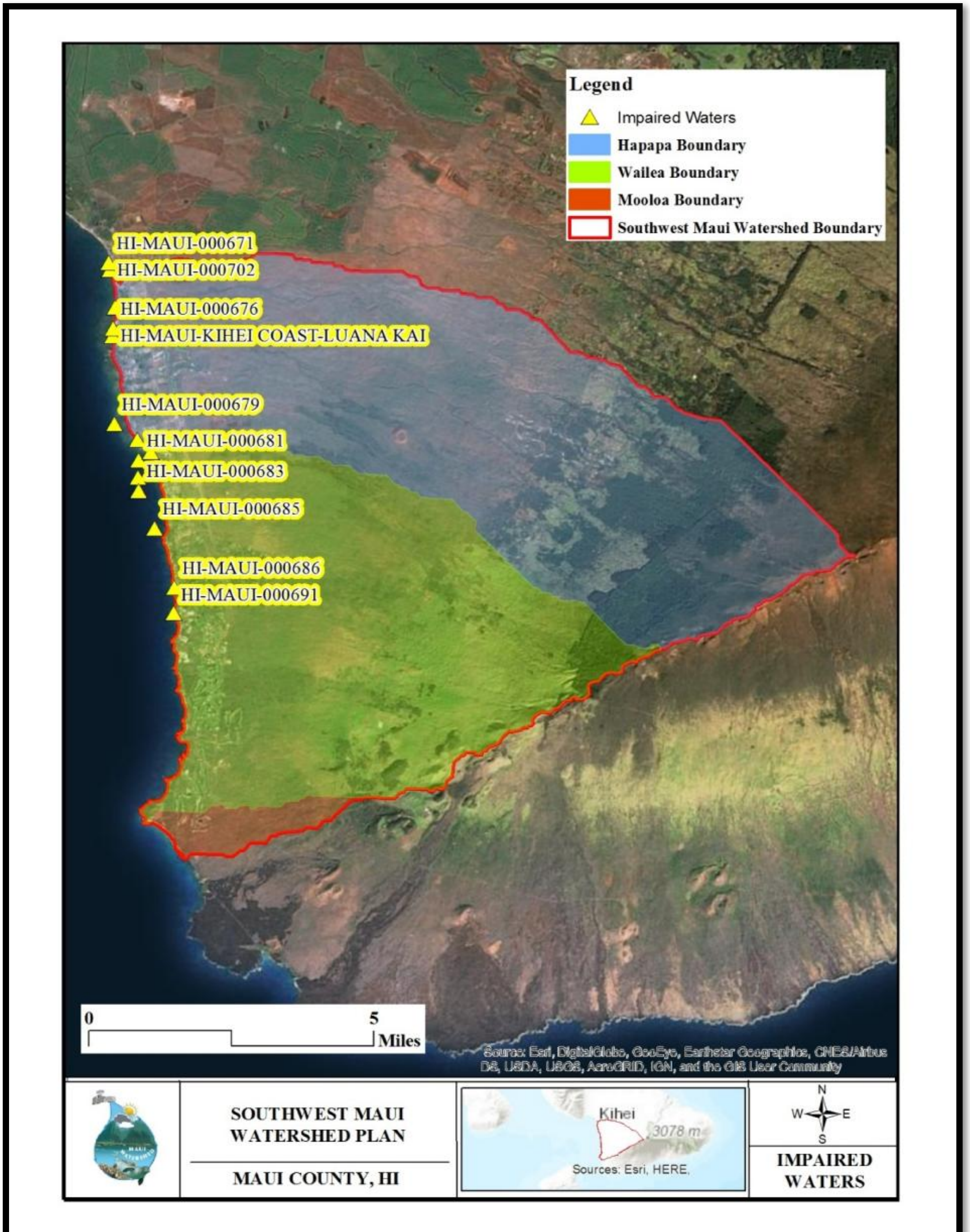

Table 1. Land Use Statistics for the Southwest Maui Watershed

Land Use	Watershed		
	Hapapa Acreage	Wailea Acreage	Mooloa Acreage
Commercial and Services	221.92	339.59	NA
Cropland and Pasture	3040.34	7121.69	164.32
Evergreen Forest Land	5482.51	1139.82	NA
Herbaceous Rangeland	90.74	13.11	NA
Mixed Rangeland	1634.69	783.66	NA
Residential	857.21	832.87	NA
Other Urban or Built-up Land	NA	355.48	NA
Shrub and Brush Rangeland	15110.88	11140.39	1044.18
Transitional Areas	67.00	247.95	NA
Orchards, Groves, Vineyards, Nurseries and Ornamentals	NA	NA	0.02
Total Acreage Per Watershed	26505.29	21974.56	1208.52
Total Acreage	49688.38		

1.2 Pollutant Loading in the Southwest Maui Watersheds

The history of this watershed over the last 300 years reflects a decline in native forest cover in favor of farming, ranching, and residential/urban uses, the introduction of grazing animals, and introduction of alien plant and animal species. Since the 1960's, residential and commercial development in Kihei has contributed to a reduction in the wetland and sand dune acreage along the shoreline. The resulting altered local climate and land use patterns have changed watershed hydrology and the characteristics of stormwater runoff. Excess stormwater causes flooding damage and pollution that are difficult and costly to clean up.

Uncontrolled stormwater runoff has many cumulative impacts on humans and the environment including:

- Flooding - Damage to public and private property
- Eroded Streambanks - Sediment clogs waterways and drainage systems, enters the ocean, kills fish and other aquatic life, and causes property loss and degradation
- Widened Stream Channels – Damage and loss of valuable property
- Sediment Filled Channels and Basins - Reduces volume for managing stormwater runoff and increases pollutant loading
- Aesthetics - Dirty water, trash and debris, foul odors, mud deposits, etc.

- Fish and Aquatic Life – Mortality, impaired health and reproduction, and tissue contamination
- Impaired Recreational Uses - Swimming, fishing, boating, diving, snorkeling, surfing, windsurfing, kite surfing, etc.
- Threats to Public Health – Contamination of drinking water, recreational waters, and fish/shellfish, and waterborne diseases
- Threats to Public Safety - Drowning or injuries occur in flood waters; debris increases hazards
- Economic Impacts – Impairments to fisheries, shellfish, ecosystems, real estate values, tourism, and recreation related businesses
- Increased Cost of Water and Wastewater Treatment - Stormwater pollution increases raw water treatment costs, reduces the assimilative capacity of water bodies (requiring greater level of wastewater treatment), and increases wastewater treatment costs and pollutant discharge loads due to stormwater inflow and infiltration into sewage collection systems

Increased sedimentation and nutrient loading on the extensive offshore reef complex threatens 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).

The 2012 *Water Quality Monitoring and Assessment Report* (Hawaii Department of Health, 2012) identified water quality impairments requiring Total Maximum Daily Loads (TMDLs) in 27 coastal segments within the Hapapa, Wailea, and Mo’oloa watershed units. Levels of nonpoint source pollutants reaching Maui’s coastal waters must be reduced in order to meet water quality criteria and support designated uses in the area. While TMDLs are required, there are none currently scheduled for development within the planning area. The development of a watershed plan provides an opportunity to address these water quality problems, and may even preclude the need for TMDL development.

Relative Loads for Total Suspended Solids (TSS) were evaluated for both current sediment load and future sediment load reduction at individual gulches and gullies within the watersheds.

1.2.1 ***Existing Conditions***

Current sediment load was calculated within the watersheds during heavy rain events using the equation:

$$Qs = Qw*Cs*k$$

where

Qs = suspended-sediment discharge, in tons per day;
Qw = water discharge, in cubic feet per second;
Cs = mean concentration of suspended sediment in the cross-section in milligrams/liter;
and k = a coefficient based on the unit of measurement of water discharge that assumes a specific weight of 2.65 for sediment, and equals 0.0027 in inch-pound units, or 0.0864 in SI units.

Water discharge for each gulch was measured using a Price AA current meter. Relative stream area was measured assuming a uniform depth and width observed at the time and location where the flow measurement was recorded.

On April 30th and October 23rd, 2017 rainfall was sufficient to cause flow at major gulches near the shoreline in the SMWP. The three major gulches identified as having the most frequent flow during rain events in the SMWP are Kulanihakoi, Waipuilani, and Keokea. Sampling was conducted at defined locations according to the Water Quality Monitoring Methodology developed for the SMWP (Appendix A). In addition, several gulches upcountry were also sampled. Sediment loads were calculated for these flow events using the method described above. Table 2 depicts sediment load measured at these locations during the two flow events.

Table 2. Sediment Load During April 30th and October 23rd 2017 Rainfall Events

Sample Location	Qw	Cs	K	Qs	tons per hour
	ft^3/sec	TSS in mg/L	0.0027	tons per day	
April 30th, 2017					
Kulaniakoi at S Kihei	124.33	1215.58	0.0027	408.07	17.00
Kulaniakoi at Piilani	102.62	1802.64	0.0027	499.48	20.81
High Intensity Zone Downstream	1.08	45.69	0.0027	0.13	0.01
High Intensity Zone Upstream	6.17	28.21	0.0027	0.47	0.02
Keokea Downstream	2.06	393.90	0.0027	2.19	0.09
Keokea Upstream	2.59	405.79	0.0027	2.84	0.12
Alae	19.29	93.66	0.0027	4.88	0.20
Ka'onoulu	no flow data	55.91	0.0027	NA	NA
Kaipoioi	no flow data	443.97	0.0027	NA	NA
Waiohuli A	15.06	75.25	0.0027	3.06	0.13
October 23rd, 2017					
Kulaniakoi at S Kihei (Barely Flowing)	5.83	1966.09	0.0027	30.95	1.29
Kulaniakoi at Piilani	38.57	10870.48	0.0027	1132.04	47.17
High Intensity Zone Downstream	NA	NA	0.0027	NA	NA
High Intensity Zone Upstream	NA	NA	0.0027	NA	NA
Keokea Downstream	NA	NA	0.0027	NA	NA
Keokea Upstream	NA	NA	0.0027	NA	NA

Sample Location	Qw	Cs	K	Qs	tons per hour
	ft³/sec	TSS in mg/L	0.0027	tons per day	
Alae	15.32	1324.95	0.0027	54.81	2.28
Ka'onoulu	10.14	896.16	0.0027	24.54	1.02
Kaipoioi	12.20	5913.23	0.0027	194.78	8.12
Waiohuli A	17.63	1567.84	0.0027	74.63	3.11

1.2.2 ***Future Conditions***

Potential future sediment load reduction values were calculated using The United States Department of Agriculture Revised Universal Soil Loss Equation 2 (RUSLE2). Areas within the watershed where implementation projects have been proposed were analyzed for erosion potential using RUSLE2. The four main factors affecting erosion are soil, climate, topography and land use. For each implementation project location, these factors were entered into the RUSLE2 database to calculate the erosion potential in tons per acre per year.

Sediment loss was estimated to be 25 tons per acre per year using the RUSLE2 equation for the areas where the initial implementation projects are being proposed. These implementation projects were identified as being the most feasible based on their location, ownership, cost, potential for success and general “shovel-readiness”. Initial implementation projects include vegetated swales placed down slope of cattle operation High Impact Zones and excavated detention basins. They are located mauka of Pi’ilani Highway as depicted in Figures 3-5.

In addition, baseline sediment loads were recorded during heavy rain events upstream and downstream of these implementation projects using the flow meter and TSS grab sample method mentioned above. Once these initial implementation projects have been completed, flow measurements and TSS samples will be taken upstream and downstream to determine the effectiveness of these projects in limiting erosion and removing sediment from stormwater runoff. These measurements will be compared with the estimated load reduction values derived from utilizing the RUSLE2 methodology.

Figure 3. High Impact Zone Mitigation Site 1 – Water Troughs 1 and 2

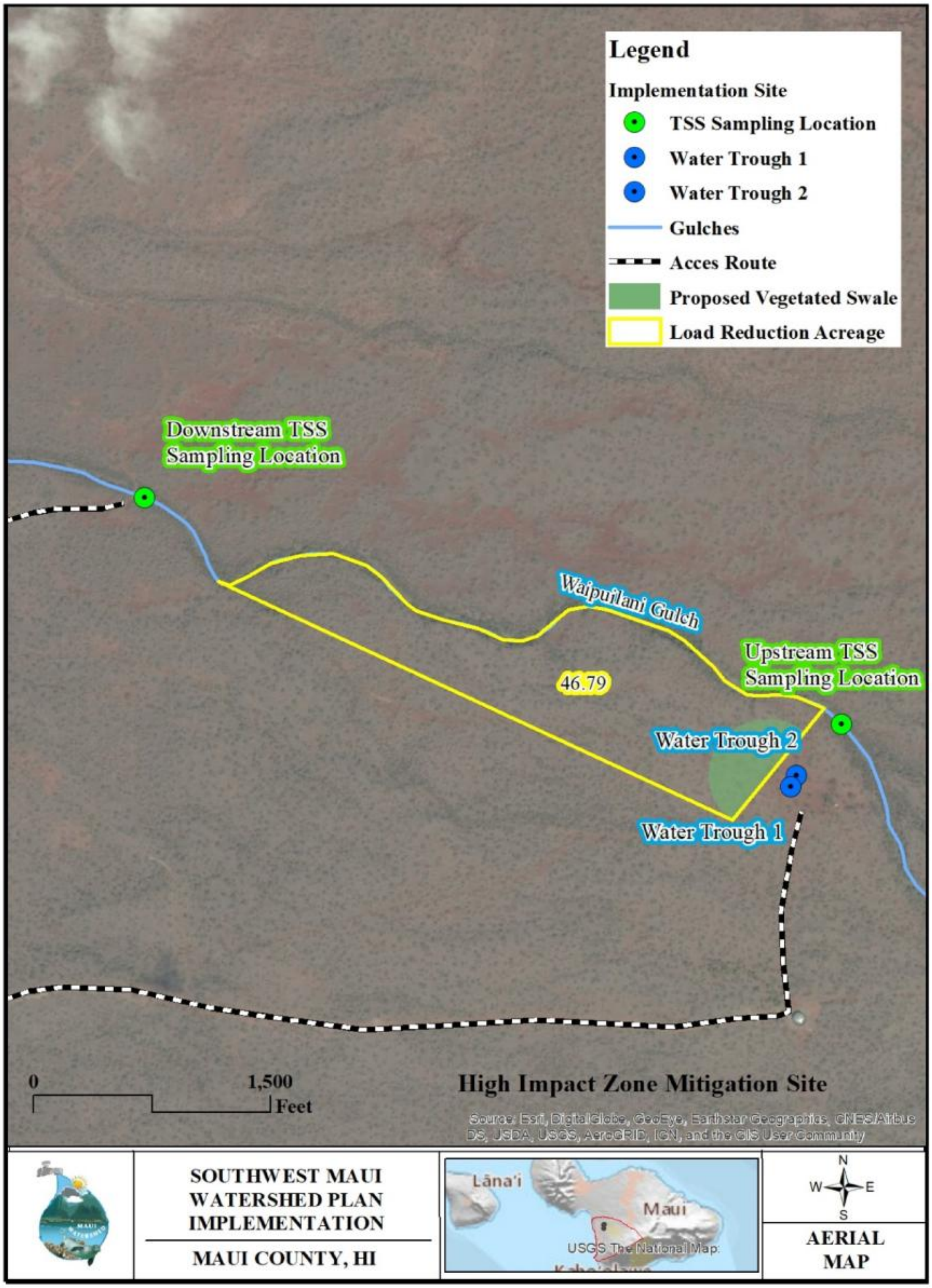

Figure 4. High Impact Zone Mitigation Site 2 – Water Trough 3

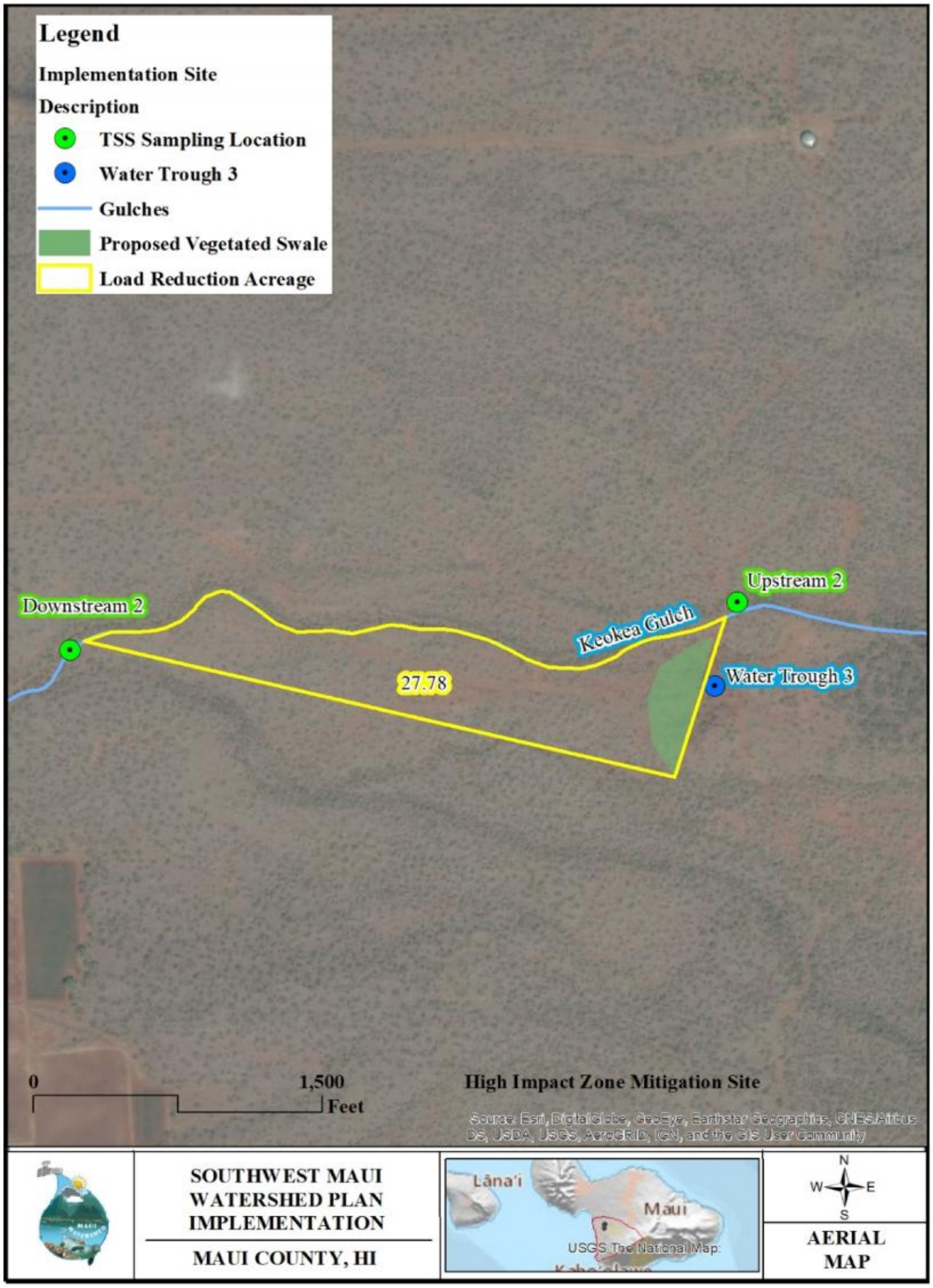

Figure 5. Small Detention Basins

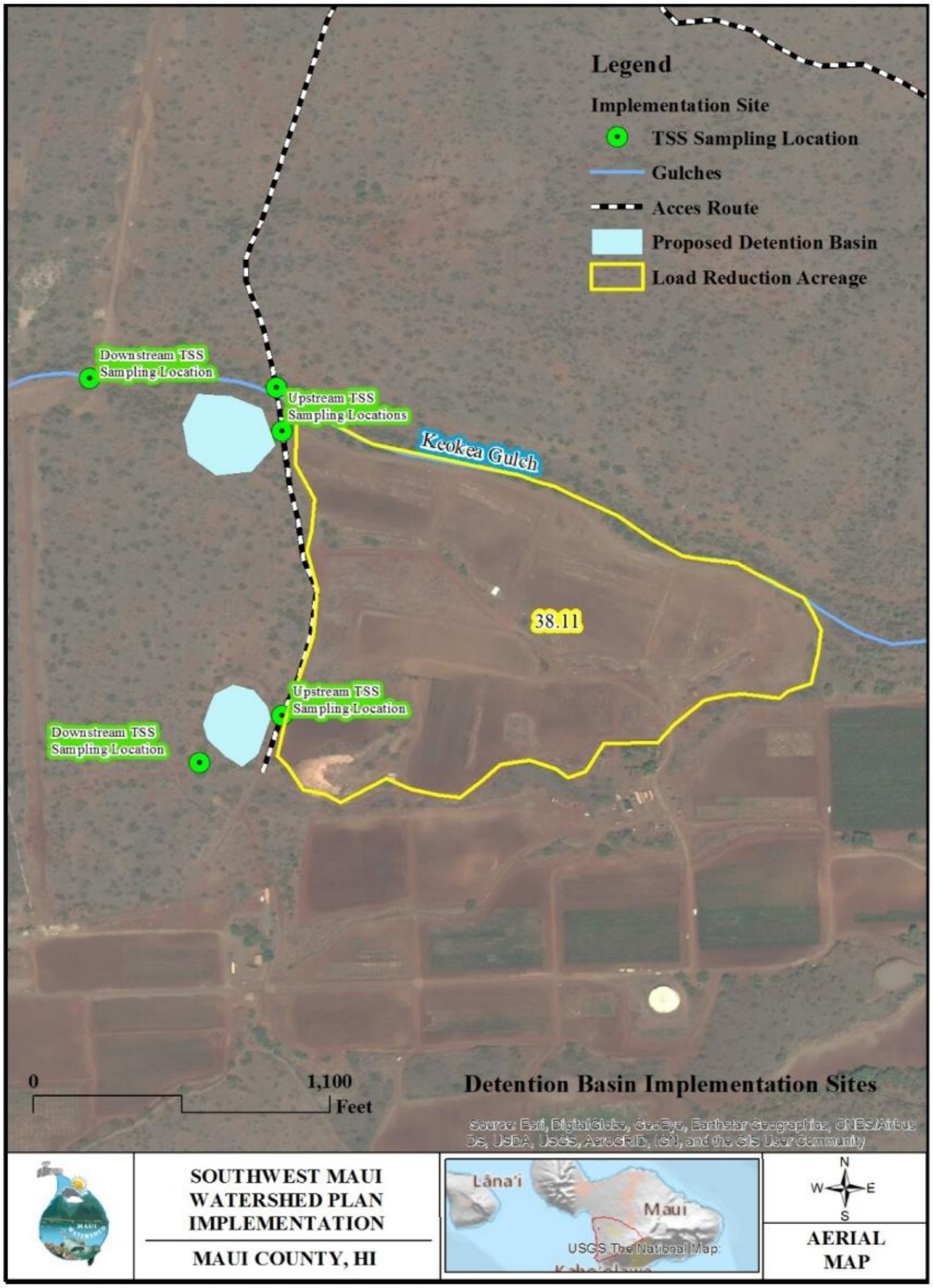

Figure 6. Riparian Protection

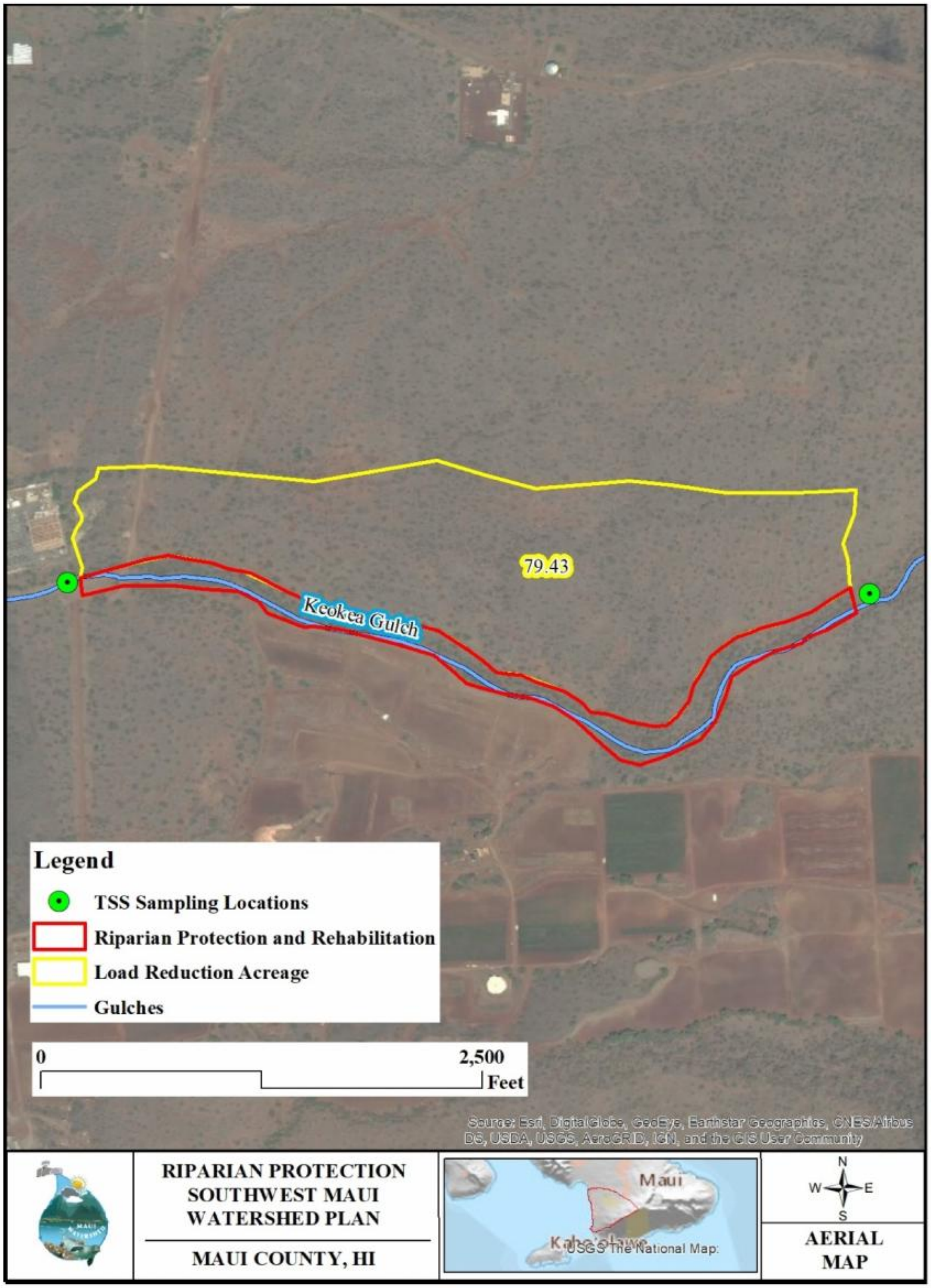

Table 3. Sediment Load Reduction Estimates for Proposed Implementation Projects

Proposed Implementation Project	RUSLE2 Coefficient	Acreage Affected	Sediment Load Reduction Estimate (Tons per Year)
High Impact Zone Mitigation Site 1	25 Tons per Acre per Year	46.79	1169.75
High Impact Mitigation Site 2	25 Tons per Acre per Year	27.78	694.5
Detention Basins	25 Tons per Acre per Year	38.11	952.75
Riparian Protection	26 Tons per Acre per Year	79.43	1985.75

1.2.3 __Implications for Watershed Management__

- Prioritizing implementation projects associated with Kulanihakoi, Waipuilani and Keokea Gulches since these areas are most prone to flooding and have the highest levels of sediment discharge within the watershed.

- A permanent Watershed Coordinator position and an ongoing monitoring program to measure fluctuations in water quality is needed in this watershed. A database containing actual measurements is important to guide implementation of BMP projects. Seasonal flows require seasonal monitoring timeframes. It's especially important to monitor in gulches before they discharge into coastal waters after rain events. Long term monitoring is recommended.

- Excavated basins in series connected by berms or channels, for sedimentation and infiltration purposes, have been identified as having a high priority as a management measure to improve water quality in the watersheds. These basins slow water moving downslope, removing sediment and acting as a means for aquifer recharge and flood prevention.

- In addition to a monitoring program, BMPs related to stormwater management are needed to reduce sediment impact to the water quality on the reef. These are referred to as "DSILT" projects, and cover urban, riparian, wetland, agricultural, and conservation/forestry BMPs. A program should be developed to educate landowners about these BMPs.

- Fertilizer/nutrient management and irrigation conservation are topics for future educational workshops in the watershed. This will help to reduce the nutrients in the stormwater runoff and also in the groundwater flowing to the ocean.

- Increased use of recycled R-1 water for irrigation will further reduce the groundwater nutrient flow. Projects to irrigate wetland and riparian areas with recycled water are to be encouraged. The County has plans to expand the R-1 system pending funding. (See South Maui R-1 Recycled Water Verification Study)

- Vegetated buffers for high impact zone mitigation sites (HIZMS) to stabilize soils and riparian areas are also advised.

- A "Gulch Guardians" program to reduce debris and trash in the gulches in the watershed should be implemented.

- County rules and regulations should be modified to promote the use of LID, SEEP, and NEMO techniques for development (e.g. rain gardens, rain barrels, green roofs, and infiltration features). These methods would reduce the amount of stormwater runoff and sediment and other pollutants reaching the ocean and reef.

- Educational workshops for managing stormwater runoff on rural, unpaved roads should be offered to equipment operators, ranchers, farmers, and conservation land managers, etc.

1.3 Caveats

The following limitations on the information presented in this report should be considered:

- Gulches within the watershed are ephemeral in nature and only flow after heavy rain events. Sediment load estimates presented in this report rely on a limited number of sampling events in the field.

- Potential future sediment load reduction values were calculated using The United States Department of Agriculture Revised Universal Soil Loss Equation 2 (RUSLE2). The four main factors affecting erosion are soil, climate, topography and land use. These factors were derived from USDA and NRCS databases and may not accurately represent all conditions in the watershed.

- While extensive field investigations and stakeholder meetings were conducted, the list of watershed restoration opportunities presented here should not be considered exhaustive.

- Total Suspended Solid and flow data were not collected at every gulch or gully in the watershed.

- The majority of the land in the watershed is on private property and not all the land was able to be inventoried for potential implementation project opportunities.

- Implementation projects are ranked based on their location, ownership, cost, potential for success and general "shovel-readiness".

- A watershed plan is meant to be a living document; revisions are anticipated as implementation advances, additional data becomes available, local priorities change, or as more stakeholders become active in the overall process.

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2.0 GOALS AND MANAGEMENT RECOMMENDATIONS

The main goals of the Southwest Maui Watershed Plan are to ensure fishable and swimmable waters, increase safety, and reduce flood related property damage in Kihei. These goals will mainly bet met by reducing the sediment load in gulches and gullies that discharge into the coastal waters of Kihei, Wailea, and Makena. The Central Maui Soil and Water Conservation District (CMSWCD) intends to serve the community through public outreach to educate stakeholders about the efforts underway to protect coastal reef environments and reduce sediment loads in the watershed. These goals will be met by performing the following management recommendations described below:

2.1 Watershed Coordinator

A permanent watershed coordinator position is needed to oversee implementation projects. In addition, this individual will act as the liaison between the Environmental Protection Agency, Hawaii Department of Health, Clean Water Branch, the CMSWCD, Maui County, land owners, and other stakeholders in the community.

2.2 Reduce Existing Sediment Load

Identify and implement various land management efforts to reduce sediment load within the watershed. The reduction of sediment in the watershed will also address other water quality concerns including nutrient loading and pathogen transmission. In addition, implementation projects that are designed to slow water before it reaches the coastline will allow time for aquifer recharge and can augment surface waters in wetlands that are presently dry most of the year due to historic land use changes.

2.3 Manage Rural Lands

DSILT (Detained Stormwater Infiltration using Low Technology)

These are projects to control pollutant delivery to the ocean by detaining stormwater, trapping sediment, and facilitating infiltration (includes sediment, nutrients, debris, and pathogens). DSILT endeavors include projects such as riparian buffers, terracing, and off-line peak flow diversion/storage. In addition, well established Best Management Practices (BMPs) including fencing, elevated cattle crossings at gulches and gullies, grade and slope stabilization with vegetation and geotextiles, HIZMS, vegetated riparian buffers, unpaved road stabilization and other methods should be employed.

2.4 Aquifer Recharge

Due to the flashy nature of the gulches in the Southwest Maui Watershed, surface water flows mauka to makai and ultimately discharges into coastal waters with little time for aquifer recharge. Historically, freshwater wetlands occurring near the coast of Kihei would have slowed this water, functioning as both a filter and as a means for aquifer recharge. Unfortunately, today many of the wetlands in Kihei have been impacted by urban development. Detention Basins in Series have been proposed to function in much the same way as historic wetlands, by slowing water before it reaches highly populated areas along the coastline. These detention basins would assist in flood prevention by retaining water upstream. These detention basins will also allow flowing water to rest, so that sediment can drop out of suspension. Lastly, because of the porous nature of soils within the watershed, these detention basins will act as aquifer recharge locations.

2.5 Wetland Restoration

Existing wetlands along the coast of Kihei Wailea and Makena should be delineated, protected and restored wherever possible. Like the detention basins discussed above, wetlands have the ability to filter stormwater for sediment, nutrients and pathogens. They are habitat for native flora and fauna. They serve as flood prevention and aquifer recharge locations. Lastly, wetlands represent greenspace within urban communities and improve the community's relationship with the natural environment.

2.6 Riparian Buffers

Riparian buffers along gulches and gullies prevent sediment laden sheet flow from entering gulches and gullies. They also offer important habitat for native flora and fauna. Operation TAKO POKE, a 319(h), R-1 irrigated riparian buffer project completed in 2005 on Keokea Gulch shows the viability and effectiveness of riparian buffer projects.

2.7 Promote and Manage Stormwater Runoff Programs for Existing Development

The development of urban areas within Kihei, Wailea and Makena have resulted in impervious structures throughout the coastal areas of the watershed. Many of the existing wetlands have been filled in and paved over to make room for this development. Stormwater is unable to filter through the soil and instead, flows over these impervious surfaces directly into the ocean, transporting sediment, oil and hazardous waste, nutrients and pathogens directly into the ocean. Programs that promote and support the use of urban stormwater best management practices including but not limited to the use of porous pavement, grassed swales, rain gardens, retention/infiltration basins, street cleaning, above ground tank spill control, and illegal dumping controls should be implemented.

2.8 Implement Community Outreach and Education

As implementation projects are undertaken, the watershed coordinator will disseminate information to the community on the progress being made. In addition, input from stakeholders and the community at large will be directed back to the CMSWCD so that issues and concerns can be addressed. Information on stormwater programs, best management practices and the state of water quality in the watershed will also be made available to the community.

2.9 Work with Maui County to meet Goals of the Kihei Drainage Master Plan

Maui County released the Pre-Final Report for the Kihei Drainage Master Plan in November of 2016. This plan addresses drainage and future development in Kihei, from Waiakoa Gulch to Kilohana Drive. Many of the proposed actions in this plan are consistent with implementation projects proposed by the Southwest Maui Watershed Plan. For example, several detention basins are proposed in the County plan that lend themselves well to the efforts and goals described in this document.

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3.0 STRUCTURAL IMPLEMENTATION PROJECTS

The implementation projects proposed in this Plan have been divided into two categories; structural and non-structural. These designations are based on whether or not the project requires changes to existing infrastructure. Structural practices proposed in this section include but are not limited to excavated detention basins in series, riparian buffers, terracing, stream diversions, elevated cattle crossings at gulches and gullies, grade and slope stabilization with vegetation and/or geotextiles, fenced and/or vegetated riparian buffers, unpaved road stabilization, installation of porous pavement, grassed swales and wetland restorations. Below we discuss several structural practices that have been deemed the most appropriate for implementation in the near future. Other structural practices mentioned above may also be implemented in the future as needs and resources dictate.

3.1 Excavated Basins / Excavated Basins in Series

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

Suitable locations for the installation of these facilities can be found in the watershed gulch systems, in locations based on the following:

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

Figure 7. Excavated Detention Basins in Series

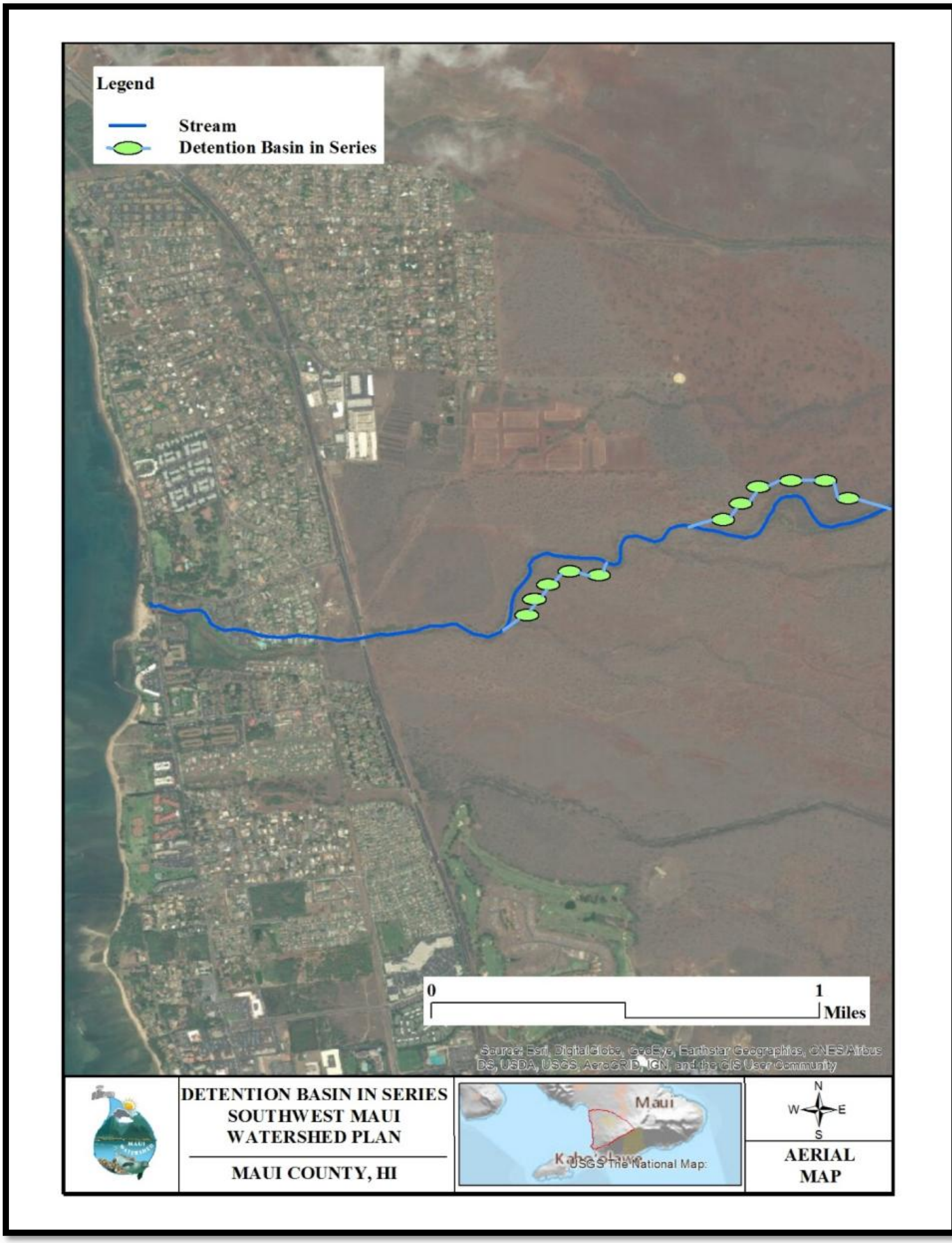


Figure 8. Examples of Shallow, Flatter Sections of Gulches Suitable for Detention Basins in Series

3.2 Stream Diversions to Contoured Terrace Ditches

Contoured terrace ditches will be used to capture, store, and divert water from gulches to detention basins. Diversion of sediment laden water during peak flow into these ditches and ultimately into detention basins in series provides multiple functions. The infiltrated water would sub-irrigate grass for cattle feed, recharge aquifers, and water left in the ponds would be used by livestock and wildlife. The terrace ditches would run perpendicular to the slope and capture overland flow runoff.

Figure 9. Examples of Stream Diversions

On any given gulch, several of these intake/drain field systems, capturing stormwater runoff after a big rain event, could remove a significant portion of the sediment load and return cleaner water to the stream. There would be several advantages to this approach, including increased productivity in the pasturelands, aquifer recharge, flood mitigation, water quality improvements, and therefore, less impact to the shoreline and reef.

The cost advantage of using this method, rather than large detention basins lower in the landscape, and the relative ease of installation make this approach more feasible. According to Unemori Engineering the general cost of constructing a large detention basin is approximately $20 per cubic foot. This would mean that a 50-acre-foot basin, like the Pi'ilani Mauka detention basin discussed later in this document, cost approximately $1.6 million to install. The comparable price of smaller excavated basins would be considerably less. Costs would depend on terrain, accessibility, and geologic conditions, among other things.

The following chart lists the major permits, some of which may be required for the implementation of this recommended management measure.

Table 4. Potential Permits needed for Excavated Basins in Series and Stream Diversions

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
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 Hawaii 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

Permit Name	Issuer	Trigger	Application Requirements	Project Improvements
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 f 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 Hawaii Department of Health	New stream intakes, road and pipeline crossings of streams and wetlands
Clean Water Act Section 401 Water Quality Certification	Clean Water Branch, State of Hawaii, 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 Hawaii Water Quality Standards compliance plan	Applies to locations requiring Department of Army Permit
Conservation District Use Application (CDUA)	State of Hawaii, Department of Land and Natural Resources	Any development actions in Conservation Districts as designated by the State Land Use Commission	Application will require a Hawaii Chapter 343 EA/EIS	Pipeline or reservoir installation in the Conservation District
National Pollution Discharge Elimination System (NPDES) Permit	Clean Water Branch, State of Hawaii, Department of Health	Required for construction site runoff management when construction area exceeds one acre and if the operation of the improvement results in discharge into water bodies	Application will require sediment and runoff management designs and a water quality monitoring plan	Applies to all construction sites with potential of erosion and runoff
Use and Occupancy Permit/Construction within a State Highway Permit	Division of Highways, State of Hawaii, 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

3.3 High Impact Zone Mitigation Sites

Intensive land use activities that reduce the vegetative cover and loosen soil can produce conditions promoting erosion. These sites are called high impact zones. Figure 9 is an example of a high impact zone on grazing lands, where a single water trough serves hundreds of acres of dry pastureland. High impact zones, related to activities such as construction, agriculture, ranching, and forestry, could benefit from a suite of management measures designed to protect water quality. They will collectively be termed High Impact Zone Mitigation Sites (HIZMS). The interception of sediment laden runoff and other pollutants caused by high impact zones is the primary objective of HIZMS.

County ordinances control the impact of construction through grading and grubbing permits and agricultural activities through conservation plans developed by the SWCDs and NRCS. For instance, the County requires silt fences to catch eroding sediments from construction sites; conservation plans require the control of runoff through vegetative methods, diversions, and sediment basins. Unfortunately, many high impact zones in the watershed exist without mitigation measures.

Mitigating practices that can be adopted to capture sediment from stormwater runoff in HIZMS include but are not limited to vegetated buffers, fabric roll runoff interceptors, berms and terraces, small detention basins, and fenced riparian corridors. These relatively low-cost mitigation measures have the potential to reduce impacts to water quality from these high intensity land uses.

Figure 10 depicts some of the mitigation measures that can be implemented as part of a HIZMS. A vegetated buffer is placed downslope of the impacted area. To prevent cattle and wildlife from grazing on the vegetation, an exclusionary fence will surround the vegetation. In addition, seeded fabric rolls can be used to further slow sheet flow. The fabric rolls can be seeded with a combination of native shrubs and grasses to enhance native habitat and create a living filter. A small berm can be used to detain water flowing down slope towards gullies and gulches and keep sediment laden water within the vegetated buffer. Sediment buildup can be monitored to demonstrate the effectiveness of this technique. It has proven successful in other similar locations (see Kohala Watershed Partnership's Pelekane Bay Watershed Restoration Project-Final Report, May 31, 2011).

Cost estimates for the various mitigation measures discussed are presented below.

- Fencing - 6' game fencing costs are estimated between $12 -$18 per foot, including materials and installation, depending on access, terrain, soil conditions, etc.
- Fabric rolls - 9' by 50' rolls are approximately $150 each, including wooden stakes, seed, and installation.
- Irrigation – systems would depend on the size and extent of the buffer and are estimated to be between $200 and $500, installed.
- Plantings - vetiver - $10 to $15 per foot with irrigation installed

- Native grasses and shrubs –These are available locally and cost will vary depending on whether seed is dispersed or nursery-grown plants are used. A sample of a portion of a local native nursery plant price list follows. Costs will depend on plant selection and quantity. General prices for nursery grown plants range from dibbles @ $4, 1 gal. @ $12-$18, 5 gal. @ $45-$85, 7 gal. @ $125, 15 gal. @ $50-$225, and 20 gal. tubs with larger trees for $200 or more.

Figure 10. Watering Trough Depicting Intensive Land Use Promoting Erosion

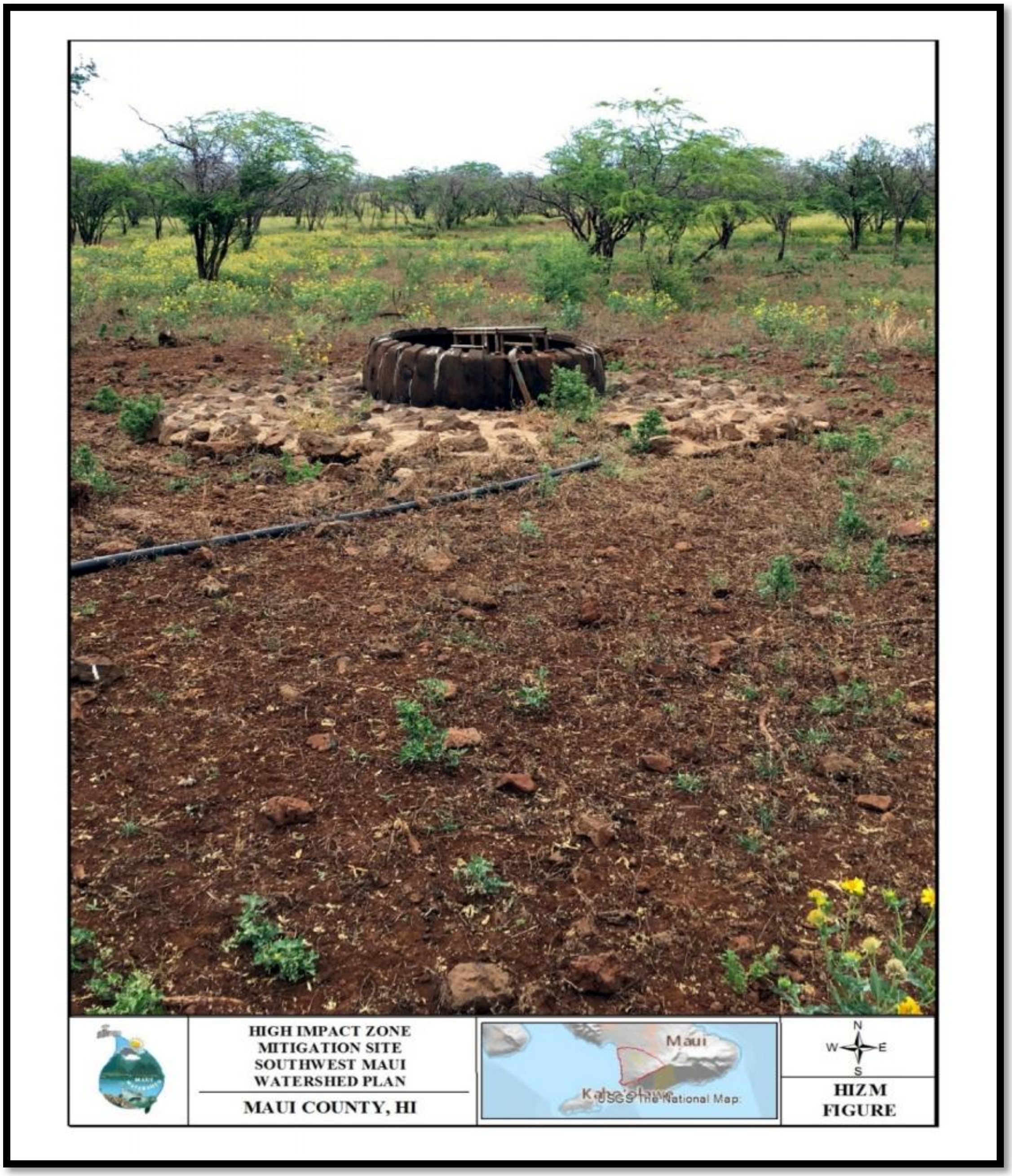
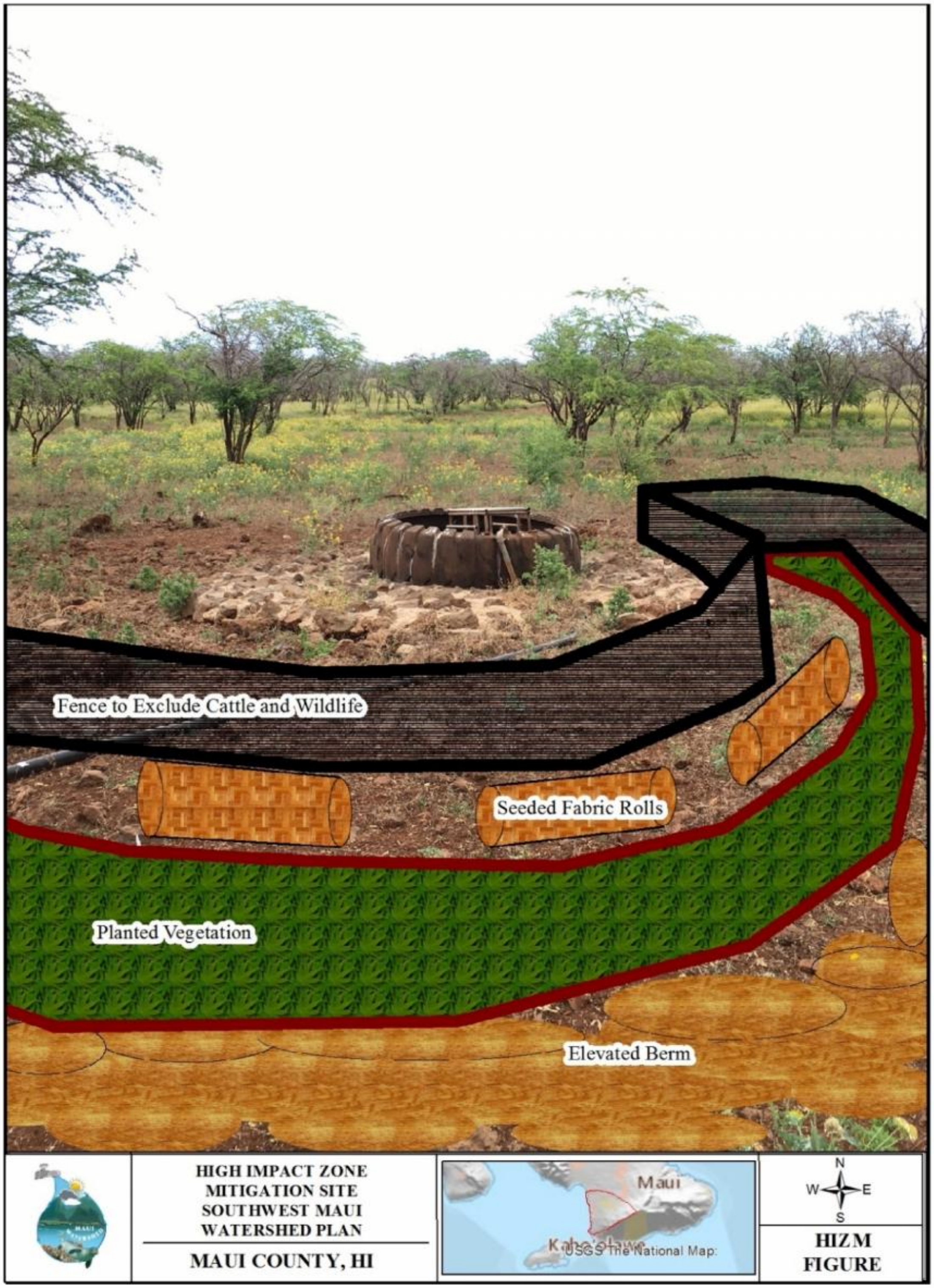


Figure 11. High Impact Mitigation Site Depicting Various Mitigation Measures



3.4 Riparian Protection and Rehabilitation

All of the gulches in the Southwest Maui Watershed project area can benefit from protection and rehabilitation management measures. Various site-specific measures can be utilized depending on the resources available. A general description of riparian protection and rehabilitation follows.

Unfenced riparian zones are grazed by livestock and provide hidden trails used by deer and other feral ungulates. As a result, vegetation is grazed and trampled and soil is loosened; this contributes to unstable stream banks and causes erosion and sediment laden stormwater during runoff events. Fencing is the primary means of protection, preventing access by hoofed animals. The effectiveness of the removal of sediments and nutrients from stormwater runoff increases with buffer width (see Riparian Buffer Width, Vegetative Cover, and Nitrogen Removal Effectiveness, EPA/600/R-05/118, October 2005). Access crossings through the gulches are incorporated into the fence design, and stream curtains are installed to prevent animals from entering the buffers while crossing. These curtains allow stormwater to pass under without destroying the fence.

A fenced, re-vegetated corridor will also provide a sediment filter for the sheet flow from adjacent lands, as demonstrated by Operation TAKO POKE, a 319(h), R-1 irrigated riparian buffer project completed in 2005 on Keokea Gulch (Figure 11). Even un-irrigated buffers will revegetate after fencing, given time. Options include allowing existing vegetation to reestablish itself, or actively seeding and out planting native grasses, shrubs, and trees to further enhance native habitat (see list of native species).

Fabric rolls impregnated with native seeds can be utilized to both intercept sediment and provide a living filter. They can be staked as check dams in the stream flow and serve as streambank stabilizers. The cost for a 9-foot wide, 50-foot long roll is approximately $150 installed.

The expense of fencing prevents landowners from committing riparian areas for protection and rehabilitation. It is therefore recommended that riparian fencing be one of the major funded implementation strategies in the watershed and that it be provided to any willing landowner. An example of per foot material costs for a typical fence can be found in the following table from the Pelekane Bay Watershed Restoration Project, Final Report, May 31, 2011. It should be noted that the fence was designed to keep goats and cattle out.

On Maui, in the last 10 years, the deer population has increased dramatically, and higher fences will be required to protect riparian buffers. Recent installed fencing costs, on Maui, for 6-foot game fencing, range from $12 to $14 per foot in the open and accessible grazing lands, to $18 per foot in inaccessible, remote upland areas at 6,000 to 8,000-foot elevation. Table 6 breaks down the materials cost of fencing riparian zones per foot.

Riparian fencing higher up in the landscape can prevent the need for bigger, more expensive solutions downslope by reducing sediment laden sheet flow from reaching gullies and gulches. However, riparian buffer fencing in the lower elevations is also important to prevent sediment from entering the stream corridors where there is more surface area and higher potential for erosion between waterways.

Figure 12. TACO POKE Riparian Buffer with Exclusionary Fence in 2005

Table 5. List of Native Plants Potentially Used to Restore Riparian Buffers

Hawaiian Name	Scientific Name	Core Plant?	Notes
ʻAʻaliʻi	*Dodonaea viscosa*	Y	Easy to collect, germinate and grow.
ʻĀkia	*Wikstroemia pulcherrima*	Y	Variable fruit output. Few fruit in 2010.
Alaheʻe	*Psydrax odorata*	N	Very slow to germinate. No longer common on Kohala.
ʻĀlaʻa	*Pouteria sandwicensis*	N	No longer common on Kohala.
ʻĀweoweo	*Chenopodium oahuense*	Y	Abundant seed, fast growing and hardy.
ʻĀwikiwiki	*Canavalia hawaiiensis*	N	Low success rate from cuttings.
Hala pepe	*Pleomele hawaiiensis*	N	* Endangered - passed on seed to STN.
Hōʻawa	*Pittosporum hosmeri*	Y	Easy to grow.
Huehue	*Cocculus orbiculatus*	N	Low success from cuttings. No fruit.
ʻIliahi	*Santalum ellipticum x. Santalum paniculatum*	Y	Common tree on our watershed; abundant flowers and fruit. Slow to germinate.
ʻIlima	*Sida fallax*	Y	Variable forms; abundant seeds.
Koiaʻa	*Acacia koaia*	Y	Low seed production in 2010.
Koali ʻawa	*Ipomea indica*	Y	Easy to grow from cuttings and seed.
Kuluʻī	*Nototrichium sandwincense*	Y	Abundant seed; easy to grow.
Lama	*Diospyros sandwicensis*	N	Very slow growing.

Table 5. Continued

Māmaki	*Pipturus albidus*	N	Field conditions too dry for this species.
Māmane	*Sophora crysophylla*	Y	Abundant seed available, esp. Mauna Kea.
Ma'o hau hele	*Hibiscus brachenridgei*	N	*Endangered - passed on seed to STN.
Naio	*Myoporum sandwicense*	N	Culled plants due to naio thrips infestation.
Olopua	*Nestigis sandwicensis*	N	Slow to germinate and grow.
Pā'ū o Hi'iaka	*Jacquemontia ovalifolia*	N	Easy to grow from cuttings.
Pili	*Heteropogon contortus*	Y	Common in lower watershed.
Pilo	*Coprosma spp.*	N	Field conditions too dry for outplanting.
Pōhinahina	*Vitex rotundifolia*	Y	Easy to grow from cuttings.
Pāpala kepau	*Pisonia sandwicensis*	N	Very hard to soak and grow sticky seeds.
Pua kala	*Argemone glauca*	Y	Easy to grow. Used seeds for direct sow.
'Ūlei	*Osteomeles anthyllidifolia*	Y	Powdery mildew reduced viability.
Wiliwili	*Erythrina sandwicensis*	Y	Abundant seed. Easy to grow.

Table 6. Materials Cost Estimate Per Foot for Riparian Buffer Fencing

Material	Details	Cost per Foot
7 ft. steel "T" posts	Pounded by hand; placed maximum 8 feet between posts. Holes drilled first when placed in rock.	$1.87
48 in. bezinal-coated woven wire	Stretched tight between posts; bottom edge no more than 2 inches above the ground.	0.91
Short steel posts	Used as "anchors" to pin down wire between posts	0.36
Bezinal-coated barbed wire	Three strands equally spaced above the woven wire.	0.48
24 in. woven wire	Added as additional "skirting" at bottom of fence when 48 in. wire is more than 2 inches above ground.	0.31
Galvanized steel pipe and fittings	Used to construct corner posts, braces, and gate posts.	0.31
Stainless steel fence hardware	Fence clips, smooth wire, etc.	0.24
Welded corral panels	Used at stream crossings & to make gates animal-proof	0.23
Rubber stall mats	Suspended from wire over streams.	0.15
	Total Fencing Materials Cost Per Foot	**$4.86**

3.5 Unpaved Roads

Many of the unpaved roads in the Southwest Maui Watershed are on slopes and much of the landscape is dry, most of the time. Occasional storms lead to runoff, which moves sediments down roads. This situation is common in many places in this and other watersheds.

In his manual entitled "Water Harvesting from Low Standard Rural Roads" (April 2006), Bill Zeedyk states that "Roads alter water movement across the landscape, which can concentrate and accelerate flow and cause soil erosion and gully formation". While this can be a problem for water quality because of sediments and other pollutants, it can also be an opportunity. In an area that has very low average rainfall (10 to 20 inches/year in the lower elevations), stormwater from these roads could be harvested to the benefit of the surrounding land.

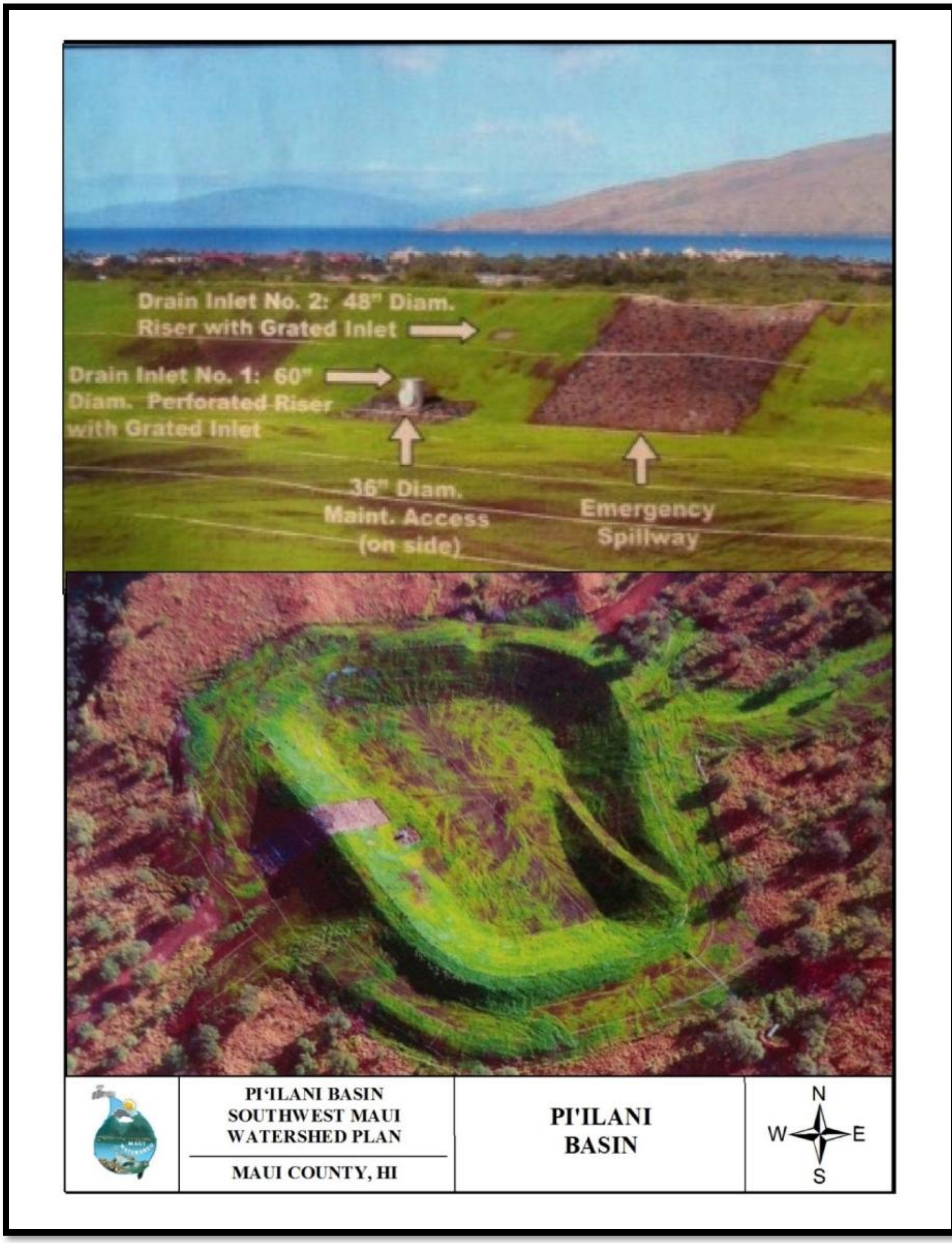
Existing unpaved roads on ranch properties mauka of Pi'ilani Highway should be stabilized to prevent washouts and erosion. Check dams and water bars can be utilized to slow the flow of water moving along unpaved roads. Vegetated swales can also be placed parallel with roads to contain water.

3.6 Pi'ilani Basin Utilization Strategy

The Pi'ilani Mauka Detention Basin No.1, located mauka of Maui Nui Golf Course in central Kihei, intercepts and captures a portion of the offsite surface runoff from a tributary to Waipu'ilani Gulch. The spillway from this detention basin continues downstream to and enters Waipu'ilani Gulch just east of Pi'ilani Highway. The detention basin is approximately 50 acre-ft. in size occupying approximately 5 acres. Overflow drains associated with this detention basin consist of 48" and 60" diameter grated drain inlet risers. The captured stormwater begins to exit the basin through 60" drain inlet no. 1, when it reaches a depth of approximately 8 feet. All water below that level remains in the basin and infiltrates down into the aquifer. Sediment remains in the basin to be cleaned out as needed.

This huge unlined detention basin has the potential to capture much more sediment laden stormwater within the Waipu'ilani drainage basin than is currently being detained. If engineering studies would accommodate it, a portion of the flow from Waipu'ilani could be diverted through this basin to allow stormwater sediments to be settled out before continuing downstream. The design would place the stormwater intake at approximately 200 ft. elevation in Waipu'ilani Gulch, and channel the water into the basin, which is located 150 to 200 ft. to the south of the gulch. Using this method, some of the sediment being carried by the stormwater could fall out of suspension before the water returns to the gulch and the eight feet of water remaining in the basin would infiltrate into the aquifer. This would change the nature of the floodwaters in Kihei by reducing their volume and sediment load. An engineering study is recommended to determine the feasibility of this project.

Figure 13. Pi'ilani Basin



3.7 Expansion of R-1 Reuse Area

Most of the wastewater from the Kihei urban area is collected and treated at the Kihei Wastewater Reclamation Facility (WWTF). Presently, the Kihei WWTF reclaims roughly 40 to 50 percent of the wastewater it treats. This amounts to approximately 1.6 to two million gallons per day (mgd). The remaining treated effluent is discharged through injection wells where it percolates into the ground. At present, the reclaimed water, also known as treated R-1 recycled water, is being reused for irrigation purposes by golf course, park, residential, commercial, and agricultural entities. Figures 13 and 14 below depict the current and proposed reclaimed water systems. These figures were provided by Maui County.

Figure 14. Current Reclaimed Water Infrastructure

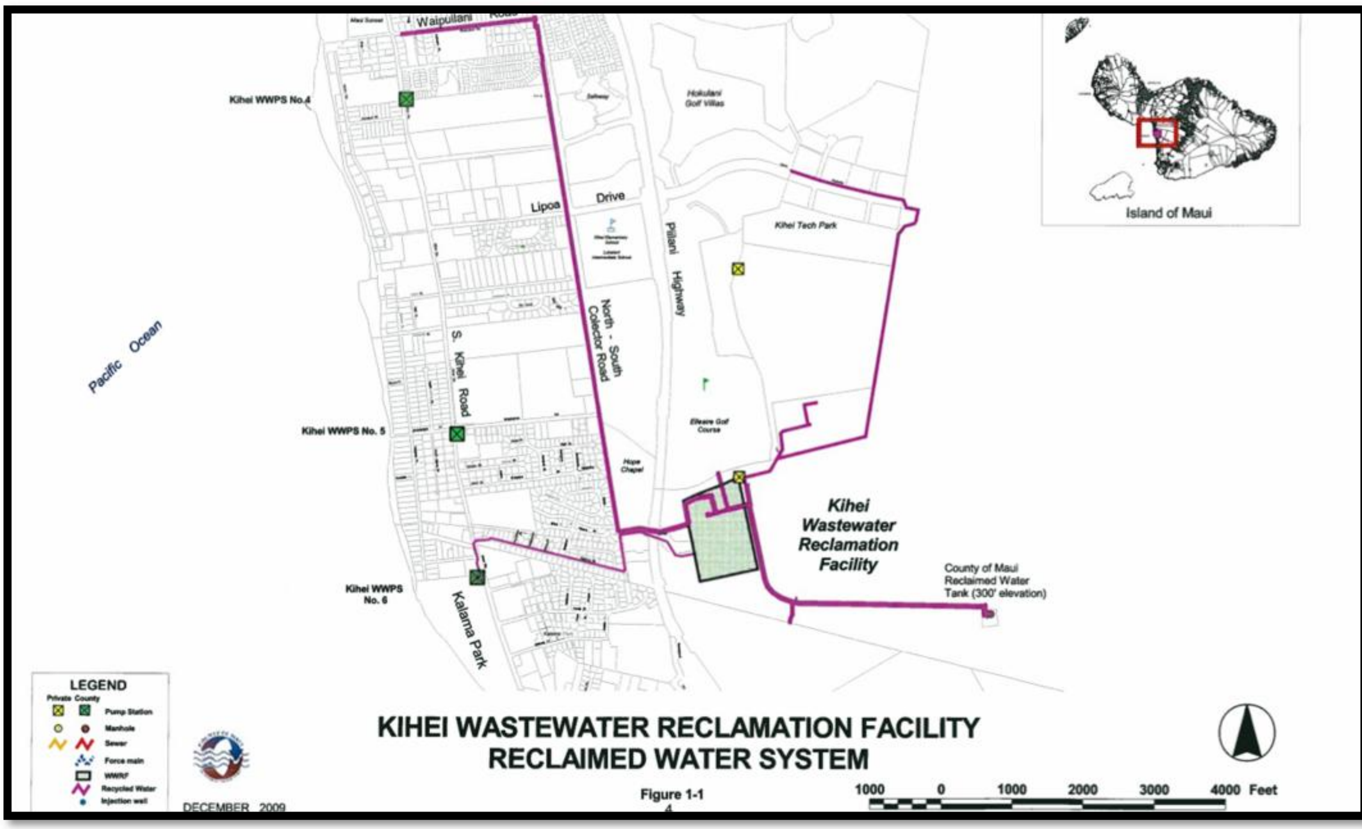


Figure 15. Proposed Reclaimed Water Infrastructure

Currently, this proposed increase in the reclaimed water distribution system is beyond the County's ability to fund. It is considered a priority by this Watershed Plan that funding be made available for R-1 reuse expansion, so that this valuable resource can be utilized and not injected and wasted. A multi-agency financial support mechanism is recommended in order to accomplish this goal.

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4.0 NON-STRUCTURAL PRACTICES

Non-structural practices proposed in this section include but are not limited to the creation of a full-time watershed coordinator position, grazing management on rural lands, community outreach and education programs, rain gardens, street cleaning services, above ground tank spill control, and illegal dumping controls. Below we discuss several non-structural practices that have been deemed the most appropriate for implementation in the near future. Other non-structural practices mentioned above may also be implemented in the future.

4.1 Watershed Coordinator

A permanent watershed coordinator position will be created to oversee implementation projects. In addition, this individual will act as the liaison between the Environmental Protection Agency, Hawaii Department of Health, Clean Water Branch, the CMSWCD, Maui County, land owners, and other stakeholders in the community. This individual will also implement an ongoing water quality monitoring program and database.

As implementation projects are undertaken, the watershed coordinator will disseminate information to the community on the progress being made. In addition, input from stakeholders and the community at large will be directed back to the CMSWCD so that issues and concerns can be addressed. Information on stormwater programs, best management practices and the state of water quality in the watershed will also be made available to the community.

4.2 Water Quality Monitoring

Due to the ephemeral, flashy nature of the gulches and gullies in the Southwest Maui Watershed, it is important to sample these systems during heavy rain events when the streams are flowing. Baseline water quality monitoring will be conducted in several key locations throughout the watershed:

- higher elevations in the watershed, where stormwater first begins to collect in gullies and gulches
- Upstream and downstream of suspected high erosion potential locations within the watershed where implementation projects will be implemented
- At locations along Pi‘ilani Highway where land use changes from rural to urban
- At locations where gulches discharge into coastal waters

In addition, water quality monitoring will be used to gauge the effectiveness of implementation projects by sampling upstream and downstream of these projects and comparing these data with baseline data collected prior to implementation.

4.3 Grazing Management Measures

More than half of the lands in the Southwest Maui Watershed are grazed by a combination of domestic and feral animals, including cattle, deer, pigs, goats, sheep, and elk. Much of the grazing acreage is rough and prone to drought, and grazing management is necessary in order to maintain the health of the watershed. While some of the ranchers have adopted managed grazing practices, much of the acreage could benefit from improved management.

4.4 Education and Outreach

The Southwest Maui Watershed Plan has identified education and outreach opportunities for both residential and business stakeholders in the community. Issues relating to flooding and erosion from stormwater, nutrient runoff, oil and hazardous materials, and wastewater reclamation should all be addressed.

- Hotels with major landscaping operations and golf courses should be educated on the use of fertilizers.
- The Watershed Coordinator should attend Kihei Community Association Meetings to disseminate information about the Southwest Maui Watershed
- Business handling and storing oils and hazardous materials should be identified. These businesses should be engaged with the Southwest Maui Watershed Plan personnel to ensure they are incorporating best management practices related to their industries. Examples of these businesses include auto mechanics, oil changing facilities, and industrial facilities.
- Pamphlets will be made available to the public on the use of rain barrels, landscaping for stormproof yards, porous pavement, etc.

4.5 Illegal Dumping Controls

Illegal dumping occurs throughout the natural areas within the urban portion of Southwest Maui. Of particular concern is the dumping of yard debris and waste into wetlands, gullies and gulches within the watershed. Wetlands provide habitat for important wildlife species. This habitat is severely degraded by the addition of pollutants from outside sources. Gullies and gulches that become clogged with debris are prone to clogging and can eventually flood. Decaying natural material such as lawn clippings and landscaping debris decay and can cause nutrient loading within the watershed.

Wetlands and other natural areas where illegal dumping is taking place should be identified. These areas should be cleaned up and preventative measures should be installed (signs, bollards, etc.) to ensure future dumping does not occur. Community outreach programs can accompany this effort to ensure stakeholders are informed about and empowered to act against illegal dumping.

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5.0 IMPLEMENTATION STRATEGY

This section outlines the preliminary implementation strategy for the Southwest Maui Watershed Plan. This implementation strategy focuses on those projects that are most needed to address sediment laden stormwater runoff in the watershed. This watershed plan is designed to be an organic document, meant to adapt to changes in the community, fiscal support, partner participation, and in the physical landscape. While complete implementation of these watershed improvement projects would take many years to decades to complete, we have compiled a list of projects that can be achieved in one to five years. As stated earlier in this document, the following projects have been given priority because they have been identified as being the most feasible based on their location, ownership, cost to complete, potential for success, and general “shovel-readiness”.

5.1 Existing Efforts

5.1.1 ***Watershed Coordinator***

The CMSWCD was able to secure a small grant through the Maui County Office of Economic Development to establish a watershed coordinator. This position is needed to ensure the Southwest Maui Watershed Plan initially developed in 2013 is elevated to priority status by the EPA and the Hawaii DOH CWB so that SMWP may become eligible for Federal 319 Grant Program funding. The DOH CWB has given the CMSWCD four specific points to address in order to elevate the Southwest Maui Watershed Plan's status. These four points include:

- Submit load reduction estimates for each implementation project listed in the watershed plan.
- Develop a robust monitoring and assessment plan to capture the effects of the watershed plan implementation projects.
- Create maps showing the specific locations where water quality measurements will be taken.
- Develop a project timeline with milestones for determining project progression.

5.1.2 ***Baseline Water Quality Monitoring***

CMSWCD has begun collecting baseline water quality data through an established water quality monitoring program (Appendix A). Baseline water quality monitoring is conducted in several key locations throughout the watershed during period of heavy rainfall when the gulches contain enough flow to discharge into coastal waters. Samples are collected at higher elevations in the watershed, where stormwater first begins to collect in gullies and gulches, upstream and downstream of suspected high erosion potential locations within the watershed where implementation projects will be implemented, at locations along Pi‘ilani Highway where land use changes from rural to urban, and at locations where gulches discharge into coastal waters. Baseline water quality monitoring will be used to gauge the effectiveness of implementation projects by sampling upstream and downstream of these projects and comparing these data with baseline data collected prior to implementation (Figures 3-6 and Appendix A).

5.1.3 ***Estimating Load Reductions from Proposed Implementation Projects***

Load reduction estimates were calculated using The United States Department of Agriculture Revised Universal Soil Loss Equation 2 (RUSLE2). Areas within the watershed where implementation projects have been proposed were analyzed for erosion potential using RUSLE2. The four main factors affecting erosion are soil, climate, topography and land use. For each implementation project location, these factors were entered into the RUSLE2 database to calculate the erosion potential in tons per acre per year.

Sediment loss was estimated to be 25 tons per acre per year using the RUSLE2 equation for the areas where the initial implementation projects are being proposed. These implementation projects were identified as being the most feasible based on their location, ownership, cost, potential for success and general “shovel-readiness”. Initial implementation projects include vegetated swales placed down slope of two cattle watering troughs, two excavated detention basins down slope from agricultural fields, and the protection and rehabilitation of a riparian corridor along Keokea gulch. They are located mauka of Pi’ilani Highway as depicted in Figures 3-6.

In addition, baseline sediment loads were recorded during heavy rain events upstream and downstream of these proposed implementation projects using the flow meter and TSS grab sample method mentioned above. Once these initial implementation projects have been completed, flow measurements and TSS samples will be taken upstream and downstream to determine the effectiveness of these projects in limiting erosion and removing sediment from the watershed. These measurements will be compared with the estimated load reduction values derived from utilizing the RUSLE2 methodology. (Figures 3-6 and Appendix A).

5.2 Proposed Implementation Projects

5.2.1 ***High Impact Zone Mitigation Sites***

Two HIZM sites have been identified as “shovel ready” due to landowner participation, cost effectiveness and overall need. The locations of these sites are identified in Figures 3 and 4. Both of these sites have high erosion potential due to cattle congregating in high numbers at water troughs. Currently, the land surrounding these troughs are sparsely covered or completely devoid of groundcover vegetation as depicted in Figure 9.

The proposed implementations projects associated with these two areas are the same in design approach. A swale will be excavated downhill from the impacted areas. A low berm will act as a backstop below the swale to assist in the capture of surface water as it moves towards existing gulches and gullies. For HIZMS 1, sediment laden stormwater will be captured and excluded from discharging into Waipu’ilani Gulch. For HIZMS 2, stormwater will be captured before it enters Keokea Gulch. Vegetation will be planted in the swales to slow water and capture sediment. An exclusionary fence will be erected around these areas to ensure that grazing cattle and wildlife do not negatively influence planted vegetation. Being water troughs for cattle operations, these two HIZM sites have existing infrastructure in place to access water for plant irrigation.

It is believed that the total acreage downstream between the water troughs and the gulches multiplied by the RUSLE2 coefficient calculated for this region represents the estimated load reduction value as described above. Table 3 referenced earlier in this document depicts the sediment load reduction estimates for the high impact zone mitigation sites. The values are approximately 1170 tons of sediment per year for HIZMS 1 and approximately 695 tons of sediment per year for HIZMS 2.

The water quality monitoring plan (Appendix A) was developed to evaluate the progress of these HIZM projects. Water Quality sampling for TSS will be collected upstream and downstream of these projects in an attempt to show their ability to capture sediment. In addition, staff gauges or similar measuring devices will be placed in the center of the swales to measure sediment deposition. The depth and area of this deposition will further show the effectiveness of the implementation project.

5.2.2 ***Excavated Basins***

Two excavated basins have been proposed down slope of an agricultural field mauka of Piʻilani Highway as depicted in Figure 5. Sediment laden stormwater flowing off these fields currently has the potential to flow into Keokea Gulch. These basins will capture and slow stormwater, offering sediment an opportunity to fall out of suspension. In addition, water captured will have the opportunity to permeate through the ground and into the aquifer. These excavated basins can be planted with vegetation to further slow water and capture sediment as necessary.

It is believed that the total acreage of the agricultural activity uphill from these basins multiplied by the RUSLE2 coefficient calculated for this region represents the estimated load reduction value as described earlier in this document. Table 3 referenced earlier depicts the sediment load reduction estimates for these two excavated basins to be approximately 953 tons of sediment per year.

Water quality monitoring stations have been established upstream and downstream of the proposed excavated basins. These stations were created as part of the water quality monitoring plan (Appendix A) meant to evaluate the effectiveness of excavated basins in reducing sediment load from Keokea Gulch. In addition, staff gauges or similar measuring devices will be placed at the center of these basins to measure any sediment deposition that occurs.

5.2.3 ***Riparian Protection and Rehabilitation***

A fenced, re-vegetated corridor has been proposed to provide a sediment filter for the sheet flow from adjacent lands, as demonstrated by Operation TAKO POKE, a 319(h), R-1 irrigated riparian buffer project completed in 2005 on Keokea Gulch (Figure 11). The TAKO POKE infrastructure is still largely in place. Currently, fencing consists of barbed wire but could easily be upgraded to an ungulate exclusion fence. In addition, sprinklers, pumps and piping from the original project remain available to distribute R-1 water for the seeding and out planting of native grasses, shrubs, and trees to further enhance native habitat. Figure 6 depicts the extent of riparian corridor to be protected and rehabilitated.

It is believed that the total acreage of the agricultural activity uphill from this riparian corridor multiplied by the RUSLE2 coefficient calculated for this region represents the estimated load reduction value as described earlier in this document. Table 3 referenced earlier depicts the sediment load reduction estimates for this implementation project to be approximately 1986 tons of sediment per year.

Water quality monitoring stations have been established upstream and downstream of the proposed riparian buffer protection and rehabilitation site. These stations were created as part of the water quality monitoring plan (Appendix A) meant to evaluate the effectiveness of this project in reducing sediment load from Keokea Gulch.

*5.2.4 **Priority Status and Timelines***

Table 7 below depicts the various implementation projects proposed in the SMWP. The locations, basic descriptions, approximate timelines to completion, and priority status of each implementation project are given.

Table 7. Implementation Project Priority Status and Approximate Timeline

Implementation Project	Location (Gulch)	Description	Approximate Timeline to Completion	Priority
Excavated Basins/Basins in Series	Kulanihakoi, Waipuilani, and Keokea	Basins capturing sheet flow prior to stormwater entering gulches would have precedent over basins connecting directly to gulches	6 Months - 4 Years	High
Contoured Terrace Ditches	Kulanihakoi, Waipuilani, and Keokea	Water bars and drainways leading to detention basins	1 Year	Low
High Impact Zone Mitigation Sites	Waipuiani	Swales and berms downslope from watering troughs	6 Months	High
Riparian Protection and Rehabilitation	Keokea	Area surrounding Keokea gulch already has fencing and water to assist in riparian rehabilitation/protection	6 Months	High
Unpaved Roads	Throughout Watershed	Stabilization of roads to prevent erosion	1-4 Years	Medium

Implementation Project	Location (Gulch)	Description	Approximate Timeline to Completion	Priority
Pi'ilani Basin Utilization Strategy	Waipuiani	Utilize Piʻilani basin to capture water from Waipuilani gulch	Unknown	Low
Expansion of R-1 Reuse Area	Kulanihakoi, Waipuilani, and Keokea	Use of R-1 to augment existing wetlands and gulches	Ongoing	Medium
Watershed Coordinator	Throughout Watershed	Watershed representative	Ongoing	High
Water Quality Monitoring	Throughout Watershed	Captures current and future water quality data	Ongoing	High
Grazing Management Measures	Throughout Watershed	Ensures rural lands are being managed to account for erosion	Ongoing	Low
Education and Outreach	Throughout Watershed	Conduct by Watershed Coordinator, ensures informed community participation	Ongoing	High
Illegal Dumping Controls	Throughout Watershed	Public outreach to educate about pollutants and the environment	6 Months	Low

APPENDIX A.

SOUTHWEST MAUI WATERSHED
MANAGEMENT PLAN

WATER QUALITY MONITORING METHODOLOGY

SOUTHWEST MAUI WATERSHED MANAGEMENT PLAN

WATER QUALITY MONITORING METHODOLOGY

Prepared for:

HAWAII DEPARTMENT OF HEALTH

CLEAN WATER BRANCH AND

THE U.S. ENVIRONMENTAL PROTECTION AGENCY

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1.0 INTRODUCTION AND PURPOSE

The Southwest Maui Watershed Plan (SMWP) was developed to include the 49,688-acre planning area designated by the State of Hawaii as the Hapapa, Wailea, and Mo‘oloa watersheds (Figure 1). The planning area extends from near the summit of Haleakala down to coastal areas, with 11 major drainage basins discharging to the Kihei, Wailea, and Makena coastlines. The upcountry areas are primarily forests, farms, and ranch lands, and the coastal areas are developed resort, urban, and residential areas. Long term rainfall averages range from 10 inches per year near the Kihei coastline to 40 inches per year at 9,400 feet elevation near the summit of Haleakala.

The primary source and most problematic pollutant is sediment carried by storm water runoff. Weather patterns are seasonal and erratic, bringing large rain events which erode land and streambanks. These storm waters overload coastal wetlands causing flooding in the urban area near the shore. State standards for water quality are not being met for many sites along the southwest Maui coastline. The development of a watershed plan provides an opportunity to address these water quality problems.

The Southwest Maui Watershed Management Plan was developed to address sediment laden stormwater runoff. Numerous implementation projects were designed to lower the amount of sediment loading in the gullies and gulches that discharge into coastal waters. In an effort to collect baseline data on sediment loading throughout the watershed, and to monitor the success of implementation projects as they are executed, a water quality monitoring program was developed.

2.0 METHODOLOGY

Relative Loads for Total Suspended Solids (TSS) were evaluated for both current sediment load and future sediment load reduction at individual gulches and gullies within the watersheds.

2.1 Sampling Locations

Baseline water quality monitoring is conducted in several key locations throughout the watershed during periods of heavy rainfall when the gulches contain enough flow to discharge into coastal waters (Figures 2-6). Samples are collected at several locations throughout the watershed:

- At higher elevations in the watershed, where stormwater first begins to collect in gullies and gulches
- Upstream and downstream of locations suspected of having high erosion potential within the watershed. These locations are likely candidate sites for implementation projects.
- At locations along Pi‘ilani Highway where land use changes from rural to urban
- At locations where gulches discharge into coastal waters

Baseline water quality monitoring will be used to gauge the effectiveness of implementation projects by sampling upstream and downstream of these projects and comparing these data with baseline data collected prior to implementation (Figures 3-5).

2.2 Existing Conditions

Current sediment load was calculated within the watersheds during heavy rain events using the equation:

$$Qs = Qw*Cs*k$$

where

Qs = suspended-sediment discharge, in tons per day;
Qw = water discharge, in cubic feet per second;
Cs = mean concentration of suspended sediment in the cross-section in milligrams/liter;
and k = a coefficient based on the unit of measurement of water discharge that assumes a specific weight of 2.65 for sediment, and equals 0.0027 in inch-pound units, or 0.0864 in SI units.

Water discharge for each gulch was measured using a Price AA current meter (Figure 7). Relative stream area was measured assuming a uniform depth and width observed at the time and location where the flow measurement was recorded. Due to safety concerns, a Van Dorn sampler unit was used to collect TSS samples when gulches were flowing at volumes too large to sample directly from the channel (Figure 8).

A standardized datasheet was created to ensure sampling teams were consistent in carrying out flow measurements, measuring gulch width and depth, and collecting grab samples for TSS. Figure 9 depicts the datasheet used during sampling events.

All TSS samples were sent to the University of Hawaii, School of Ocean and Earth Science and Technology (SOEST) Laboratory for Analytical Biogeochemistry (S-LAB). Water samples were processed for TSS using a 0.7μm filter and reported in milligrams per liter.

2.3 Future Conditions

Potential future sediment load reduction values were calculated using The United States Department of Agriculture Revised Universal Soil Loss Equation 2 (RUSLE2). Areas within the watershed where implementation projects have been proposed were analyzed for erosion potential using RUSLE2. The four main factors affecting erosion are soil, climate, topography and land use. For each implementation project location, these factors were entered into the RUSLE2 database to calculate the erosion potential in tons per acre per year.

As depicted in Table 1, sediment loss was estimated to be 25 tons per acre per year using the RUSLE2 equation for the areas where the initial implementation projects are being proposed (Figures 3-5). These implementation projects were identified as being the most feasible based on their location, ownership, cost, potential for success and general “shovel-readiness”. Initial implementation projects include vegetated swales placed down slope of cattle operation High

Impact Zones, excavated detention basins, and riparian zone protection and rehabilitation. They are located mauka of Pi'ilani Highway as depicted in Figures 3-6.

In addition, baseline sediment loads were recorded during heavy rain events upstream and downstream of these implementation projects using the flow meter and TSS grab sample method mentioned above. Once these initial implementation projects have been completed, flow measurements and TSS samples will be taken upstream and downstream to determine the effectiveness of these projects in limiting erosion and removing sediment from stormwater runoff. These measurements will be compared with the estimated load reduction values derived from utilizing the RUSLE2 methodology.

Table 1. Sediment Load Reduction Estimates for Proposed Implementation Projects

Proposed Implementation Project	RUSLE2 Coefficient	Acreage Affected	Sediment Load Reduction Estimate (Tons per Year)
High Impact Zone Mitigation Site 1	25 Tons per Acre per Year	46.79	1169.75
High Impact Mitigation Site 2	25 Tons per Acre per Year	27.78	694.5
Detention Basins	25 Tons per Acre per Year	38.11	952.75
Riparian Protection	26 Tons per Acre per Year	79.43	1985.75

Figure 1. Southwest Maui Watersheds

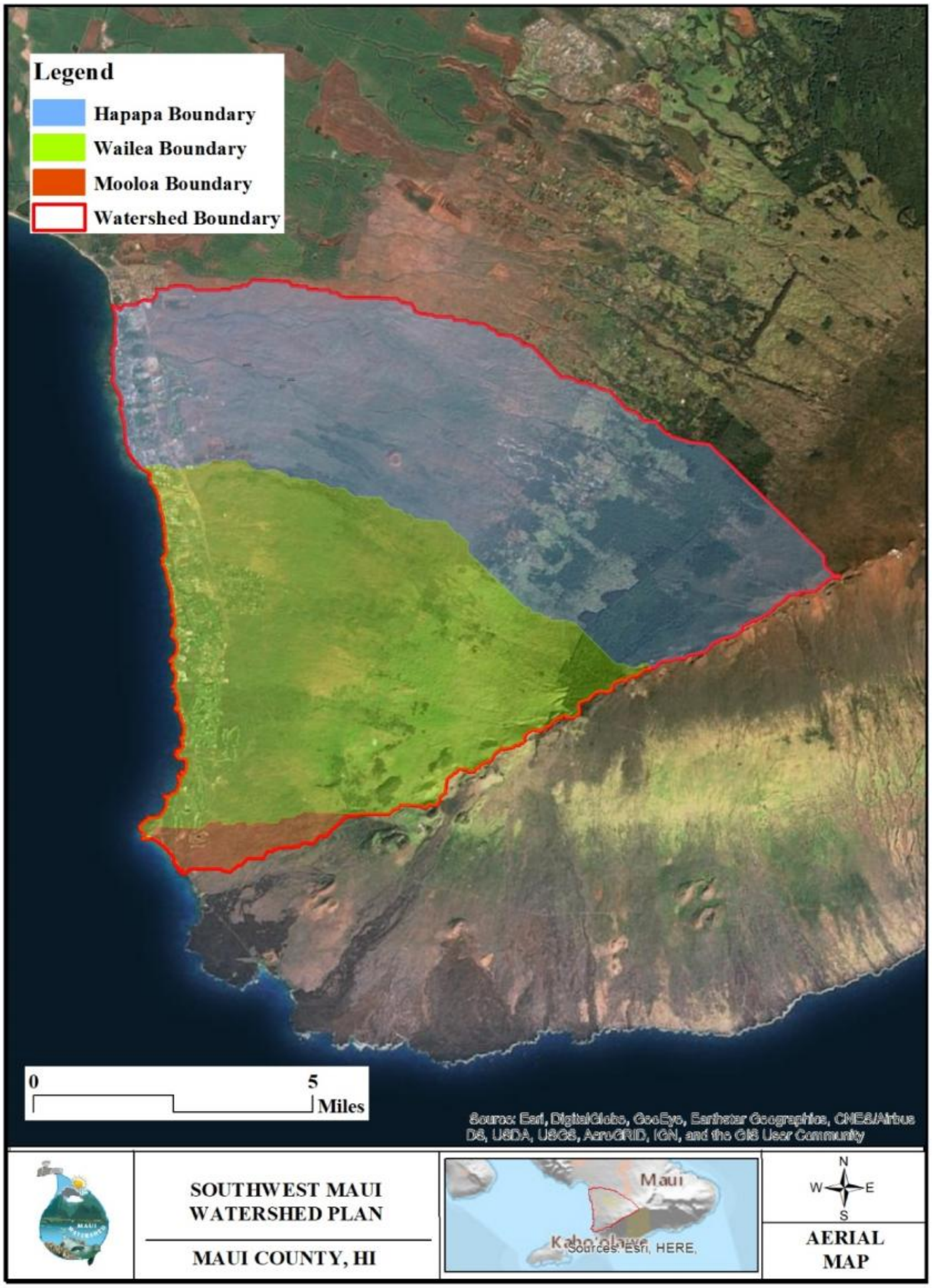

Figure 2. Kihei Water Quality Sampling Locations

Figure 3. High Impact Zone Mitigation Site #1 Sampling Map

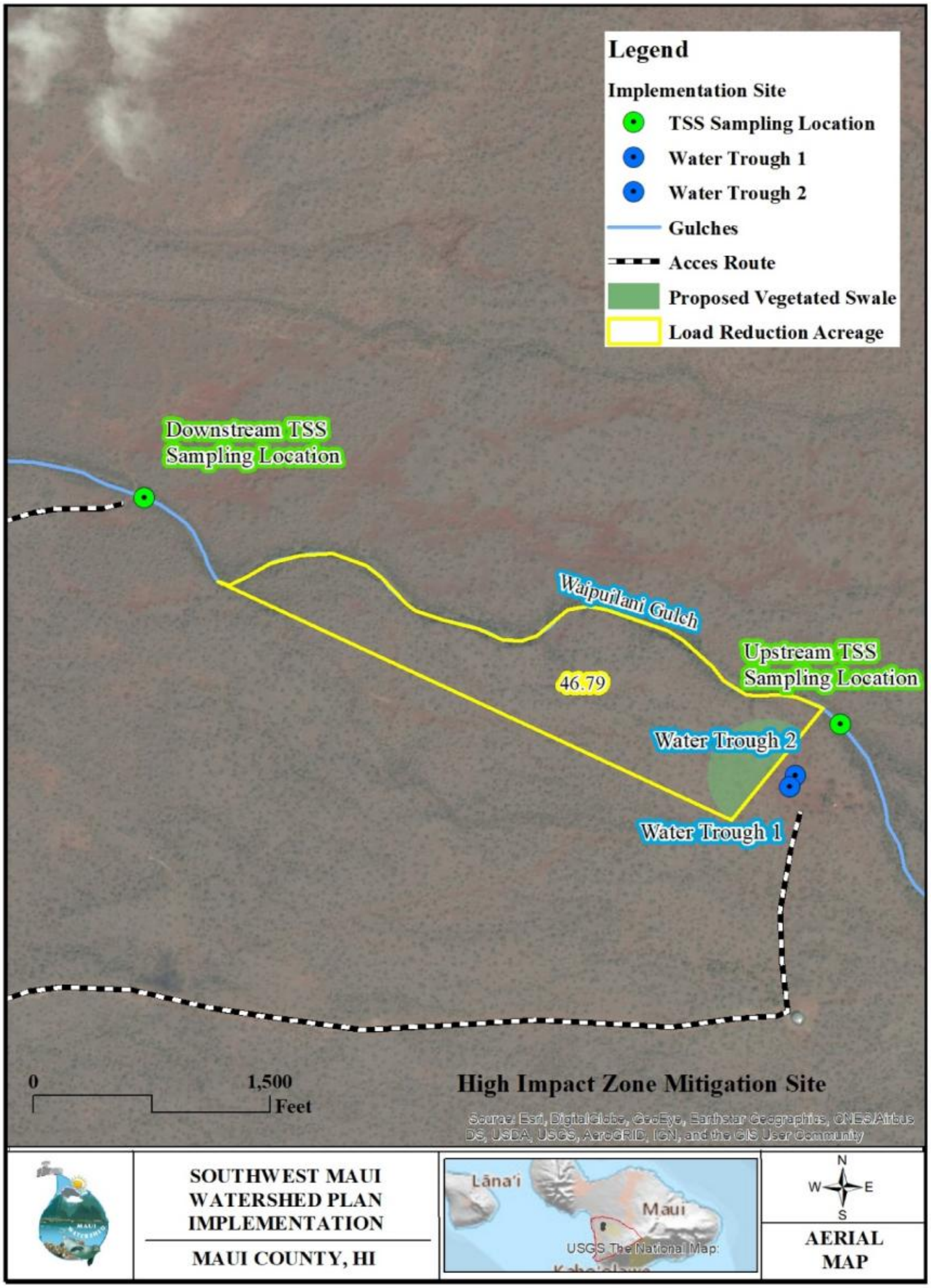

Figure 4. High Impact Zone Mitigation Site #2 Sampling Map

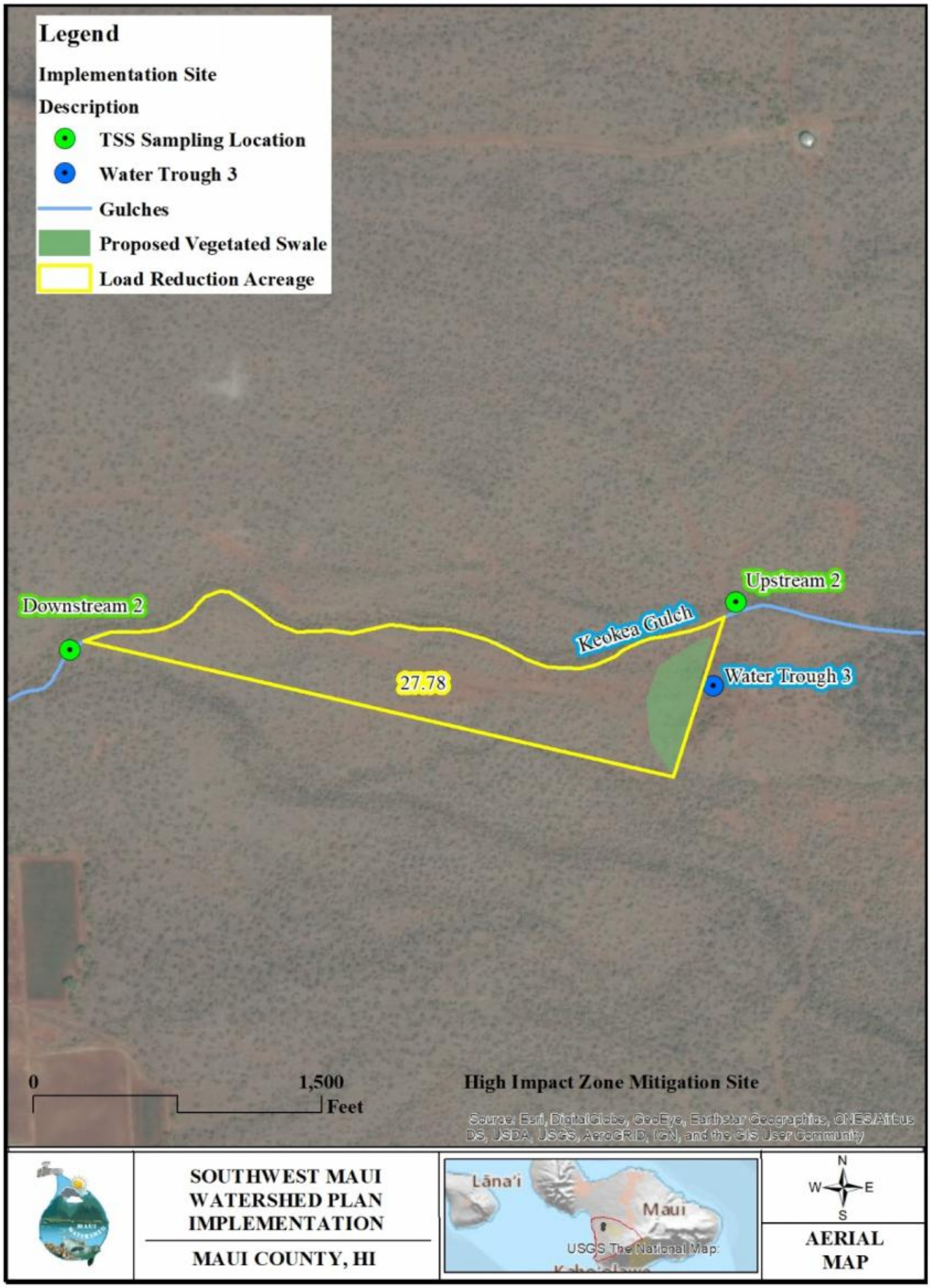

Figure 5. Small Detention Basins Sampling Map

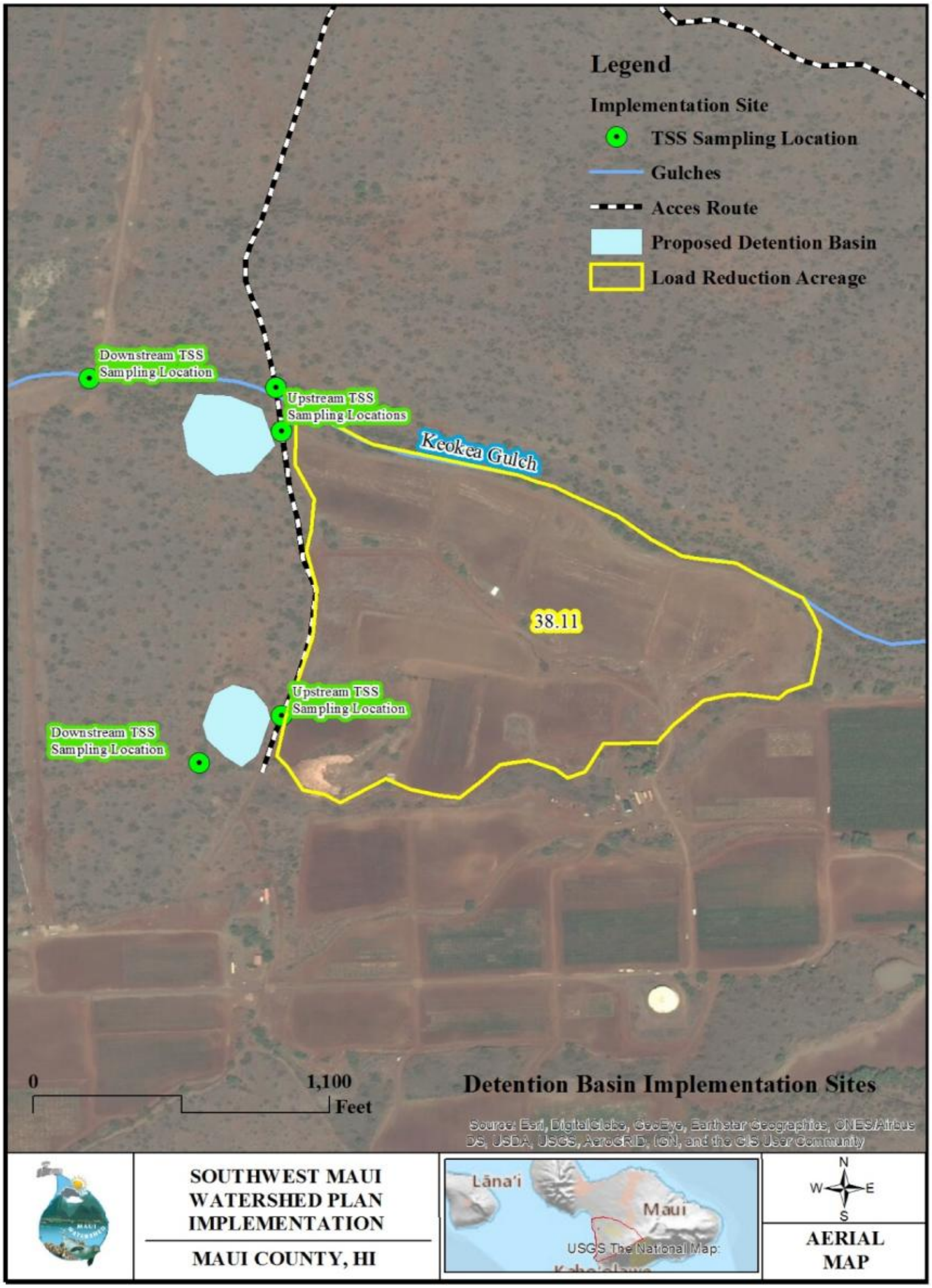

Figure 6. Riparian Protection Sampling Locations

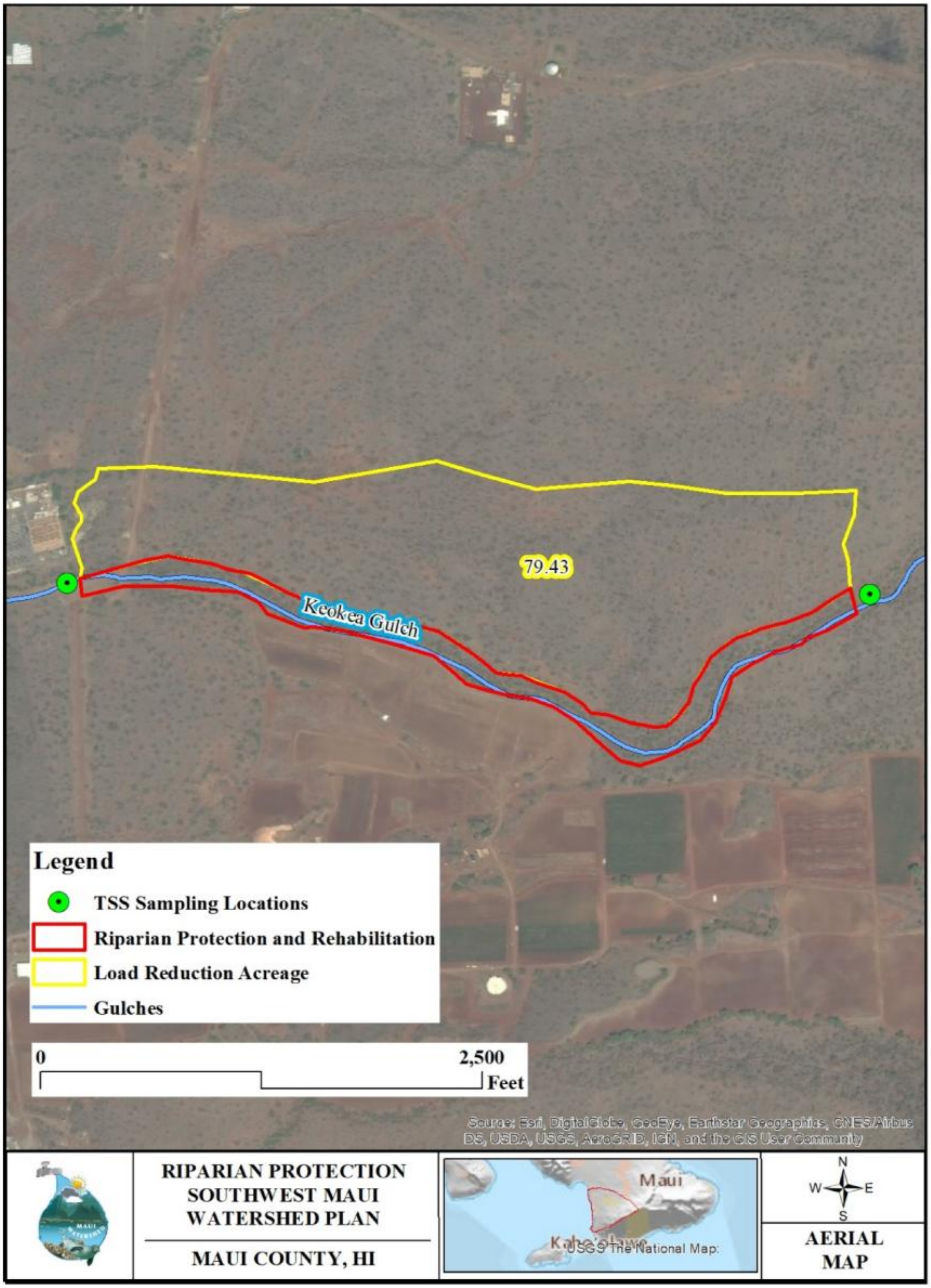

Figure 7. Upcountry Water Quality Sampling Locations

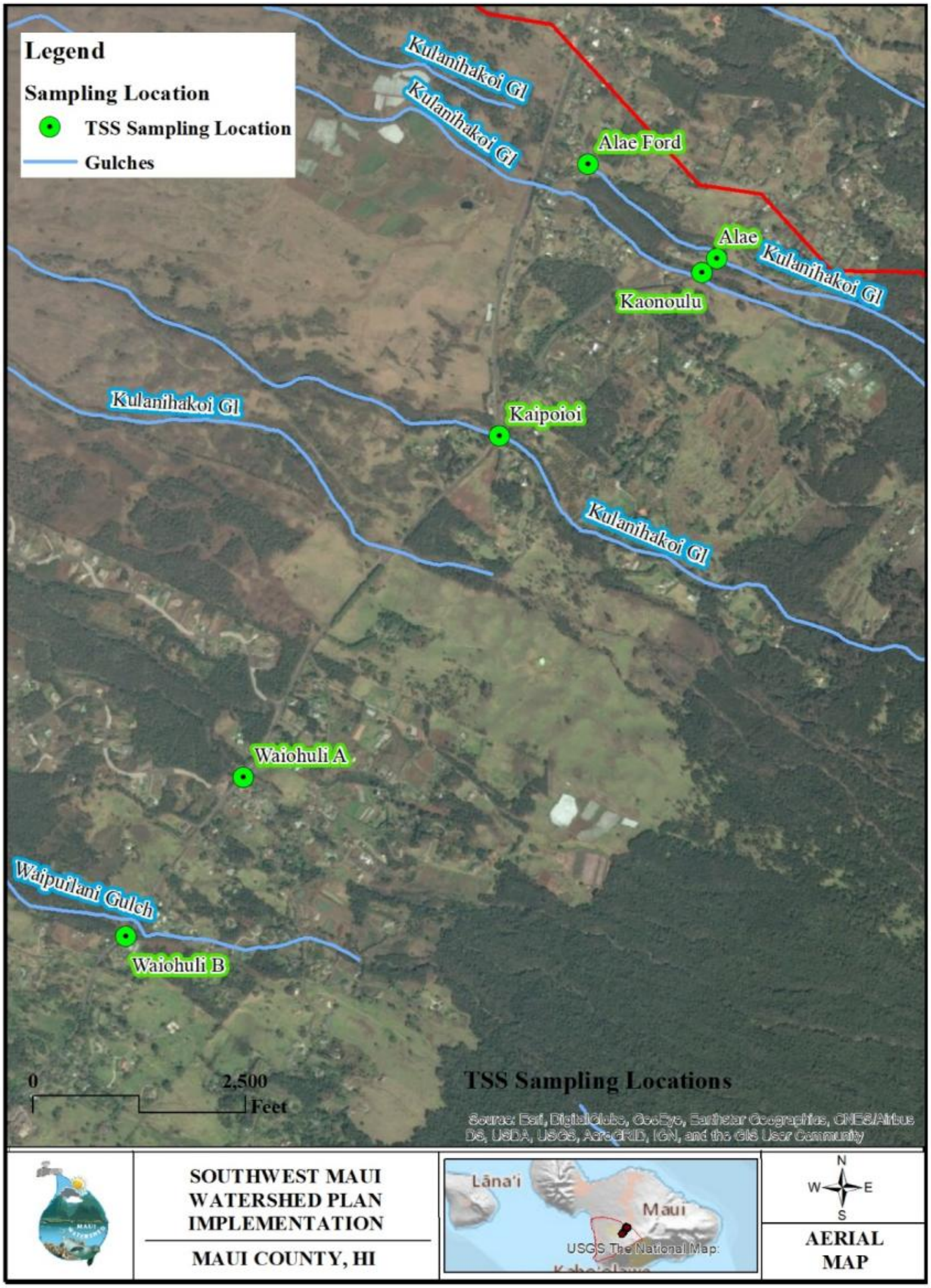

Figure 8. Price AA Flow Meter

Figure 9. Van Dorn Water Sampler

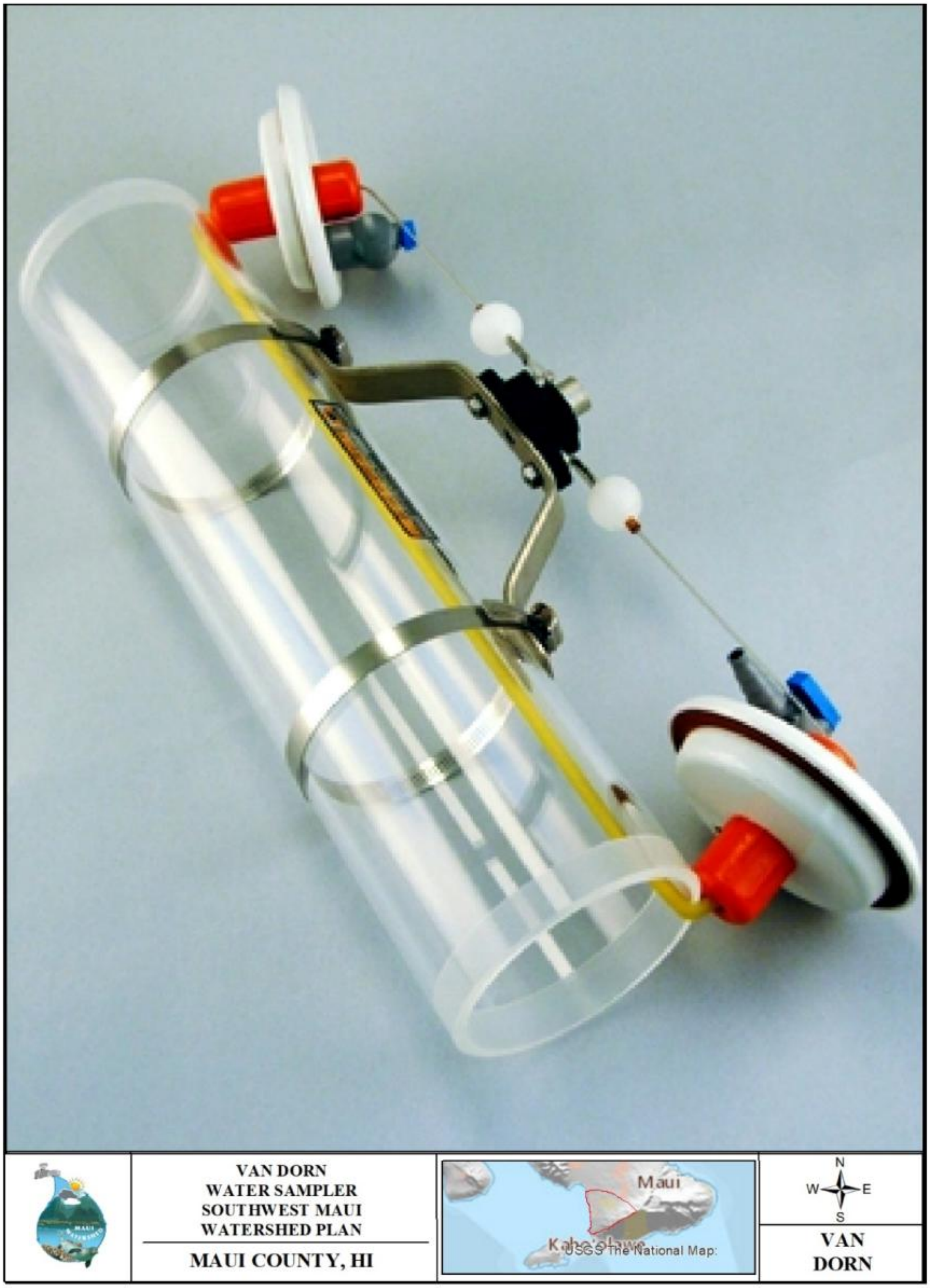

Figure 10. Standardized Water Quality and Flow Monitoring Data Sheet

Central Maui Soil and Water Conservation District									
Southwest Maui Watershed Plan									
Sampling Datasheet									
Date Sampled:						Sampling Team:			
Weather:									
Station Name	Time	Flow			Width (ft)	Depth (ft)	0.5L TSS Sample Taken (Y/N)	Pictures Taken (Y/N)	Notes

Flow Meter Instructions:
Press ON/SELECT and make sure 1-1:AA is selected
Press COUNT/STOP and confirm counter is set to 40 seconds
Press COUNT/STOP again. The count LCD will go blank and the timer LCD will set itself to zero
Submerge Flow Meter to begin measurement, assuring that fly wheel is able to spin unimpeded
Take three flow meter readings per station

Grab Sample Instructions:
Record Station ID, Time, Date, and your Intials on unopened 0.5L water bottle with black sharpie
Unscrew cap and drain all the water from the bottle
Invert water bottle so that the opening is facing down
Submerge arm elbow deep in the water (if possible) and turn bottle upward and allow to fill
Make sure water bottle is completely full
Replace cap