# WEST MAUI WATERSHED PLAN:
# Kahana, Honokahua and Honolua Watersheds
# Strategies and Implementation Report



**September 2016**

WEST MAUI Ridge 2 Reef INITIATIVE

**Prepared For:**

U.S. Army
Corps of Engineer

State of Hawai'i
Department of Land
and Natural Resources

**Cover Photos:**

Left - Honokahua Valley and southern ridge (Cami Kloster)

Middle - West Maui aerial (Tova Callender)

Right - Kaʻōpala coastline after rain (John Seebart)

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By:

GROUP 70 INTERNATIONAL

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# ABBREVIATIONS & ACRONYMS

| | |
|---|---|
| BMPs | Best Management Practices |
| CC&R | Covenants, Conditions, and Restrictions |
| CCA | Crustose Coralline Algae |
| COM | County of Maui |
| CORAL | Coral Reef Alliance |
| CWRM | Commission on Water Resource Management |
| DAR | Division of Aquatic Resources |
| DLNR | Department of Land and Natural Resources |
| DoD | Department of Defense |
| DOFAW | Division of Forestry and Wildlife |
| DOH | Department of Health |
| DOI | Department of the Interior |
| DoJ | Department of Justice |
| DOS | Department of State |
| DOT | Department of Transportation |
| EA | Environmental Assessment |
| EIS | Environmental Impact Statement |
| EPA | Environmental Protection Agency |
| FAST | Funding and Agency Support Team |
| FSA | Farm Service Agency |
| FWS | Fish and Wildlife Service |
| HELC | Highly Erodible Land Conservation |
| HTY | Honolulu Theater for Youth |
| IAL | Important Agricultural Lands |
| KOA | Kāʻanapali Operations Association |
| LID | Low Impact Development |
| MCL | Maui Cultural Lands |
| ML&P | Maui Land & Pineapple, Inc. |
| NATA | National Aeronautics and Space Administration |
| NEPA | National Environmental Policy Act |
| NFWF | National Fish and Wildlife Foundation |
| NGO | Non-Governmental Organizations |
| NOAA | National Oceanic and Atmospheric Administration |
| NRCS | Natural Resources Conservation Services |
| NSF | National Science Foundation |
| OSDS | Onsite Sewage Disposal System |
| R2R | Ridge to Reef |
| RFD | Request for Determination |
| RMA | Risk Management Agency |
| SMA | Shoreline Management Area |
| USAID | US Agency for International Development |
| US CRTF | US Coral Reef Task Force |
| USDA | US Department of Agriculture |
| USGS | US Geological Survey |
| WC | Wetland Conservation |
| WMR2RWG | West Maui Ridge 2 Reef Working Group |
| WMMWP | West Maui Mountains Watershed Partnership |
| WMSWCD | West Maui Soil and Water Conservation District |
| WQC | Water Quality Certification |
| WRDA | Water Resources Development Act |

# EXECUTIVE SUMMARY

Land-based pollutants are one of the major factors impairing the health of West Maui's watersheds and coral reefs. In response, the *West Maui Watershed Plan* is being developed under Section 729 of the Water Resources Development Act (WRDA) of 1986 which authorizes the development of multi-purpose, multi-objective watershed plans developed in cooperation with Federal, State and local government entities.

The US Army Corps of Engineers and the State of Hawai'i Department of Land and Natural Resources are cosponsors of this plan. The West Maui Watershed Plan collaborative planning process draws upon the efforts and resources of Federal, State and private entities and on ground representation via the West Maui Ridge 2 Reef Working Group.

The *West Maui Watershed Plan* will serve as a guide to restore and enhance the health and resiliency of West Maui coral reefs and nearshore waters through the reduction of land-based pollution threats from the summit of Pu'u Kukui to the outer reef. These efforts will be guided by the values and traditions of West Maui. The Plan's objectives are to:

- Reduce land-based sources of pollution impacts to Maui's coral reefs through the year 2065 to reduce further decline of the coral ecosystem.
- Empower the West Maui community to steward the terrestrial and coral resources and drive good decision-making that benefits the resources and community over the next 50 years.
- Protect and restore native ecosystems of West Maui to benefit nearshore resources through 2065.

The *Kahana, Honokahua and Honolua Watersheds Characterization Report* evaluated watershed processes and determined land uses and activities that might be generating pollutants, and provides the basis for identifying management practices to remediate pollutants in this *Kahana, Honokahua and Honolua Watersheds Strategies and Implementation Report*. Both reports are interim reports of the West Maui Watershed Plan. The two reports for the Kahana, Honokahua and Honolua watersheds, together with the two volumes of the Wahikuli-Honokōwai Watershed Management Plan, will assist in inventorying and forecasting conditions for the overall five-watershed West Maui Watershed Plan and provide needs, opportunities and measures for evaluation and selection of a long-term integrated strategy.

## ES.1 Pollutant Source Prioritization and Data Gaps

Pollutant sources are prioritized based on available information, including water quality and land use data, as detailed in Chapter 2 Priorities and Implementation Strategy.

Nearshore water turbidity data and observed rainfall runoff indicate that Kahana, Ka'ōpala, Honokahua and Honolua subwatersheds are significant sources of sediments to nearshore waters. During recent field work USGS verified that streams and gulches bordering on former agricultural lands have sediment terraces from field and road creation. Smaller gulches have 1 to 3 meter deep terraces, and larger stream valleys have 3 to 7 meter deep sediment terraces. Because every subwatershed contained agricultural fields at one time, all are sediment sources.

Testing of nutrients by DOH in nearshore waters has recently begun. Because of this data gap, land uses inform pollutant source identification. The well-maintained landscaping in Nāpili, Kapalua, Honokahua and Honolua are assumed to be sources of nitrogen and pesticides.

Data gaps for prioritization of pollutant sources and measures are presented in Chapter 2 and in Table ES.1.

Guidance in this document is provided primarily through proposed actions called measures.

**Policy Measures** are policies that can prevent or reduce pollutant sources to improve water quality and reduce impacts on the coral reef ecosystem. These are described in Chapter 3.

**Management Measures** are actions that can prevent or reduce pollutant sources to improve water quality and reduce impacts on the coral reef ecosystem. Management measures may include Best Management Practices (BMPs) that have been evaluated and accepted to be effective means to prevent or reduce pollutant sources. These measures are found in Chapters 4, 5, and 6.

The priority policy and management measures are found in Chapter 2 and a complete listing of measures is found in subsequent chapters. Chapter 7 lists outreach initiatives, actions for implementing this plan via behavioral changes to affect implementation of management measures.

The data gaps are prioritized by timeframe based upon how soon information is needed to inform pollutant sources or measure identification (Table ES.1).

**Table ES.1 Data Gaps Summary**

| DATA GAPS | |
|---|---|
| **Immediate/Short-Term Priority Data Gaps** | |
| A | Sediments Locations in Streams & Gulches Not Yet Surveyed |
| B | Identification of Management Measures to Address Accumulated Stream and Gulch Sediments |
| C | Effectiveness of Existing Desilting Basins |
| D | Storm Water System Mapping |
| E | Regional Drainage Analysis |
| F | Testing of Water Quality Samples for Nitrogen Stable Isotope Ratios (Delta N-15) |
| G | Well Testing for Nitrogen |
| H | Identification of Cesspool Locations |
| I | Baseline Testing for Current Use Contaminants |
| **Mid-Term Priority Data Gaps** | |
| J | Further Research on Pollutant Impacts on Corals |
| K | Genetic Testing of Coral Offshore and Coral Larvae Sources in Southern West Maui |
| L | Waste Water System & Connections Assessment |
| M | Bacteriological Testing |
| N | Submarine Ground Water Discharge |
| **Long-Term Priority Data Gaps** | |
| O | Periodic Testing for Emerging Contaminants of Concern |
| P | Land Use / Cover Hydrology Impacts |
| Q | Streamflow Data |

## ES.2 Priority Policy Measures

Priority policy measures (Chapter 3) include measures that:

- Remove barriers to implementation to reduce watershed pollutants
- Provide the foundation or framework upon which measures can be can be built
- Can directly reduce land based pollution including:
  - ***Comprehensive County Storm Water Management Plan***
  - ***Enforcement of Temporary Construction Storm water BMPs***
  - ***Post Construction Storm water Ordinance: Drainage Master Plan Requirement***
  - ***Requirement for BMP Management Plans and Reporting by Large Scale Nutrient and Pesticide Users***
  - ***Water Quality Monitoring Program***
  - ***Agricultural Conservation Plan Requirement for Ag Lands***
  - ***Storm Water Fees Establishment***

## ES.3 Stream & Gulch/Agricultural & Conservation Management Measures Priorities

Streams and gulches are a major source of sediment reaching the ocean. Priority management measures for stream and gulch areas (Chapter 4) and for agricultural and conservation lands (Chapter 5) are ones that:

1) **Stop sediment from entering streams and gulches**
   Ongoing sedimentation issues should be addressed.
   - ***Push Pile Assessment and Stabilization***
   - ***Stream Crossings Stabilization***
   - ***Access Road Improvements***

2) **Prevent future sedimentation sources**
   Best management practices can prevent sedimentation from future activities.
   - ***Construction Best Management Practices***
   - ***Grazing Best Management Practices***
   - ***"Go Time" Wildfire Plan***

3) **Keep existing in stream sediment deposits from moving down stream to the ocean**
   There are significant information gaps where sediments are located and types of management measures to best stabilize sediment terraces.
   - ***Identification of Sediment Terraces in Streams and Gulches***
   - ***Researching, Piloting and Implementation of Stream/Gulch Bank Management Measures***
   - ***Restoration of Traditional Lo'i Kalo***

4) **Address current instream sediment movement**
   It is best to address instream sediments where they exist. If there are limited management measures to stabilize sediments in place, downstream mitigation will also be necessary.
   - ***Kahana Desilting Basin Maintenance***
   - ***Desilting Basin Monitoring and Analysis***
   - ***Desilting Basin Retrofits***
   - ***Potential New Desilting / Sediment Basins***

5) **Increase ground water recharge and slow surface flows**
   Where the land is covered with trees and plants, rainfall can infiltrate into the ground and is slowly released into streams and nearshore waters. This can reduce the pulses of storm water in stream and decrease the forces that erode the sediment terraces.
   - ***Conservation Boundary Fencing***
   - ***Active Ungulate & Invasive Weed Management***
   - ***Landscape Restoration***

## ES.4 Priority Urban Measures

The priority urban measures include management measures (Chapter 6), policy measures (Chapter 3) and outreach initiatives (Chapter 7). Priorities are due to their overall positive impact on reducing pollutant contributions.

**Urban Policy Measure Priorities**

- ***Comprehensive Storm Water Management Plan***
- ***Low Impact Development Requirement for development, redevelopment and improvement projects > 1 acre*** *(State, County and private sector)* ***to incorporate LID measures into design and construction***
- ***Increased Enforcement of Construction Storm water BMPs***
- ***Storm Water Fee Establishment***
- ***Golf Courses and Landscaping BMP Management Plans***
- ***Pool and Vehicle Wash Water Discharge Policy***
- ***Storm Water Management Asset Mapping***
- ***Regional Drainage Analysis***

**Urban Management Measures Priorities**

- ***Roadside Erosion (Honoapi'ilani Highway and Lower Road)***
- ***Cesspool Identification and Conversion***
- ***Urban Storm Water Management Retrofits***

  As water quality data and drainage and storm water system maps are available, specific pollutant sources and geographic areas can be targeted. In the meantime, urban retrofits are encouraged throughout the three watersheds where opportunities exist.

The urban outreach initiatives are discussed below.

## ES.5 Priority Outreach Initiatives

The priority outreach initiatives (Table ES.2) are from Chapter 7. The highest overall priority for outreach is to continue funding watershed and outreach coordinators to organize and communicate outreach initiatives and facilitate implementation of policy and management measures.

**Table ES.2 Priority Outreach Initiatives**

| Outreach Initiatives |
|---|
| ***1) West Maui Kumuwai Campaign*** |
| ***2) Community Stewardship Program*** |
| ***3) Construction Industry Outreach on Storm Water Best Management Practices*** |
| ***4) Low Impact Development Training*** |
| ***5) Landscapers and Property Managers Outreach*** |
| ***6) Pu'u Kukui Watershed Preserve Public Outreach Campaign*** |

## ES.6 Next Steps

The collective efforts of government agencies, landowners, non-profits, residents and visitors are all important components of an adaptive management approach to implemented a watershed plan to improve the health of coral reef ecosystems.

The adaptive management approach involves implementation, assessment implementation impacts and adjusting future implementation strategies toward achieving the overall goal. The next steps for implementation of the *Kahana, Honokahua and Honolua Watershed Strategies and Implementation Plan* include:

- Filling data gaps to identify priority areas/pollutants and prioritize management measure locations
- Implementing priority policy and management measures and outreach initiatives
- Piloting measures to assess effectiveness (e.g. stream management measures)
- Assessing pilots for broader implementation
- Monitoring to adjust implementation of future measures.

Adaptive management and implementation strategies will be further discussed in the follow-on five watershed West Maui Watershed Plan.

# 1.0 INTRODUCTION

## 1.1 West Maui Watershed Plan Overview

Nearly 30% of the West Maui coral reef cover has been lost over the last 30 years. Impacts to the coral reef and declines in watershed health are due in part to the history of land use changes including loss of forestland, plantation era agricultural practices, legacy sediments in streams and gulches, stream channelization, and urban development. These land uses have resulted in land-based pollutants, which impair water quality and adversely impact the marine ecosystem.

The West Maui Watershed Plan is being developed under Section 729 of the Water Resources Development Act (WRDA) of 1986. Section 729 of WRDA 1986 authorizes the development of watershed plans that are multi-purpose and multi-objective in scope and developed in cooperation with Federal, State and local government entities. Consistent with Section 729, West Maui Watershed Plan will identify alternative strategies for restoring coral reefs and protecting watersheds by reducing land based pollution. The West Maui Watershed Plan will look at actions to modify existing infrastructure and land-based pollution inputs interfering with the health and recovery of nearshore coral reefs. The study will evaluate the five (5) watersheds along the West Maui coastline, which includes Wahikuli, Honokōwai, Kahana, Honokahua and Honolua in Figure 1.1.

The US Army Corps of Engineers and the State of Hawai'i Department of Land and Natural Resources (DLNR) are cosponsors of this plan. The West Maui Watershed Plan collaborative planning process draws upon the efforts and resources of Federal, State and private entities and on the ground representation via the West Maui Ridge 2 Reef Working Group. Collectively this entire interactive and collaborative process is called the West Maui Ridge to Reef (West Maui R2R) Initiative.

This *West Maui Watershed Plan: Kahana, Honokahua and Honolua Watersheds Strategies and Implementation Report* identifies policy and management measures to help restore coral reefs by addressing land-based pollution impacts as well as empower the West Maui community to steward terrestrial and coastal resources and restore native ecosystems. The report also includes an overall report strategy, public education plan and monitoring plan to evaluate the effectiveness of implementation.

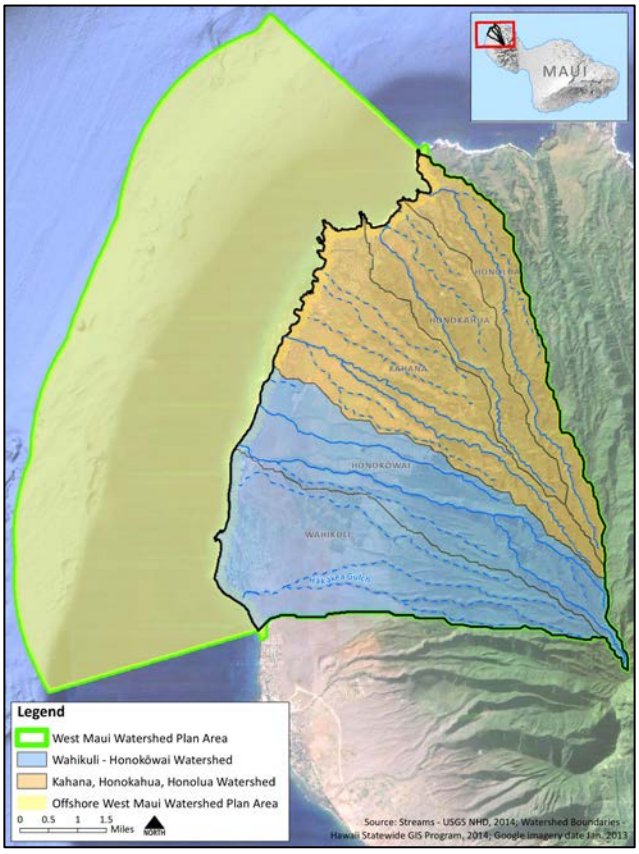



**Figure 1.1 West Maui Watershed Plan Area**

This report along with the *Kahana, Honokahua and Honolua Watersheds Characterization Report* and the Wahikuli and Honokōwai watersheds reports will be compiled into a larger comprehensive West Maui Watershed Plan scheduled for completion in 2017 (Figure 1.2).

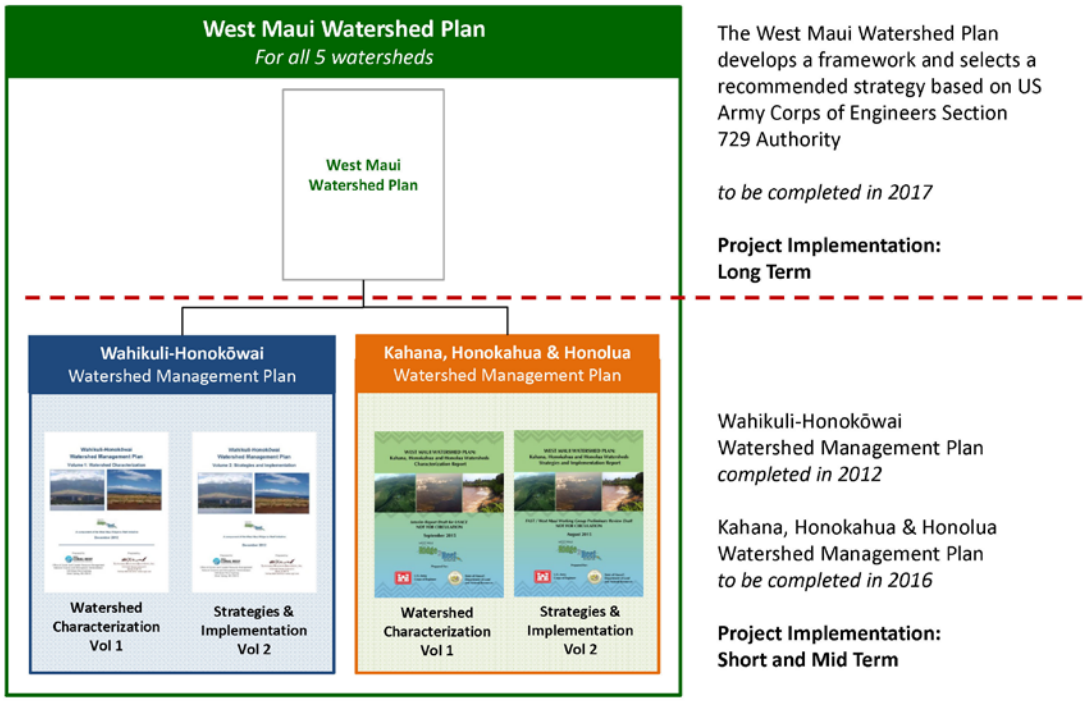



**Figure 1.2 West Maui Watershed Plan Efforts: Purposes and Timeframes**

### 1.1.1 West Maui Watershed Plan Focus and Collaboration

The focus of the comprehensive West Maui Watershed Plan is identification of policy and management measures (projects) to restore and enhance the health and resiliency of the West Maui coral reefs and nearshore waters by reducing land-based pollution threats from the summit of Puʻu Kukui, to the outer reef.

This plan supports a US Coral Reef Task Force interagency priority initiative that was identified as a national action item for the National Ocean Council in 2011. Other partners include the State of Hawaiʻi Department of Health (DOH), National Oceanic and Atmospheric Administration (NOAA), Environmental Protection Agency (EPA), Natural Resources Conservation Service (NRCS), US Geological Survey (USGS), US Fish and Wildlife Service (FWS) and National Fish and Wildlife Foundation (NFWF). The participating State and Federal agencies meet regularly and are referred to as the Funding and Agency Support Team, or "FAST" (Figure 1.3).

Maui representation is comprised of two groups, the West Maui Ridge 2 Reef Working Group (WMR2RWG), and the Ridge to Reef (R2R) Hui. Members of the WMR2RWG include representatives from the large landowners such as Maui Land & Pineapple, Inc. (ML&P), tourism sector, agricultural sector, Native Hawaiian community, Non-Governmental Organizations (NGO), Maui County and DLNR Division of Aquatic Resources (DAR) Maui office.

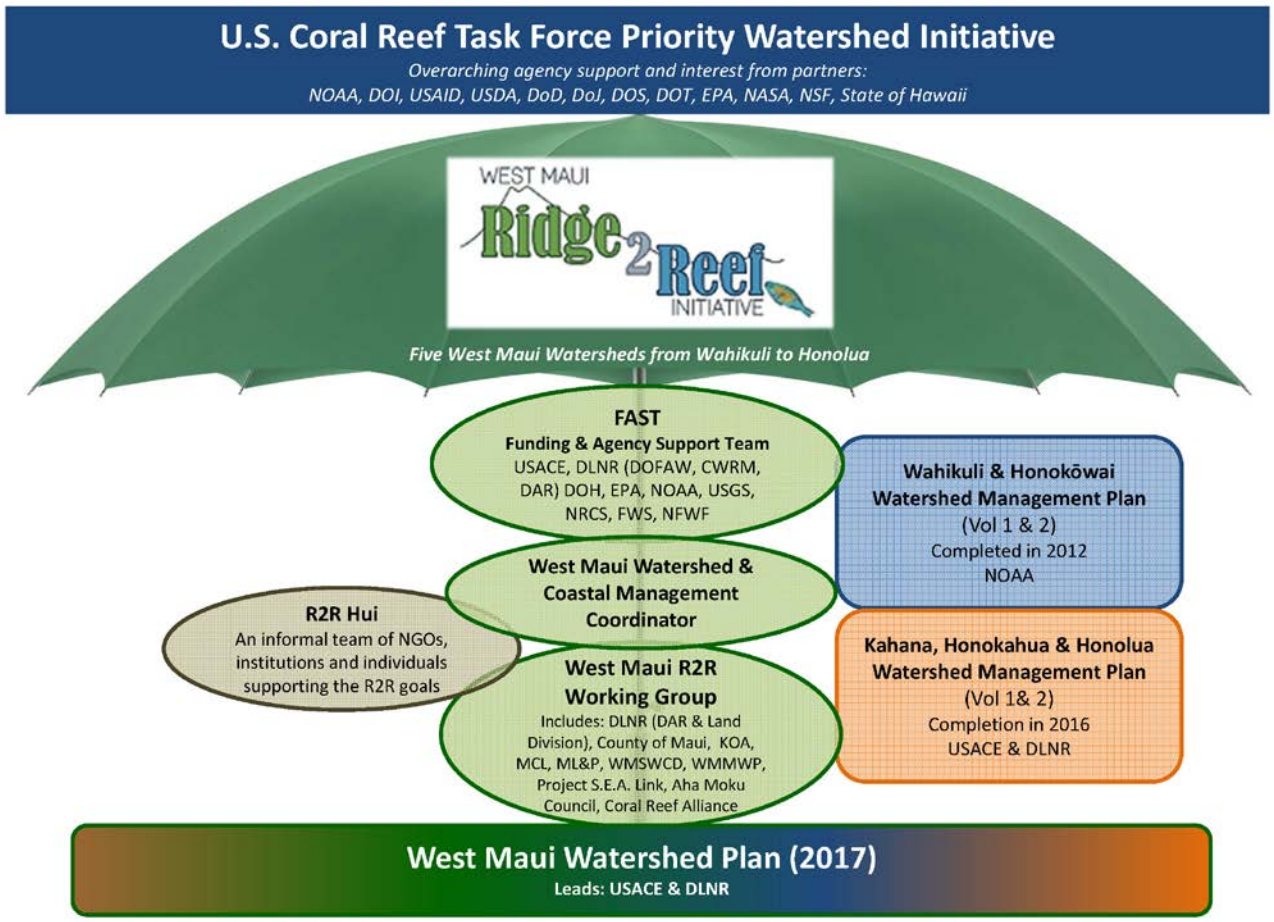



**Figure 1.3 West Maui Watershed Plan Framework**

The Working Group is chaired by DAR and provides input on community concerns and priorities to the FAST. The Ridge to Reef (R2R) Hui is a loosely affiliated group of community and NGO representatives that have also provided support to the West Maui watershed planning initiative. Organizations in the R2R Hui include Kāʻanapali Makai Watch, Coral Reef Alliance, Project S.E.A.-Link, Maui Nui Marine Resources Council, Surfrider Foundation, The Nature Conservancy, University of Hawaiʻi and many more. Collectively this entire interactive and collaborative process is called the West Maui Ridge to Reef (West Maui R2R) Initiative. The West Maui Watershed Coordinator has a critical role in facilitating the WMR2RWG, serving on the FAST, coordinating with the R2R Hui and conducting outreach to the local community.

### 1.1.2 Plan Vision, Goal and Objectives

The plan vision, goal and objectives were collaboratively developed by the FAST and other stakeholders to articulate and guide the *West Maui Watershed Plan* and are listed below in Figure 1.4.

**Vision**

*West Maui's coral reef ecosystem is diverse and abundant because of consistent community and agency support for reducing impacts from ma uka to ma kai.*

**Goal**

*Restore and enhance the health and resiliency of West Maui coral reefs and nearshore waters through the reduction of land-based pollution threats from the summit of Puʻu Kukui to the outer reef. These efforts will be guided by the values and traditions of West Maui.*

**Objectives**

- Reduce land-based sources of pollution impacts to West Maui's coral reefs through the year 2065 to reduce further decline of the coral ecosystem.
- Empower the West Maui community to steward the terrestrial and coral resources and drive good decision-making that benefits the resources and community over the next 50 years.
- Protect and restore native ecosystems of West Maui to benefit nearshore resources through 2065.

**Figure 1.4 Vision, Goal & Objectives for the West Maui Ridge 2 Reef Initiative and West Maui Watershed Plan**

### 1.1.3 Planning Constraints & Considerations

Planning constraints and considerations were identified through the collaborative planning process. Constraints are restrictions that limit the extent of the planning process. For *West Maui Watershed Plan* these include the need to:

- Avoid any additional loss of the flood plain (in accordance with Executive Order 11988 Flood Plain Management).
- Minimize impacts to cultural sites and landscapes.
- Minimize the proliferation of alien species.
- Minimize loss of ongoing livelihood in West Maui.
- Minimize loss of shoreline access or recreational opportunities.
- Minimize community divisiveness during the planning or implementation of the study actions.

Planning considerations were identified that will need to be carefully considered in the development of the watershed plan. These include the following:

- Most of the land is held in private ownership, and therefore any recommended strategies need to take into account the willingness and ability of the landowners to implement the recommended actions.

- There are many different landowners in the lower watershed making coordination a challenge.
- There is limited availability of water storage and retention throughout the five watersheds.
- There is an increasing demand for housing in West Maui, which is one of the drivers behind the proposed urban development and change in land use from agriculture to urban.
- Much of the agricultural land is planned for development therefore any long-term management strategies must address the planned development pressures.

### 1.1.4 Planning Process Timeline

The West Maui watershed planning process is being developed in multiple phases. Based on input from stakeholders, this phased planning process allows for implementation of short- and mid-term solutions to address identified priorities, while planning for long-term solutions that will be addressed in the comprehensive *West Maui Watershed Plan*. The *West Maui Watershed Plan* will also incorporate information that is still being collected (e.g. more detailed stream and gulch analysis and coral coverage data).

The *Kahana, Honokahua and Honolua Watersheds Characterization Report*, along with the *Wahikuli-Honokōwai Watershed Management Plan Watershed Characterization* will provide the basis for Chapters 1, 2, and 3 of the more comprehensive *West Maui Watershed Plan*. This *Kahana, Honokahua and Honolua Watersheds Strategies and Implementation Report*, along with the *Wahikuli-Honokōwai Strategies and Implementation* volume will provide measures for alternative formulation and evaluation in the *West Maui Watershed Plan*.

### 1.1.5 Public Involvement

While this document does not have a National Environmental Policy Act (NEPA) requirement for public involvement, public outreach has been prioritized as an essential component to the success of the plan. Public engagement in the watershed management planning process will be a key factor in garnering community support and in successfully developing and implementing the plan.

To date there have been five public meetings to gather stakeholder input into the planning process. The first two meetings were held to obtain public input on the Wahikuli-Honokōwai Watershed Plan. The third meeting was on the comprehensive watershed planning process. The fourth public meeting, held in November 2014, provided the public with an opportunity to review maps and data gathered for the characterization of the northern three watersheds of Kahana, Honokahua and Honolua. Community input has been positive, and issues raised during the public process have been incorporated into the planning process. Key concerns raised were for proposed management strategies to consider Hawaiian values and traditions, and for management measures to avoid further hardening of the landscape. A fifth public meeting coincided with release of the draft Kahana, Honokahua and Honolua Watersheds Strategies and Implementation Report. Additional community input will be sought when the comprehensive West Maui Watershed Plan draft is completed.

Input has also been gathered through frequent public outreach events held to raise awareness about watershed issues. These have ranged from an annual “Ridge to Reef Rendezvous“ to volunteer conservation and monitoring activities, and the planting of two community rain gardens at shoreline beach parks. The West Maui Watershed Coordinator has played a key role in gathering public input through public outreach events and reaching out to various community groups and members.

## 1.2 Kahana, Honokahua and Honolua Watersheds

### 1.2.1 Report Area

The Kahana, Honokahua and Honolua watersheds are located in West Maui (Figure 1.5). The ma kai boundary of the study area extends from Kahana Beach up to Līpoa Point, and encompasses the communities of Kahana, Nāpili and Kapalua. The study area extends ma uka into Mauna Kahalawai also known as the West Maui Mountains and ma kai to the outer reef. The focus of this report is on the upland and freshwater contributors of land-based pollution impacts to the nearshore.

### 1.2.2 Kahana, Honokahua and Honolua Watershed Management Goals

The goal of this watershed management plan is to guide actions to restore and protect water quality and aquatic life. This may be achieved in part through meeting appropriate water quality standards. However, the strength of the plan to achieve this goal is through assessment of the pollutant sources and identification of solutions to address and reduce the pollutant loads into waterbodies.

Guidance in this report is provided primarily through proposed actions called measures. Policy measures are policies that can prevent or reduce pollutant sources to improve water quality and reduce impacts on the coral reef ecosystem (Chapter 3). Management measures are actions that can prevent or reduce pollutant sources to improve water quality and reduce impacts on the coral reef ecosystem. Management measures may include Best Management Practices (BMPs) that have been evaluated and accepted to be effective means of preventing or reducing pollutant sources (Chapters 4, 5 and 6).

The priority policy and management measures can be found in the Executive Summary and Chapter 2. Chapter 7 provides outreach initiatives which are also actions for implementing this plan via behavioral changes and or affecting implementation of management measures.

Because information on pollutant identification is limited, data gaps have also been identified. The filling of the data gaps will further assist in assessing problems and in identifying measures to address the problems.

### 1.2.3 Relationship to Characterization Report and West Maui Watershed Plan

The *Kahana, Honokahua and Honolua Watersheds Characterization Report* evaluated watershed processes and determined land uses and activities that might be generating pollutants and provides the basis for identifying management practices to remediate pollutants in this *Kahana, Honokahua and Honolua Watersheds Strategies and Implementation Report.* Both reports are interim reports of the *West Maui Watershed Plan.*

The two reports for the Kahana, Honokahua and Honolua Watersheds, together with the two volumes *Wahikuli-Honokōwai Watershed Management Plan,* will assist in inventorying and forecasting conditions for the overall five-watershed *West Maui Watershed Plan* as well as providing needs, opportunities and measures for evaluation and selection of the long-term integrated strategy.

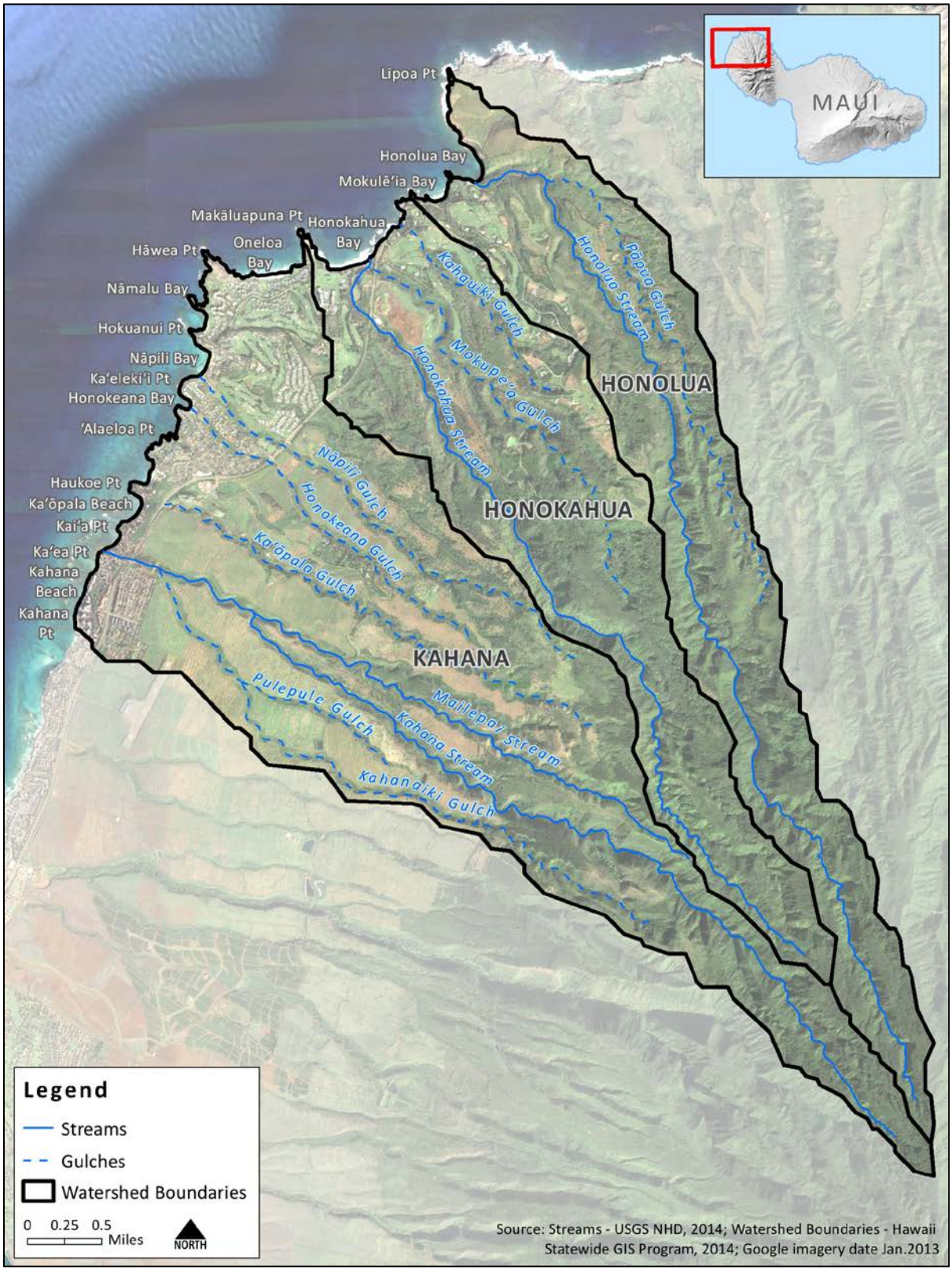



**Figure 1.5 Kahana, Honokahua and Honolua Watersheds Strategies and Implementation Report Area**

The *Kahana, Honokahua and Honolua Watersheds Characterization Report* addresses Steps 1-3 (Define Study Area, Identify Problems and Opportunities, and Inventory and Forecast Resources) of the *West Maui Watershed Plan*, USACE watershed planning process and addresses Element 1 of the EPA Nine Elements of a Watershed Plan (Identification of Causes and Sources of Water Quality). This *Kahana, Honokahua and Honolua Watersheds Strategies and Implementation Report* will inform Step 4 (Evaluate & Compare Alternative Approaches) and 5 (Strategy Selection) of the USACE watershed planning process for the *West Maui Watershed Plan.* The *Kahana, Honokahua and Honolua Watersheds Strategies and Implementation Report* will also address Elements 2-9 of the EPA Nine Elements for Watershed Plans which are Estimated Load Reductions Management Measures, Technical and Financial Assistance, Information/Education, Schedule, Measurable Milestones, Evaluation of Progress and Monitoring.

Together the two reports will be in accordance with USACE watershed planning regulations and policies and will also address the EPA's Nine Key Components for Watershed-Based Plans. Implementation of the Reports may be eligible for funding from multiple federal, state, and private financial assistance programs including but not limited to: State of Hawai'i DOH under its Polluted Runoff Control Program Clean Water Act Section 319 grants; NOAA funding under the coral program; NRCS under various Environmental Quality Incentives Program EQIP grants; and NFWF program grants.

### 1.2.4 Methodology and Plan Limitations

Available information on existing and future pollutant sources is presented in the *Kahana, Honokahua and Honolua Watersheds Characterization Report*. Policy and management measures were developed based on this information; however, numerous data gaps remain including water quality, stream/gulch sediment locations and drainage patterns. As data gaps are filled, priorities can be revised and measures updated. Appendix C lists the research activities currently in progress and their implications for guiding future priorities and policies and actions.

# 2.0 PRIORITIES AND IMPLEMENTATION STRATEGY

This chapter provides the priorities and implementation next steps drawn from Chapters 3-9. The overall prioritization of pollutant sources is described in Section 2.1. Section 2.2 lists the priority policy and management measures based on information in Section 2.1 and the ability of the measures to address the sources. Section 2.3 concludes with next steps for implementation and provides priorities for addressing the identified data gaps.

## 2.1 Pollutant Source Prioritization

Three criteria used for prioritization are: pollutant effects on coral reef ecosystems, pollutant quantities and pollutant transport. However, due to significant data gaps the following represents the best assumptions based on available information.

Available information is primarily drawn the *Kahana, Honokahua and Honolua Watershed Characterization Report* and is summarized in Appendix B.

The assumptions for this report are provided in text boxes. Research in progress and data gaps in understanding pollutant effects, quantities, and transport are provided below each text box. A listing of the research in progress can be found in Appendix C. Data gaps are identified based on the ability of the existing information to guide good decision making that reduces impacts of land-based sources of pollutants. The end of this chapter provides a summary and prioritization of the data gaps.

### 2.1.1 Pollutant Effects on Coral Reef Ecosystem

The typical starting point for developing strategies and management measures to address pollutants is to determine which pollutants are most harmful. Previous studies have shown the harmful effects of suspended sediments and nutrients on coral health. The magnitude of harmful effects of other contaminants (such as pesticides) is being studied. No one pollutant has been clearly identified as a more significant threat to corals than other pollutants. Nor is there an understanding of the synergistic effects multiple pollutants can have on corals.

> Report Assumption: The "cocktail" of current pollutants needs to be reduced without targeting one pollutant over another. Where a particular pollutant is more abundant than another, its effects will be assumed to be dominant.

Research in Progress: 1) Effects of stressors on coral reefs by looking at different "biomarkers"; 2) research on coral nutrient thresholds; and 3) impacts of historic water quality and conditions on coral reef health.

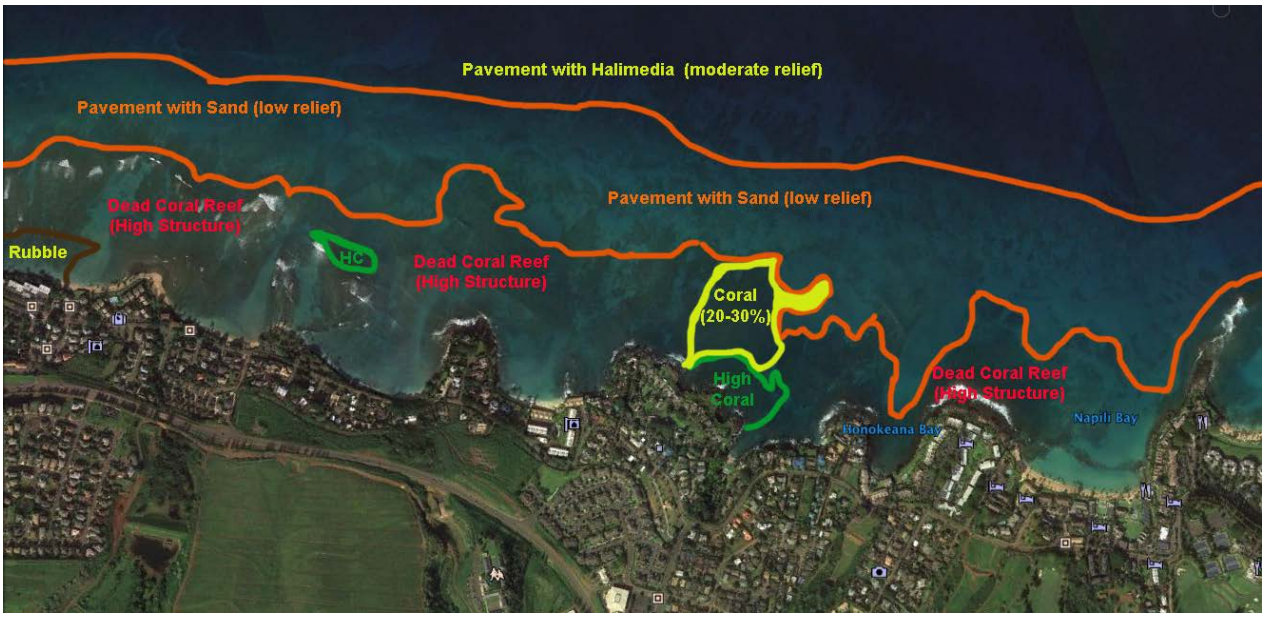
Data Gaps: This is an emerging field of understanding for corals in Hawai'i, and additional research will be important for further understanding of pollutant impacts of both known stressors and those to be identified in the future (Section 2.1.5.3).

### 2.1.2 Coral Reef Locations and Circulation

Pollutant effects are differential based on coral location and exposure to the pollutants. Figure 2.1 shows coral reef locations based on ongoing research. In addition to noting areas with coral, it also denotes areas of pavement. Pavement is defined by NOAA as low-relief, carbonate rock with algal coverage, hard coral and vertebrates (Monaco 2012). Areas of pavement may indicate areas of previous coral establishment. Pavement that has vertical relief and is less subject to sand scouring may provide opportunities for re-establishing coral populations. In addition to vertical relief, conditions that help to promote the re-establishment of coral include low turbidity, low nutrient levels, suitable salinity and temperature, and ample coral larval supply.

> Report assumption: The preliminary results in Figure 2.1 show areas close to shore either have coral reef or are high relief (high structure) areas and therefore have coral recovery potential along most of the Kahana shoreline. Based on this information, this entire coastline should be seen as needing improved water quality for coral reef protection and recovery.

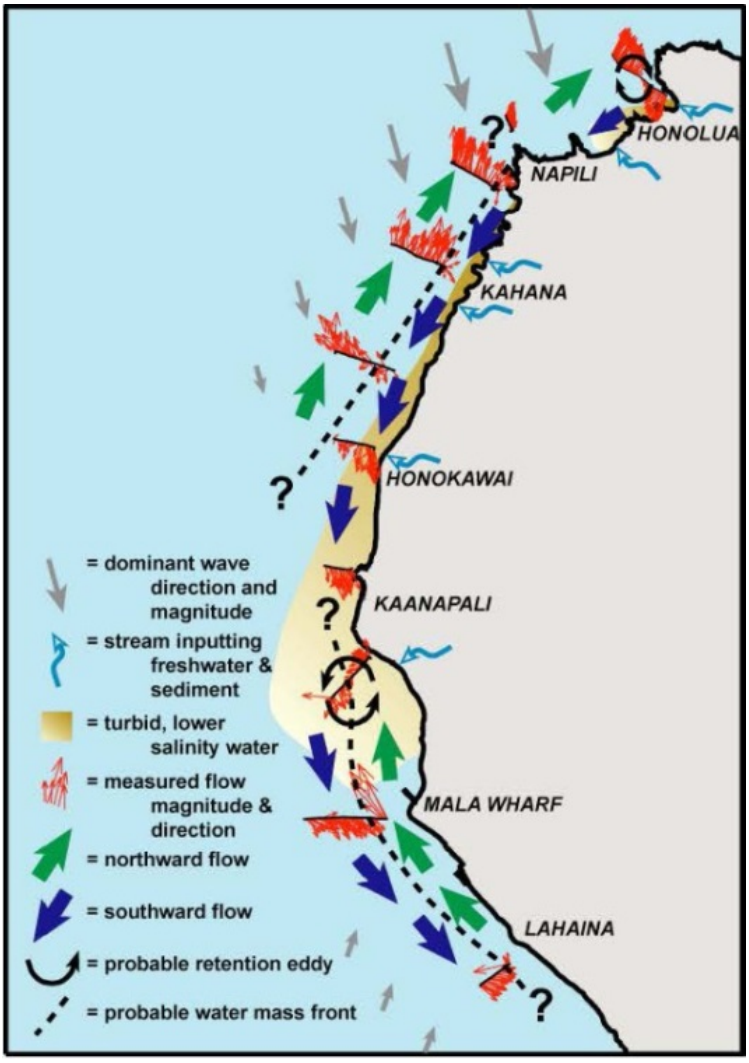
Research in Progress: Coral reef locations are being identified and classified along the entire shoreline to inform prioritization of measures and as a baseline for future monitoring. Preliminary results from John Rooney's NOAA research shows pavement along the Kahana watershed coastline and significant patches along Honokahua and Honolua watersheds. Pavement is one of the necessary conditions for future coral reef reestablishment.




*Source: DLNR Division of Aquatic Resources*

**Figure 2.1 Preliminary Kahana Benthic Mapping**

Nearshore water circulation patterns in West Maui are best described by the conceptual model created by Storlazzi and Field (2008) which found that the waters closer to shore (inshore waters) are more affected by trade winds and carry the turbid, lower-salinity water south over the shallow reef areas (Figure 2.2). Honolua Bay was shown to have a higher degree of recirculation within the bay except during the winter months when stream flow is high and there are large wave events.




Source: Storlazzi and Field, 2008

**Figure 2.2 Currents and Circulation**

More recent work by Storlazzi on modeling coral larvae dispersal patterns shows that the larvae from West Maui provide the coral larvae to seed West Maui areas, as well as other areas in Maui Nui. (C. Storlazzi Pers. Comm.). The general direction of the coral larvae movement is from the south and generally offshore which corresponds with the offshore current shown with green arrows in Figure 2.2.

Circulation patterns also disperse coral larvae which are needed to seed coral reefs. The general direction of the coral larvae movement is from the south and generally offshore which corresponds with offshore current shown with green arrows in Figure 2.2.

Without a source of coral larvae, the coral reef is not protected. A recent USGS study by Storlazzi (submitted for journal for review and not yet finalized) suggests that Kamalo (Molokaʻi), Kapua (Lānaʻi), Olowalu (West Maui), and Kihei (South Maui) reefs have the greatest potential to help maintain the health and sustainability of coral reefs in Maui Nui based solely on their size, interconnected nature, and balance between no self-seeding to high self-seeding. The findings suggest these areas meet the criteria for Marine Protected Areas design. Marine Protected Areas are defined by 76 Federal Register (FR) 6119 as "Any area of the marine environment that has been reserved by federal, state, tribal, territorial, or local laws or regulations to provide lasting protection for part or all of the natural and cultural resources therein." West Maui coral larvae seed sources should be protected even if they are outside of the West Maui Watershed Plan area.

Research in Progress: An offshore water circulation study is ongoing. The circulation data paired with water quality data will help to indicate where pollutants may be adversely affecting coral.

Data Gap: Genetic data connecting coral off shore of the study area to coral larval "seed" sources in southern West Maui is currently unavailable. This information could further demonstrate the need for coral larval source protection.

### 2.1.3 Pollutant Transport / Delivery to Nearshore Waters

Understanding water flow and associated pollutants helps in connecting water quality issues to potential pollutant sources. However, limited data on surface water drainage patterns is available. Land alterations have affected and changed natural flow patterns. For example, desilting basins and highway crossings alter flows before reaching the urban area, and the existing storm water system is not mapped or well understood. The agriculture and urban storm water systems are likely interconnected as new development drainage sometimes ties into plantation drainage systems.

*Report assumption: Close proximity of pollutant sources to ocean, gulches, or streams means more direct delivery of pollutants into nearshore waters than pollutant sources further away.*

Data Gaps: Information which would help in understanding watershed pollutant transport: 1) regional drainage analysis; and 2) mapping the storm water management system.

### 2.1.4 Coral Stress and Bleaching

When coral is stressed, it can lose the algae inside the coral tissue and appear white or bleached. Coral reef ecosystems experience bleaching under warmer ocean water conditions such as El Niño events and climate change.

Maintaining submarine water discharge (cool fresh water entering nearshore waters via ground water) may provide buffering from temperature changes. Water travelling underground maintains lower temperatures. Water flowing over land is generally warmer, as it has greater exposure to the sun and land warmed by the sun.

The route by which waters from the land enters nearshore water can also effect the rate and amounts of water entering the ocean. Surface water runoff often occurs as a single large event or pulse, while ground water usually enters the ocean more slowly and over a longer period of time. Even delivery of freshwater to nearshore waters is less stressful than larger pulse events from rainstorms.

Coral reef recovery can take weeks to years once ocean temperature is lower. The Nature Conservancy led Reef Resilience Network reports that bleached coral may have slower rates of growth and reproduction and increased mortality rates and susceptibility to diseases. The ability of coral reef to recover from disturbance can depend on its resiliency. A study by McClanahan (2012) lists eleven resiliency factors which include species types, temperature variability, nutrient, sediment and other pollution, coral diversity, herbivore biomass and macroalgae.

Data Gap: Understanding West Maui coral reef resiliency would help to assess the potential reef recovery from stressors.

### 2.1.5 Pollutant Quantities & Priority Watersheds

A summary from the *Kahana, Honokahua and Honolua Watershed Characterization Report* of pollutant quantities estimated using modeling and available water quality data is found in Appendix B. Priority source areas for sediments, nutrients and other contaminants are described below based on this information.

#### *2.1.5.1 Sediments*

Hawai'i State Department of Health (DOH) water quality data for the watersheds include turbidity data which is a measure of water clarity. High turbidity (low visibility in the water) is associated with suspended sediments. The highest turbidity readings over time have been recorded at Ka'ōpala and Kahana (S-Turns/Pohaku data) followed by Honokahua and Honolua Bay. These locations also recorded high turbidity readings in the DOH data from 2008 to 2011.

Field work by John Stock of the USGS in collaboration with ML&P in selected subwatersheds has yielded data on possible sources of sediments. Preliminary results from October 2015 field investigations of Pāpua Gulch (tributary of Honolua Stream) and Ka'ōpala Gulch found extensive sediment terraces which erode during storm events and add sediments to nearshore waters. The USGS study in press (Stock et al, 2015) modeled a suspended sediment load of more than 345 tons per year from Honolua Stream.

Ka'ōpala subwatershed is a priority area for sediment source reduction based on water quality, past land uses, access road and stream crossings and desilting basin sizing. Ka'ōpala Bay has the highest turbidity water quality data of the coastline's sampled areas. Ka'ōpala subwatershed fields were previously extensively cultivated and were likely contributors to legacy sediments in Ka'ōpala Gulch. The subwatershed contains over 12 miles of access roads and many stream crossings. The Ka'ōpala desilting basin is undersized.

Kahana subwatershed is a priority watershed for sediment source reduction based on multiple factors. The turbidity water quality data for the nearby S-Turns is very high. The drainage area of the subwatershed is very large at 3,237 acres, and although it has a relatively large desilting basin, a preliminary assessment deemed the basin as undersized. Like Ka'ōpala subwatershed, Kahana subwatershed had large cultivated areas and still has many miles of access roads with many stream and gulch crossings. It is also planned for future ranching use.

Honolua subwatershed is a priority watershed for sediment source reduction because turbidity in the Bay is high and compared to other places where sediments are more readily flushed out, and sediments in Honolua Bay can be resuspended for long periods which is harmful to the coral reef ecosystem. Past pineapple cultivation in the subwatershed created a network of many miles of access roads and stream crossings that may be contributing sediments to nearshore waters.

> Report assumption: Ka'ōpala, Kahana, Honokahua and Honolua subwatersheds (Figure 2.3) have the highest sediment loads and are priority areas for addressing sediment sources. Honokahua, Nāpili 2-3 and Nāpili 4-5 subwatersheds are also priorities due to the size and steepness of the future Kapalua Mauka development.

Research in progress: Analysis of the recent field work by USGS (John Stock) will provide sediment terrace locations in Pāpua and Ka'ōpala Gulches.

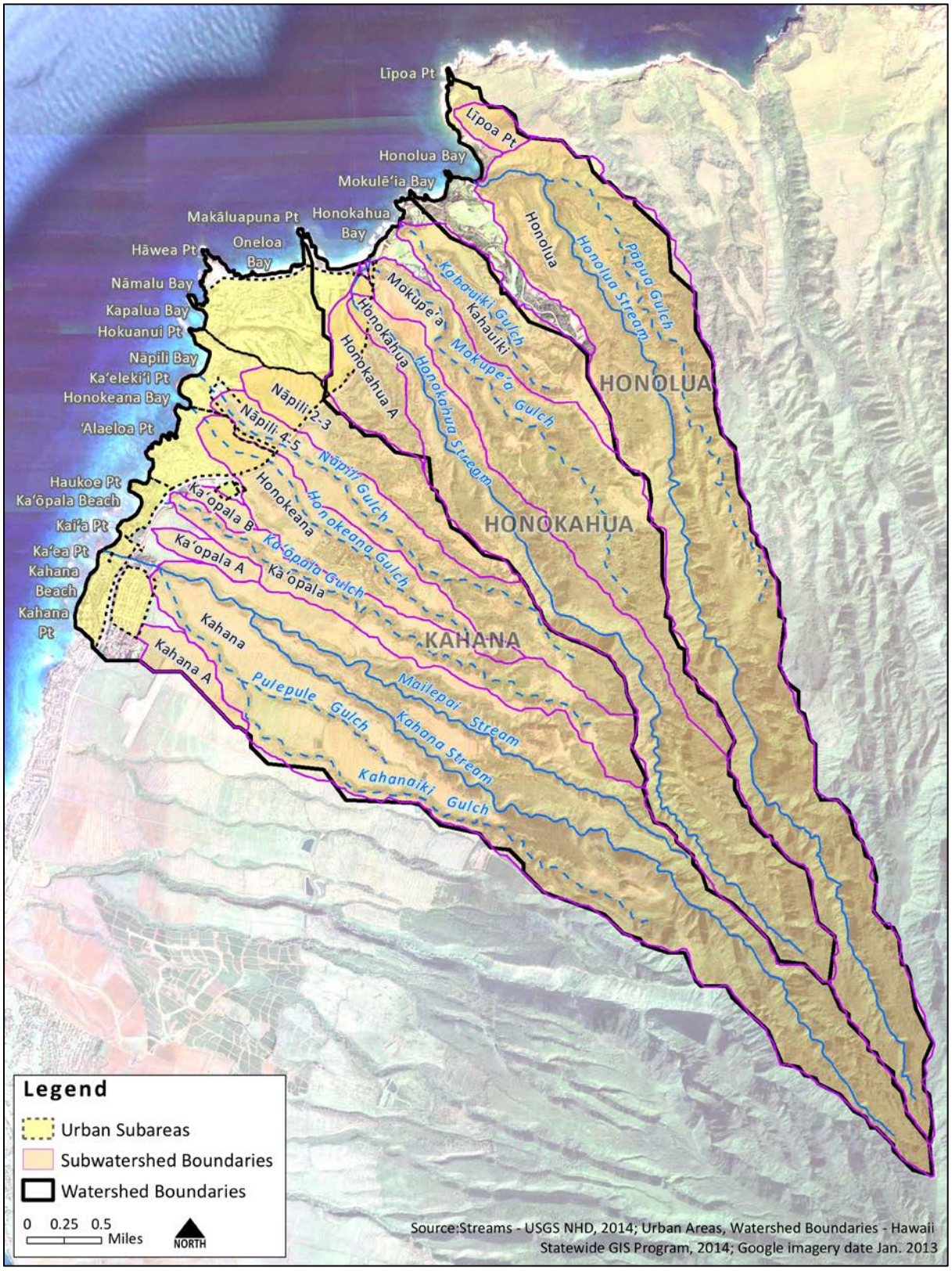



**Figure 2.3 Watersheds, Subwatershed Drainages, and Urban Sub-Areas**

Data Gaps: 1) Identification of sediment deposits in Honokahua watershed and unsurveyed subwatersheds in the other two watersheds; 2) Development of locally specific management measures to address sediments terraces; and 3) Analysis of existing desilting basins effectiveness in capturing sediments (Chapter 4).

### *2.1.5.2 Nutrients*

Lack of nutrient data has made land area pollutant reduction prioritization challenging. Water quality monitoring efforts in progress will soon guide where best to address nutrient inputs. Report assumptions of nutrient sources are made based on land uses and potential sources. Preliminary analysis of publicly available DOH data shows Kapalua Bay and S-Turns/Pohaku (just south of Kahana) as having high nitrogen levels.

> Report assumption: Given the extent and desire for lush landscaping along the coastline, and the relatively inexpensive cost of fertilizers, it is likely that nutrients from excess fertilizers applications are making their way to nearshore waters. The expansive acreage of golf courses, resort and condo landscaping are priority locations for nutrient reducing measures.

Research in Progress: Comprehensive nutrient testing along the coastline by DOH began in March 2015. Water quality testing continues for two years, and a report with data analysis will be forthcoming in 2017. This data should be monitored for and compared to other data (see below) to see if specific pollutants sources can be identified.

Research in Progress: Submarine ground water discharge can also bring naturally occurring nitrogen or "background" levels of nitrogen to nearshore waters. Research is underway to provide data on submarine ground water discharges and nutrient loads to nearshore waters. This information can then be evaluated along with the above DOH nearshore nutrient sampling to better understand the multiple possible nutrient contributions to nearshore waters.

Research in Progress: A recent USGS study by Nancy Prouty in the Kahekili area south of the three report watersheds is not yet been finalized but preliminary findings suggest that elevated nutrients and lower pH water discharging from the vents are strongly indicative of effluent. These results suggest nutrient loading from human activity are greatly escalating bioerosion (removal of calcium carbonate from the reef structure through biological processes) rates under low pH/ocean acidification conditions.

Data Gap: Preliminary DOH data analysis shows areas with elevated nitrogen levels. Follow-up testing, or if possible concurrent testing, of nitrogen stable isotopes ratios would help determine nitrogen sources, e.g. cesspool, fertilizers. Research into nitrogen stable isotope ratios (Delta N-15) in water quality samples could help to more specifically identify nutrient sources. Delta N-15 testing is available through a University of Hawai'i laboratory and was used to identify nutrient sources in the Wahikuli coastal waters.

Data Gap: In the late 90's wells were sampled for nutrients. Re-sampling of those well locations would provide locations of these contaminants and a comparison with the 1997 Soicher and Peterson data, and could inform a calculation of the rate at which legacy nutrients and other contaminants from agriculture are working through the ground water and entering coastal waters.

Data Gap: Identification of cesspool locations would aid in promoting conversions with the newly enacted tax credit, and 2) waste water system and connections should be reviewed as potential sources.

#### *2.1.5.3 Other Contaminants*

Testing for other potential contaminants has been limited. Water quality data near Kapalua showed pesticides in the water quality samples (Woodley et. al 2013).

> Report assumption: *Because pesticides are probably linked to landscaping and property maintenance efforts, pesticide reduction measures and strategies can be coupled with nutrient reduction until more detailed information on other contaminants is available.*

Research in Progress: A study using semi-permeable membrane devices is looking at possible contaminants that can accumulate in fat tissue by USGS Pacific Coastal and Marine Science Center.

Data Gap: Testing for current use contaminants. Testing for contaminants can be very expensive and should be governed by 1) the likelihood of their presence in the watershed (based on historic human activities/land use) and 2) the potential negative impact on water quality.

## 2.2 Priority Measures Selection

Priority management and policy measures and outreach initiatives have been selected based on their potential to meet the watershed objectives in Chapter 1. The management measures were selected based primarily on their ability to reduce pollutants, while outreach initiatives were selected for both their ability to reduce pollutants and engage the public. The ability of a measure to restore ecosystem functionality was considered where there were approximately equivalent levels of pollutant reduction. Feasibility and costs are significant factors for consideration. Financial and technical feasibility will be addressed in the overall West Maui Watershed Plan.

### 2.2.1 Priority Policy Measures

Priority policy measures (from Chapter 3) are ones that:

- Remove barriers to measure implementation to reduce watershed pollutants (Table 2.1)
- Provide the foundation or framework upon which measures can be can be built (Table 2.2)
- Can directly reduce land based pollution (Table 2.3)

**Table 2.1 Priority Policy Measures: Removing Barriers**

| Policy, Program and Regulation Measures | Expected Results from Barrier Removal | Timeframe to Implement | Implementing Entity | Potential Support / Funding |
|---|---|---|---|---|
| Key | | Short Term < 1 year<br>Mid Term 1-4 years<br>Long Term >5 years | | |
| ***Elimination of conflicting codes for Low Impact Development BMPs***<br>For example, allow subdivisions to use alternatives to curb and gutters to increase storm water infiltration | More widespread use of Low Impact Development (LID) | Short Term | COM Public Works | DOH/EPA |
| ***Community reporting website/phone/mobile app*** | Increase reporting of water quality issues and more timely resolution | Mid Term | COM: IT Services | |
| ***Special Management Permit and/or Shoreline Setback Area Variance exclusion for storm water BMPs*** | Increase the amount of storm water BMPs in the SMA for greater pollutant reduction | Mid Term | Maui County Planning Commission / COM Planning Department | DOH/EPA |
| ***Homeowner association rules cannot exclude rain gardens installation or other storm water BMPs*** | Increase the opportunities for implementing storm water BMPs | Short Term | COM Public Works | DOH/EPA |
| ***Adoption of current International Plumbing Code to allow non-potable water reuse in buildings from rainfall, graywater and treated effluent*** | Decrease the volume of runoff or waste water needing treatment and decrease potable water demand | Short Term (scheduled) | COM Planning Department | |
| ***Streamline permitting for loʻi kalo restoration and establishment*** | Increase loʻi kalo and sediment retention | Short/Mid Term | USACE, State DOH & DLNR CWRM | USACE, State DOH & DLNR CWRM |

**Table 2.2 Priority Policy Measures Needed for Follow-on Efforts**

| Policy, Program and Regulation Measures | Expected Follow-on Effort | Timeframe to Implement | Implementing Entity | Potential Support / Funding |
|---|---|---|---|---|
| Key | Low, Med, High (based on extent of area and degree of impact) | Short Term < 1 year<br>Mid Term 1-4 years<br>Long Term >5 years | | |
| ***Development of an asset management system for storm sewer system including outfall mapping***<br><br>Future projects should be required to provide geo-referenced as-built drainage plans and features | Understanding storm water runoff flows and patterns will help to effectively identify pollutants being transported to nearshore waters and implement measures to reduce the impacts. | Mid Term | COM Public Works | DOH/EPA |
| ***Resolve County policy on vehicle and pool water Disposal*** | Clarify preferred disposal mechanism for development of the Illicit discharge ordinance | Short Term | COM Public Works & Water Reclamation | DOH/EPA |
| ***Ordinances to prohibit illicit discharges*** | Ability to address and minimize illicit discharges | Short Term | COM Public Works | DOH/EPA |
| ***County conservation property tax rate to be equal or be less than agricultural property*** | Increase incentive for placing lands into the Conservation District | Short Term | COM Finance | DLNR DOFAW |

## Table 2.3 Priority Policy Measures: High Impact

| Policy, Program and Regulation Measures | Potential Impact on Pollutant Load Reduction | Timeframe to Implement | Implementing Entity | Potential Support / Funding |
|---|---|---|---|---|
| Key | Low, Med, High (based on extent of area and degree of impact) | Short Term < 1 year<br>Mid Term 1-4 years<br>Long Term >5 years | | |
| ***Comprehensive County Storm Water Management Plan*** | Med/High | Mid/Long Term | COM w/ DOH/EPA assistance | |
| ***Enforcement of temporary construction storm water BMPs*** | Med/High | Mid/Long Term | COM Public Works | DOH/EPA |
| ***Revisions to post construction storm water ordinance: drainage master plan requirement*** | High | Mid Term | COM Public Works | DOH/EPA |
| ***Requirement for development and redevelopment projects > 1 acre*** (State, County & private sector) ***to incorporate LID measures into design and construction*** | Med/High | Short/Mid Term | COM Public Works | DOH/EPA |
| ***Requirement for active BMP management plans and reporting for large scale users of pesticides and nutrients*** | Med/High | Short Term | COM Public Works | DOH/EPA/ NRCS/ WMSWCD |
| ***Agricultural Conservation Plan Requirement for All Ag Lands (could be part of requirement for ag use assessment for lower property tax rate) with:***<br>• Erosion and Sediment Controls<br>• Nutrient Management<br>• Pesticide Management<br>• Irrigation Management<br>***including Conservation Plan Implementation Verification Program with penalties for non-compliance and updates every 5 years*** | Med/High | Mid/Long Term | COM Planning and Finance | NRCS/ WMSWCD |

**Table 2.3 Priority Policy Measures: High Impact (Continued)**

| Policy, Program and Regulation Measures | Potential Impact on Pollutant Load Reduction | Timeframe to Implement | Implementing Entity | Potential Support / Funding |
|---|---|---|---|---|
| Key | Low, Med, High (based on extent of area and degree of impact) | Short Term < 1 year<br>Mid Term 1-4 years<br>Long Term >5 years | | |
| ***Water quality monitoring program*** | Med/High | Mid Term | State DOH / COM Public Works & Wastewater Reclamation | DOH/EPA/ DAR |
| ***Storm water fees establishment***<br>Storm water fees would provide funding for storm water projects & retrofits | Med/High | Long | COM Finance / Public Works | DOH/EPA |

### 2.2.2 Stream & Gulch / Agricultural & Conservation Management Measures Priorities

The priority management measures were chosen based on their ability to reduce pollutants and feasibility to implement. Opportunities to engage the West Maui community with these measures may be limited due to access issues; however, whenever possible community opportunities should be provided. Priority management measures are listed in Table 2.4.

**Table 2.4 Priority Stream, Gulch, Agriculture and Conservation Management Measures & Subwatershed Applicability**

| Management Measures | Subwatersheds | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Kahana | Ka'ōpala | Honokeana | Nāpili 4-5 | Nāpili 2-3 | Honokahua | Mokupe'a | Kahauiki | Honolua |
| **STOP SEDIMENT FROM ENTERING STREAMS** | | | | | | | | | |
| ***Push Pile Assessment and Stabilization*** | x | x | x | x | x | x | x | x | x |
| ***Stream Crossings Stabilization*** | **P** | x | x | x | x | x | x | x | **P** |
| ***Access Road Improvements*** | x | x | x | x | x | x | x | x | x |
| **PREVENT FUTURE SEDIMENT SOURCES** | | | | | | | | | |
| ***Construction Best Management Practices*** | x | x | x | **P** | **P** | **P** | x | x | x |
| ***Grazing Best Management Practices*** | x | x | | | | | | | |
| ***"Go Time" Wildfire Plan*** | x | x | x | x | x | x | x | x | x |
| **KEEP EXISTING IN STREAM SEDIMENT DEPOSITS FROM MOVING DOWN STREAM TO THE OCEAN** | | | | | | | | | |
| ***Identification of Sediment Terraces*** | x | | x | x | x | x | x | x | x |
| ***Researching, Piloting and Implementation of Stream/Gulch Bank Management Measures*** | **P** | **P** | **P** | **P** | **P** | **P** | **P** | **P** | **P** |
| **ADDRESS CURRENT INSTREAM SEDIMENT MOVEMENT** | | | | | | | | | |
| ***Restoration of Traditional Lo'i Kalo***[1] | **P** | nd | nd | nd | nd | **P** | nd | nd | **P** |
| ***Kahana Desilting Basin Maintenance*** | **P** | | | | | | | | |
| ***Desilting Basin Monitoring and Analysis*** | **P** | **P** | x | x | **P** | | | | |
| ***Desilting Basin Retrofits*** | **P** | **P** | x | | x | | | | |
| ***Potential New Desilting / Sediment Basins*** | x | x | x | x | x | x | x | x | x |
| **IMPROVE GROUND WATER RECHARGE AND SLOW SURFACE WATER FLOWS** | | | | | | | | | |
| ***Conservation Boundary Fencing*** | x | x | x | x | x | x | x | x | x |
| ***Active Ungulate & Invasive Weed Management*** | x | x | x | x | x | x | x | x | x |
| ***Landscape Restoration*** | x | x | x | x | x | x | x | x | x |

Legend: **P** indicates priority subwatershed
x denotes applicable subwatersheds
nd means not determined at this time
Shaded cells are subwatersheds in which the management measure is not applicable.

[1] Based on data provided in the Statewide Agricultural Land Use Baseline (2015); available stream flow will be the determining factor.

### 2.2.3 Priority Urban Management Measures

The priority urban measures include management measures (Chapter 6), policy measures (Chapter 3) and outreach initiatives (Chapter 7). Priorities are based on the measures ability to have an overall positive impact on reducing pollutant contributions.

#### *2.2.3.1 Urban Policy Measure Priorities*

***Comprehensive Storm Water Management Plan***
A comprehensive County Storm Water Management Plan (SWMP) would have significant impacts on reducing water quality pollutants. Some of the items listed below would be part of a SWMP; however, development and implementation of the whole SWMP is recommended.

***Low Impact Development (LID) requirement for development, redevelopment and improvement projects > 1 acre (State, County and private sector) to incorporate LID into design and construction***
The County agencies and private developers should be mandated and private developers highly encouraged to implement LID management measures / retrofits whenever improvements are being designed and/or installed.

***Increased Enforcement of Construction Storm Water BMPs***
With appropriate selection and timely use, construction storm water BMPs are effective ways to prevent pulses of sediments from leaving construction sites and moving into nearshore waters. Zero sediment impacts from construction activities should be the goal. Implementation of construction storm water BMPs are more efficient and technically feasible than addressing sediments once they enter waters. Education is critical for designers, developers, and enforcement personnel to ensure outcome driven storm water prevention plan implementation.

***Storm Water Fee Establishment***
A storm water management fee would provide a funding source for storm water retrofits. Lack of funding is a significant barrier to implementing many of the management measures in this chapter.

***Golf Courses and Landscaping BMP Management Plans***
Golf courses and landscaping practices in the Kapalua area and other places along the coastline contribute nutrients and pesticides to nearshore waters. Fertilizer requirements and pesticide usage should be evaluated, with subsequent management efforts pursued to eliminate leaching into ground water or runoff. This may involve analyzing soil needs to prevent excess nutrient application, scheduling applications to reduce runoff, and using slow-release fertilizers and integrated pest management techniques. Education on fertilizer and pesticide usage and installation of vegetated filter strips and installation of raingardens along the coastline can reduce the amount of nutrient and pesticides entering nearshore waters. Irrigation usage should be minimal or extremely controlled to reduce transport of fertilizers and pesticides into nearshore waters.

***Pool and Vehicle Wash Water Discharge Policy***
The County of Maui will need to determine the appropriate pool and vehicle wash water disposal methods, and inform pool owners and others. The follow up steps should include monitoring and enforcement to reduce these pollutant contributions.

***Storm Water Management Asset Mapping (including outfall mapping)***
***Regional Drainage Analysis***
These two gaps need to be addressed to aid in the identification of contributing pollutants and their sources. Without this understanding the linkage of sources with water quality issues, identification of specific pollutant sources will be difficult. A regional drainage analysis will assist in planning for LID retrofits in existing neighborhoods.

*2.2.3.2 Urban Management Measure Priorities*

***Roadside Erosion***
Roadside erosion is also a priority for sediments to address identified erosion along Honoapi'ilani Highway and Lower Road. To make a case for securing these roadside sediments, erosion rates could be monitored and assessed. For Lower Road, LID infrastructure could create a win-win situation with Green Streets which provide improved drainage, storm water treatment, and pedestrian and bicyclist experience by integrating multi-purpose traffic calming devices. For example, narrowing the roadway in certain sections creates places for vegetation that can increase storm water infiltration and the reduced roadway width has been shown to slow vehicular traffic speed.

***Cesspool Conversion***
With recent legislation (House Bill (HB) 1140) a tax credit will be available to upgrade certain cesspools. Properties that meet the criteria should be identified, and every effort made to inform landowners of the available tax credit. This may entail door-to-door surveys to identify properties without sewer connections as this information is not available from the County.

***Urban Storm Water Management Retrofits***
The County agencies and private developers should be mandated to implement storm water management measures (Table 6.7) when infrastructure improvements are being designed or installed. Funding or permitting mechanisms and incentives should also be used to encourage developers to adopt these measures.

As water quality data and drainage and storm water system maps are available, specific pollutant sources and geographic areas can be targeted. In the meantime, urban retrofits are encouraged throughout the three watersheds were opportunities existing. Data should be used to target subwatersheds with specific hot spots, and general priorities are along the coast and sites that have direct drainage to gulches or streams.

Wherever possible, management measures in public areas should have interpretive signage included that explains storm water management strategy in order to build awareness, pride and support for other management and policy measures. To promoted urban LID retrofits, developers, designers, County staff, construction industry and property managers should be educated on the LID approach and techniques.

### 2.2.4 Priority Outreach Initiatives

The following outreach priority initiatives are from Chapter 7 Public Outreach Plan and listed with possible implementers and funding needs (Table 2.5). The highest overall priority for outreach is to continue funding watershed and outreach coordinators as they implement these measures.

**Table 2.5 Priority Outreach Initiatives**

| Outreach Initiatives | Implementing Entity | Potential Support / Funding |
|---|---|---|
| ***1) West Maui Kumuwai Campaign*** | WMR2R | DOH / EPA / WMR2R / COM |
| ***2) Community Stewardship Program*** | WMR2R | |
| ***3) Construction Industry Outreach on Storm water Best Management Practices*** | COM Public Works | DOH / EPA / WMR2R/CORAL |
| ***4) Low Impact Development Training*** | COM Public Works | DOH / EPA / WMR2R |
| ***5) Landscapers and Property Managers Outreach*** | WMR2R / COM Public Works | COM Public Works / DOH / EPA |
| ***6) Pu'u Kukui Watershed Preserve Public Outreach Campaign*** | ML&P | Many partners |

### 2.2.5 Priority Data Gaps

The Data Gaps listed throughout this chapter are summarized in Table 2.6 and assigned a relative priority in terms of the ability of the gap to guide work to address the overall goal of improving the coral reef ecosystems.

**Table 2.6 Data Gaps Summary and Timeline**

| DATA GAPS | | Implications |
|---|---|---|
| **Immediate/Short Term Priority Data Gaps** | | |
| A | **Sediments Locations in Streams & Gulches** (already completed: Pāpua & Ka'ōpala Gulches) | Sediment locations will help to prioritize subwatersheds. |
| B | **Identification of Measures to Address Accumulated Stream and Gulch Sediments** | Expert knowledge to be solicited and inform pilot projects. |
| C | **Effectiveness of Existing Desilting Basins** | This will guide retrofit plan development. |
| D | **Storm Water System Mapping** | Mapping will provide for better placement of urban retrofits. |
| E | **Regional Drainage Analysis** | This analysis will identify storm water flows to guide urban retrofit placement. |
| F | **Water Quality Testing for Nitrogen Stable Isotope Ratios** (Delta N-15) | Testing would help to identify potential nutrient sources. |
| G | **Well testing for Nitrogen** | This data can be compared with 1997 data to track ground water nutrients. |
| H | **Identification of Cesspool Locations** | Cesspool locations will guide promotion of upgrades. |
| I | **Baseline Testing for Current Use Contaminants** | Current use contaminant data is needed to assess impacts and identify sources. |
| **Mid Term Priority Data Gaps** | | |
| J | **Further Research on Pollutant Impacts on Corals** | The research would help identify relative pollutant impacts. |
| K | **Genetic Testing of Coral Offshore and Coral Larvae "seed" Sources in Southern West Maui** | Testing would help to ensure protection of West Maui coral larval sources. |
| L | **Waste Water System & Connections Assessment** | This assessment will help to identify nitrogen and other pollutant sources. |
| M | **Bacteriological Testing** | This will inform water quality exceedances and human and coral reef health implications. |
| N | **Submarine Ground Water Discharge** | Nutrients and contaminants from this pathway would aid in better understanding sources. |
| **Long Term Priority Data Gaps** | | |
| O | **Periodic Testing for Emerging Contaminants of Concern** | Emerging contaminants of concern need to tracked and monitored. |
| P | **Land Use / Cover Hydrology Impacts** | This data gaps would support efforts to predict impacts of land cover and land use and changes. |
| Q | **Streamflow Data** | This data would help in quantifying pollutant loading and monitoring of restoration efforts. |

## 2.3 Next Steps

No single entity can single-handedly develop and implement a watershed plan. The efforts of government agencies, landowners, non-profits, residents and visitors are all important components of successfully implementing a watershed plan conducive to a state of healthy coral reef ecosystems.

Due to data gaps, some projects will require additional information and analysis before specific efforts can be implemented. Therefore, next steps include both addressing of data gaps and implementation of priority measures.

Monitoring to see how the system is responding, and adaptive management to assess the changes are also critical components of an overall strategy for learning from efforts and adjusting future measures to reduce land-based sources of pollutants, improve water quality and ultimately restore the health and resiliency of the West Maui coral reef ecosystems.

# 3.0 POLICIES, PROGRAMS AND REGULATIONS

Policies, programs and regulations at Federal, State and County levels guide existing and proposed land use in an effort to protect natural resources from impacts due to human activities. Existing policies, programs and regulations relevant to activities within the watersheds are described in Appendix D. The County of Maui listing of proposed development provides the context of future development and shows opportunities to maintain water quality during construction and post construction (Section 3.1).

New and revised policy and programmatic measures including regulations to improve and enhance protection of the natural resources within the watersheds are presented in Section 3.2 along with a rough assessment of the policy measure's relative contribution toward pollutant reduction and an implementation timeframe. Priority policy measures for implementation are described in Section 3.3.

## 3.1 County of Maui: Proposed Development Listing

Residential development projects are tracked by County of Maui Department of Planning Long-Range Planning Division. These projects are listed by the County categories in Table 3.1 and shown in Figure 3.1. The extent to which the developments have obtained the needed permits prior to construction is also provided to show where there are opportunities for working with developers to minimize pollutant impacts.

For the County of Maui list of proposed development in Kahana, Honokahua and Honolua watersheds, most projects already have the needed permits with the exception of building permits. However, care should be taken that conditions of the permits and entitlements obtained are enforced. These projects should also incorporate Plan recommendations such as stream and gulch buffers and setbacks. The use of low impact development should be encouraged and may have benefits to the developer as well (Chapter 6).

The County Proposed Development listing is from February 2014 and additional development projects may be added in the future. Agricultural subdivisions and projects within the Maui Island Plan growth boundary may not be tracked by the County of Maui Planning Department as they do not necessarily require land use entitlements.

## Table 3.1 County of Maui Development Projects Mapping List

| Name of Project | Extent (Acres) | Single Family Units | Multi-Family Units | Time Share / Resort | Maui Island Plan (MIP) Conformance | West Maui Community Plan Conformance | Environmental Impact Statement (EIS) or Environmental Assessment (EA) | State Land Use District Amendment | County Zoning Conformance | Special Management Use Permit | Grubbing & Grading / Building Permits |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Committed (Entitled) Projects**[1] | | | | | | | | | | | |
| Kapalua Mauka Residential | 919 | 690 | - | - | Yes | Yes | Completed | Obtained | Yes | NA | No |
| Pailolo Place | 4 | - | 42 | - | Yes | Yes | NA | Conforming | Yes | No | No |
| West Maui Village Affordable Condominiums | 10 | - | 158 | - | Yes | Yes | NA | Conforming | Yes | NA | Yes |
| Pulelehua | 319 | 935 | 214 | - | Yes | Yes | Completed | Obtained | Yes | NA | No |

Shaded boxes highlights entitlement or overlay has been fulfilled or is not applicable

[1] Projects identified as "committed" have inclusion in the Maui Island Plan Growth Boundaries and generally have conforming Community Plan and zoning entitlements. "Committed" refers to the status of the land relative to the primary county land use entitlement, but is in no way intended to convey the level of commitment by the land owner or the developer to proceed with development or convey any time frame for development.

*Source: County of Maui's Department of Planning Long-Range Planning Division, February 2014 and County of Maui Planning Department for Special Management Use Permits and Grubbing and Grading/Building Permit information (June 2015)*

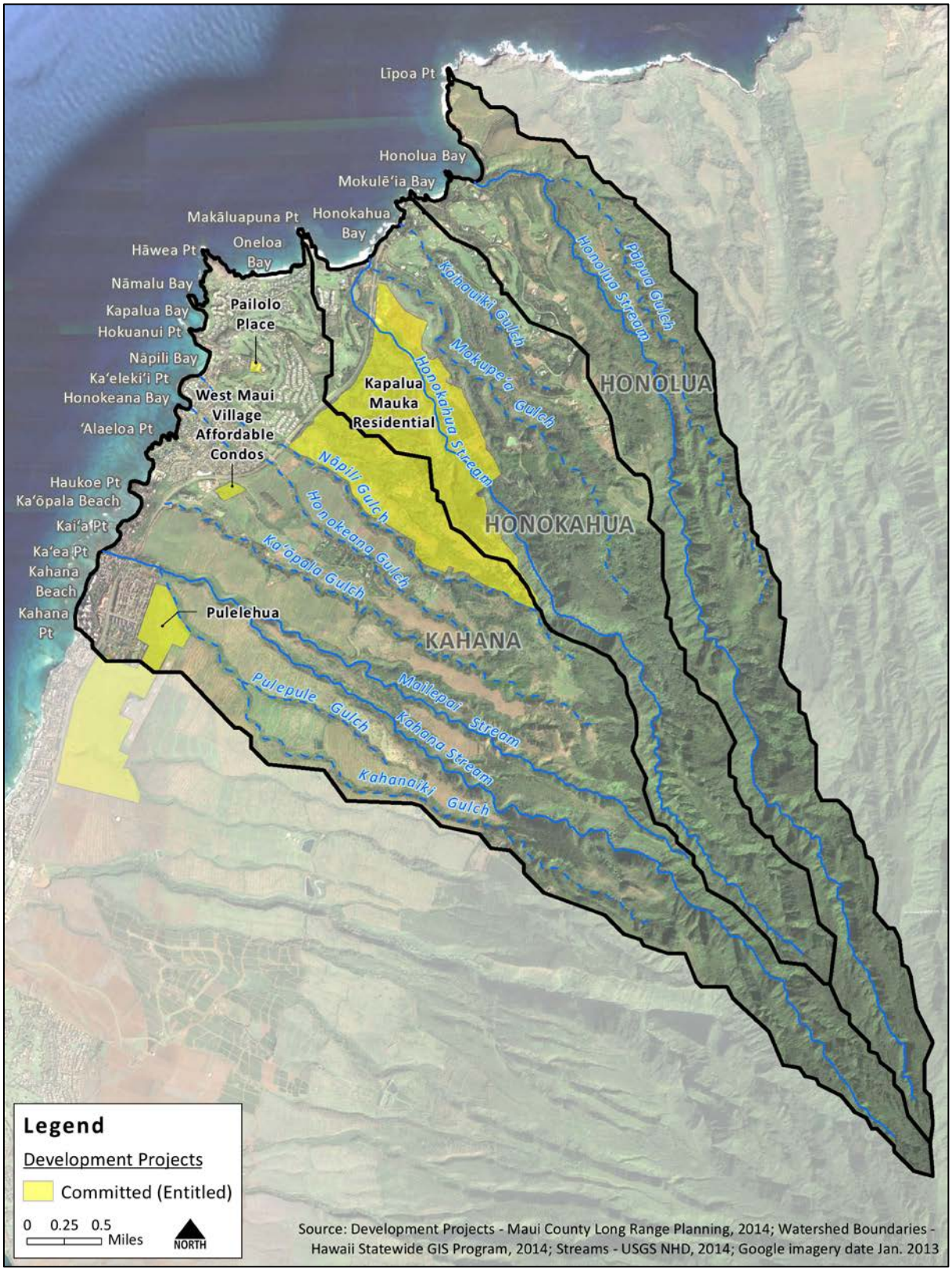



**Figure 3.1 County of Maui Development Projects Mapping**

## 3.2 Potential Policies, Programs and Regulations

Policies, programs and regulations play an important role in preventing pollution from occurring in the first place. Pollution prevention is preferable over mitigating pollution which is resource intensive and usually less effective. This section presents new policy measures, and potential additional or expanded policies, programs and regulations to reduce pollutant loading based on known pollutant sources and existing regulations.

Policies, programs and regulations lay the groundwork for affecting behavior changes through incentives and penalties. Enforcement and reporting programs also play a role in behavioral changes. Educational programs, such as those promoting alternatives to pesticides or providing information on proper chemical storage, are needed in concert with the policies (Chapters 6-7).

The policy measures are presented by land use in Table 3.2 Urban Policy Measures, Table 3.3 Agricultural, Conservation, Golf Course and Landscaping Policy Measures and Table 3.4 Stream and Other Policy Measures. All policy measures will need to be reviewed and vetted by the County of Maui.

For each policy measure the following information is provided:

- **Impact on Pollutant Load Reduction**
  This is a rough order of magnitude estimate based on what area the policy measure might impact and its degree of impact.

- **Timeframe to Implement**
  The timeframe to implement is based on the ability of the implementing entity to enact the policy measure, as well as a consideration for the political support that might be needed.

- **Implementing Entity**
  The entity named to implement the project will most likely come from one of the various County of Maui departments and divisions. This listing should not be construed as agreement to implement policy measures but rather a list of entities that might be able to implement the potential measure.

- **Potential Support / Funding**
  Most of the policy measures will require some level of support such as funding, technical support. The County of Maui is unable to bear this responsibility alone. Possible supporting entities are listed not as commitments, but rather as possibilities. In some cases the support provided may come from competitive grants.

**Abbreviations used in Tables 3.2, 3.3 & 3.4:**

| | |
|---|---|
| COM=County of Maui | EPA= US Environmental Protection Agency |
| DLNR=Department of Land and Natural Resources | NRCS=Natural Resources Conservation Service |
| DOFAW=Division of Forestry and Wildlife | WMSWCD=West Maui Soil and Water Conservation District |
| DOH=Hawai'i State Department of Health | |

## Table 3.2 Potential Urban Policy Measures

| Policy, Program and Regulation Measures | Potential Impact on Pollutant Load Reduction | Timeframe to Implement | Implementing Entity | Potential Support / Funding |
|---|---|---|---|---|
| Key | Low, Med, High (based on extent of area and degree of impact) | Short Term < 1 year<br>Mid Term 1-4 years<br>Long Term >5 years | | |
| **URBAN STORM WATER** | | | | |
| **COMPREHENSIVE COUNTY STORM WATER MANAGEMENT PLAN** *(subsections listed below)* | Med/High | Med/Long Term | COM Public Works | DOH/EPA |
| **Development of an asset management system for storm sewer system including outfall mapping**<br>Future projects should be required to provide geo-referenced as-built drainage plans and features | Med/High | Mid Term | COM Public Works | DOH/EPA |
| **Construction Site Runoff Control** | | | | |
| **Trainings and materials for contractors, developers and County personnel on effective implementation of construction storm water BMPs**<br>Consider a Recognition or Certification Program for Developers and Contractors on Construction Pollution Prevention with possible incentives for projects with certified individuals | Med | Short Term | COM Public Works | DOH/EPA |
| **Increased enforcement of construction storm water BMPs** with a requirement to fund 3rd Party review where County finds plans or implementation inadequate | Med/High | Mid/Long Term | COM Public Works | DOH/EPA |

**Table 3.2 Potential Urban Policy Measures (Continued)**

| Policy, Program and Regulation Measures | Potential Impact on Pollutant Load Reduction | Timeframe to Implement | Implementing Entity | Potential Support / Funding |
|---|---|---|---|---|
| Key | Low, Med, High (based on extent of area and degree of impact) | Short Term < 1 year<br>Mid Term 1-4 years<br>Long Term >5 years | | |
| **COMPREHENSIVE STORM WATER MANAGEMENT PLAN** *(subsections listed below) – continued* | | | | |
| **Post-Construction Runoff Control** | | | | |
| **Revisions to post construction storm water ordinance: drainage master plan requirement** with loading, assessment and confirmation of BMPs to address load reductions, approval of a separate post construction BMP plan, owner certifications, O&M plans, regular reporting and testing, cumulative impact assessment | High | Mid Term | COM Public Works | DOH/EPA |
| **Revisions to post construction storm water ordinance: increased mandatory retention of storm runoff** | Med | Mid Term | COM Public Works | DOH/EPA |
| **Trainings and materials for engineers, architects and developers** on BMPs selection and integration into site design | Med | Short Term | COM Public Works | DOH/EPA |
| **Prescriptive storm water BMPs** for small developments < 1 acre | Low/Med | Mid Term | COM Public Works | DOH/EPA |
| **Regular inspection of storm water BMPs** with penalties for lack of maintenance | Low/Med | Mid Term | COM Public Works | DOH/EPA |
| **Homeowner Association rules must allow for rain gardens installation and other storm water BMPs** | Low | Short Term | COM Public Works | DOH/EPA |

**Table 3.2 Potential Urban Policy Measures (Continued)**

| Policy, Program and Regulation Measures | Potential Impact on Pollutant Load Reduction | Timeframe to Implement | Implementing Entity | Potential Support / Funding |
|---|---|---|---|---|
| Key | Low, Med, High (based on extent of area and degree of impact) | Short Term < 1 year<br>Mid Term 1-4 years<br>Long Term >5 years | | |
| **COMPREHENSIVE STORM WATER MANAGEMENT PLAN** *(subsections listed below) – continued* | | | | |
| **Special Management Permit and/or Shoreline Setback Area Variance Exclusion for Storm water BMPs** implementation along coastline | Low/Med | Mid Term | Maui County Planning Commission / COM Planning Department | DOH/EPA |
| **Elimination of conflicting codes for Low Impact Development BMPs** (e.g. allow subdivision roads without curb and gutters)* | Med/High | Short Term | COM Public Works | DOH/EPA |
| **Low Impact Development requirement for development, redevelopment and improvement projects > 1 acre (State, County and private sector) to incorporate LID measures into design and construction** | Med/High | Short Term | COM Public Works | DOH/EPA |
| **Illicit Discharge Detection and Elimination** | | | | |
| **Development of an asset management system for storm sewer system*** | High | Mid Term | COM Public Works | DOH/EPA |
| **Ordinances to prohibit illicit discharges*** | Med/High | Short Term | COM Public Works | DOH/EPA |
| **Program to detect and enforce illicit discharges** | Low/Med | Mid Term | COM Public Works | DOH/EPA |

*This project is a precursor to other efforts and potential impact considers that this enables other pollution reduction efforts.

**Table 3.2 Potential Urban Policy Measures (Continued)**

| Policy, Program and Regulation Measures | Potential Impact on Pollutant Load Reduction | Timeframe to Implement | Implementing Entity | Potential Support / Funding |
|---|---|---|---|---|
| Key | Low, Med, High (based on extent of area and degree of impact) | Short Term < 1 year<br>Mid Term 1-4 years<br>Long Term >5 years | | |
| **COMPREHENSIVE STORM WATER MANAGEMENT PLAN** *(subsections listed below) – continued* | | | | |
| **Onsite Sewage Disposal Systems (OSDS) requirement for treatment** | Number of OSDS is unknown | Short Term | COM Public Works | DOH/EPA |
| **Participation in a comprehensive water quality monitoring program (see Chapter 8)** | Med/High | Mid Term | State DOH / COM Public Works & Wastewater Reclamation | DOH/EPA/DAR |
| **Educational program development regarding illicit discharge hazards** (chemical storage, wash water) | Low/Med | Short Term | COM Public Works | DOH/EPA/DAR/ Kumuwai |
| **Community reporting via website/phone/mobile platform** and allow anonymous complaints | Low | Mid Term | COM: IT Services | |
| **Pollution Prevention/Good Housekeeping** | | | | |
| **Require active BMP management plans and reporting for large scale users of pesticides and nutrients** (Ag and Urban lands) | Med/High | Short Term | COM Public Works | DOH/EPA/NRCS/ WMSWCD |
| **Adoption of ordinances to promote good housekeeping** (e.g. require covered dumpster storage) | Low/Med | Mid Term | COM Public Works | DOH/EPA |
| **County and State pollution prevention programs** | Low/Med | Short Term | COM Public Works | DOH/EPA/West Maui Kumuwai/ State DOT Highways |

**Table 3.2 Potential Urban Policy Measures (Continued)**

| Policy, Program and Regulation Measures | Potential Impact on Pollutant Load Reduction | Timeframe to Implement | Implementing Entity | Potential Support / Funding |
|---|---|---|---|---|
| Key | Low, Med, High (based on extent of area and degree of impact) | Short Term < 1 year<br>Mid Term 1-4 years<br>Long Term >5 years | | |
| **COMPREHENSIVE STORM WATER MANAGEMENT PLAN** *(subsections listed below) – continued* | | | | |
| **Public Education and Outreach** | | | | |
| **Information to residents and businesses** on reducing storm water discharge impacts on local water bodies | Low/Med | Short Term | COM Public Works | DOH/EPA/West Maui Kumuwai |
| **Funding Options** | | | | |
| **Storm water fee establishment**<br>Storm water fees could provide additional funding for Storm water projects and retrofits above what is currently available with Department of Health Clean Water Act 319 funding.<br>Fees could be flat fee or based on percent impervious surface with reductions for projects that provide retention and treatment on site. | Med/High | Long Term | COM Finance & Public Works | DOH/EPA |
| **Revolving fund for urban project retrofits**<br>Using County Storm Water fees a Revolving Fund could be established for low impact development retrofits such as pervious paving to replace standard paving, and bioswales and raingarden construction. | Low | Long Term | COM Finance | DOH/EPA |

**Table 3.2 Potential Urban Policy Measures (Continued)**

| Policy, Program and Regulation Measures | Potential Impact on Pollutant Load Reduction | Timeframe to Implement | Implementing Entity | Potential Support / Funding |
|---|---|---|---|---|
| Key | Low, Med, High (based on extent of area and degree of impact) | Short Term < 1 year<br>Mid Term 1-4 years<br>Long Term >5 years | | |
| **URBAN WATER** | | | | |
| Development / Resort **landscaping requirement to eliminate or limit irrigation using potable water** | Low | Short Term | COM Water Supply | |
| **Adoption of current International Plumbing Code to allow non-potable water reuse in buildings** from rainfall, graywater and treated effluent | Low | Short Term (scheduled) | COM Planning Department | |
| **Water fee structure revision** to provide greater incentives for water conservation | Low | Long Term | COM Water Supply | |
| **URBAN WASTEWATER** | | | | |
| **Requirement that treated wastewater meet water reuse standards** (for large scale development) | Low | Mid Term | COM Water Reclamation | |
| **Restriction of effluent discharge into ground (e.g. use of zero discharge wastewater systems)** | Med | Mid Term | COM Water Reclamation | |
| **Code update on pool and vehicle wash water disposal** (prohibited into Wastewater system and not desirable into nearshore waters)* | Med | Short Term | COM Public Works & Water Reclamation | DOH/EPA |

*This project is a precursor to other efforts and potential impact considers that this enables other pollution reduction efforts.

**Table 3.2 Potential Urban Policy Measures (Continued)**

| Policy, Program and Regulation Measures | Potential Impact on Pollutant Load Reduction | Timeframe to Implement | Implementing Entity | Potential Support / Funding |
|---|---|---|---|---|
| Key | Low, Med, High (based on extent of area and degree of impact) | Short Term < 1 year<br>Mid Term 1-4 years<br>Long Term >5 years | | |
| **URBAN WASTEWATER (Continued)** | | | | |
| **Promote the conversion of cesspools to higher level of wastewater treatment** especially in areas located within 200 feet from a shoreline, perennial stream, wetland or a source water assessment area which are eligible for tax credits | Low/Med | Short/Mid Term | Individual Landowners | State of Hawai'i tax credits |
| **URBAN DEVELOPMENT** | | | | |
| **Promotion of development clustering to minimize impervious surfaces** | Low/Med | Mid Term | COM Public Works / Planning | |
| **Promotion of multi-use open spaces** (including parks) **for fire prevention and infiltration opportunities** | Low/Med | Long Term | COM Public Works / Parks & Rec | |
| **PRODUCT BANS** | | | | |
| **Possible product bans** for certain brake types (asbestos, copper, other metals), cold tar sealant, sunscreens with oxybenzone and benzophenone-2 and spray sunscreens with coral reef health implications | Unknown | Mid Term | COM / State Department of Health | |

**Table 3.3 Potential Agricultural, Golf Course, Landscaping & Conservation Policy Measures**

| Policy, Program and Regulation Measures | Potential Impact on Pollutant Load Reduction | Timeframe to Implement | Implementing Entity | Potential Support / Funding |
|---|---|---|---|---|
| Key | Low, Med, High (based on extent of area and degree of impact) | Short Term < 1 year<br>Mid Term 1-4 years<br>Long Term >5 years | | |
| **AGRICULTURE, GOLF COURSE & LANDSCAPING** | | | | |
| **Agricultural Conservation Plan requirement for all ag lands** (could be part of requirement for ag use assessment for lower property tax rate) with:<br>• **Erosion and Sediment Controls**<br>• **Nutrient Management**<br>• **Pesticide Management**<br>• **Irrigation Management**<br><br>Golf courses should follow the *Guidelines Applicable to Golf Courses in Hawai'i* (July 2002 – Version 6).<br><br>including **Conservation Plan Implementation Verification Program** with penalties for non-compliance and updates every 5 years. | Med/High | Mid/Long Term | COM Planning and Finance | NRCS / WMSWCD |
| **Access road requirements under grubbing and grading** (length of access road as trigger)<br>• Require measures to route water for infiltration instead of runoff and streamside management, and with stream crossing measures to minimize stream impacts<br>• Develop a manual on design and maintenance<br>• Enforce the requirement and have violations for non-compliance | Med | Mid/Long Term | COM Planning | NRCS / WMSWCD |

## Table 3.3 Potential Agricultural, Golf Course, Landscaping & Conservation Policy Measures

| Policy, Program and Regulation Measures | Potential Impact on Pollutant Load Reduction | Timeframe to Implement | Implementing Entity | Potential Support / Funding |
|---|---|---|---|---|
| Key | Low, Med, High (based on extent of area and degree of impact) | Short Term < 1 year<br>Mid Term 1-4 years<br>Long Term >5 years | | |
| **AGRICULTURE, GOLF COURSE & LANDSCAPING (continued)** | | | | |
| **Fuel management requirement for agricultural lands** | Med/High | Short/Mid Term | COM Fire and Public Safety | NRCS |
| **Requirement for landscaped areas > 1 acre have a post construction drainage and storm water management plan** | Med | Short/Mid Term | COM Public Works | |
| **Covenants, Conditions, and Restrictions (CC&R) to prohibit invasive species** to prevent spread into conservation areas and reduce potential fuel loads | Low | Short Term | COM Fire and Public Safety | |
| **Standards for fuel breaks in new development** (can be multi-purpose e.g. bike or walking path) | Low/Med | Short Term | COM Planning | DOH/EPA/DLNR DOFAW |
| **Fee levied on nutrient and pesticides sales to fund mitigation and prevention measures** | Med | Mid/Long Term | COM Finance | DOH |
| **CONSERVATION** | | | | |
| **Strengthen penalties for transfer of game species** | Low | Short Term | COM/State | |
| **Expansion** (double or triple) **the Watershed Partnership Grant Program** | Med | Short/Mid Term | COM Water Supply | |
| **Hiring of additional inspectors to prevent entry of invasive species at ports of entry** | Low | Mid/Long Term | Department of Agriculture | |
| **County conservation property tax rate to be less than agricultural property** | Low | Short Term | COM Finance | DLNR DOFAW |

## Table 3.4 Potential Stream & Other Policy Measures

| Policy, Program and Regulation Measures | Potential Impact on Pollutant Load Reduction | Timeframe to Implement | Implementing Entity | Potential Support / Funding |
|---|---|---|---|---|
| Key | Low, Med, High (based on extent of area and degree of impact) | Short Term < 1 year<br>Mid Term 1-4 years<br>Long Term >5 years | | |
| **STREAM/RIPARIAN** | | | | |
| **Requirement of riparian** – or more specifically Gulch/Stream Edge - **setbacks for future development** (Agriculture and Other Uses) | Med/High | Mid/Long Term | COM Planning | DOH/EPA |
| **Conservation easements** of Acquisition for Planned Development with Land Use Entitlements | Med/High | Short-Long Term | Land Trusts & landowners | County and State, non-profits orgs |
| **Use of County Open Space Districts for stream corridors; pursue possible conversion to State Conservation** with tax incentives (see above) | Med/High | Short-Long Term | COM Planning | DLNR |
| **Encourage soft engineering for stream banks and riparian areas** instead of hardening | Med | COM Planning | COM Planning | |
| **Streamline permitting for loʻi kalo restoration and establishment** | High | Mid Term | USACE, State DOH & DLNR CWRM | USACE, State DOH & DLNR CWRM |
| **OTHER** | | | | |
| Continuance of the **Ridge 2 Reef Initiative through ongoing funding to support coordination positions** | Med/High | Short-Long Term | Non-profit orgs. | Government agencies, non-profits, grants, etc. |

## 3.3 Priority Policy Measures

Priority policy measures for implementation fall into three categories:

- Policy measures to remove barriers to reducing reduce pollutants.
- Policy measures needed before follow-on efforts can be effectively implemented.
- High impact policy measures in pollutant reduction.

### 3.3.1 Policy measures needed to remove barriers:

- **Elimination of conflicting codes for Low Impact Development BMPs**

  Some tools and techniques for implementing Low Impact Development (LID) (Section 6.1.3) are not allowed under current County of Maui Code of Ordinances. For example, curbs and gutters are required for urban subdivisions. However, bioswales should be an allowable alternative which also improves water quality. Other codes could be updated to allow smaller street widths and decrease the amount of impervious surfaces. The Center for Watershed Protection's Code & Ordinance Worksheet is being used to further identify the areas where code revisions may be needed.

- **Community reporting website/phone number/mobile app** (allow anonymous community complaints to encourage reporting)

  Community reporting of storm water violations (e.g. construction sediment runoff, illegal connections to the storm water system, dumping of wash water into streams) expands the ability of the County to identify and address these issues. Having a convenient and anonymous mechanism for reporting will further increase the effectiveness and reach of the County's efforts. Note: this would also help to meet the second plan objective of community empowerment and participation.

- **Special Management Permit and/or Shoreline Setback Area Variance Exclusion for Storm Water BMPs implementation along coastline.**

  Properties along the shoreline often have limited space for management measures to slow and treat storm water. Appropriate management measures, such as installing hydrodynamic separators or rain gardens with subterranean drainage, can trigger the need for a Special Management Area Permit or variance. These permits can have significant costs that may exceed project costs. Allowing for a variance for improvements that improve water quality and/or reduce or slow runoff entering near shore waters could increase the number of management measures installed. Until this barrier is resolved, projects inside the SMA may be limited to filter / buffer strips and outreach to affect behavioral changes.

- **Homeowner Association rules cannot exclude rain gardens installation or other storm water BMPs.**

  Homeowner association rules set expectations for landowner behaviors and land uses. Typically association rules address behaviors that would interfere with other property owners' use and enjoyment of the property, including aesthetics of improvements. However, these rules should support an individual's ability to install a raingarden or other system for storm water capture and reuse, provided it is consistent the pre-determined aesthetic of the development.

- **Adoption of current plumbing code to allow non-potable water reuse in buildings** from rainfall, graywater and treated effluent.

  Maui County should adopt the current Plumbing Code which would allow non-potable water reuse in buildings. This could reduce the amount of runoff by allowing capture and reuse – and could reduce waste water treatment by allowing gray water reuse.

- **Streamline permitting for loʻi kalo restoration and establishment**

  The permitting process for loʻi kalo (taro paddies) is very costly and time consuming (Appendix D). It can require permits / approval from US Army Corps of Engineers, State Department of Health and State Department of Land and Natural Resources Commission on Water Resource Management. Streamlining this permitting process would facilitate the re-establishment of loʻi kalo which can function as stream microbasins to capture stream sediments.

### 3.3.2 Policy measures that serve as precursors to follow-on efforts:

- **Development of an asset management system for storm sewer system.**

  A storm water asset management system would assist in identification of pathways water takes before reaching the ocean. When water quality issues are identified, pollutants may be more readily traced to sources. The asset management system would also assist in system maintenance and help avoid system failures.

  To keep the storm sewer system mapping up-to-date (or even as a starting point), submission of geo-referenced as-built drainage plans and features should be required for understanding and inventorying regional drainage and relationships between ma uka and ma kai flows.

- **Resolve recommendation for vehicle and pool water disposal**

  Currently vehicle wash water and pool water disposal are prohibited from being discharged into the wastewater system. They are also not recommended for disposal into nearshore waters without prior treatment. Proper disposal of these wastes may need to be clarified in Code revisions.

- **Ordinances to prohibit illicit discharges.**

  Storm water flows directly into gulches, streams and nearshore waters without treatment (unlike waste water). Storm water illicit discharges are any discharge into the storm water system other than water. Wash water, untreated pool water, vehicle fluids, fertilizers and pesticides are examples of illicit discharges. Prior to conducting an education and enforcement program, ordinances should be enacted that clearly prohibit illicit discharges.

- **County conservation property tax rate to be equal or be less than agricultural property**

  Conservation property has limited land uses and typically has extensive vegetated land cover (e.g. forest) which is more valuable for watershed protection. With a lower tax rate, more lands might be put into conservation. In particular, stream and gulch corridors might be considered for conversion to minimize land cover disruptions and increase restoration opportunities.

### 3.3.3 High impact policy measures[1]:

- **Implementation of a Comprehensive Storm Water Management Plan**

  A comprehensive County Storm Water Management Plan (SWMP) has multiple components that would have significant impacts on reducing water quality pollutants. Specific priority components of a SWMP are listed below. However, the implementation of the entire SWMP is recommended for the greatest reduction in pollutants.

- **Enforcement of Construction Storm Water BMPs**

  During construction, developments are required to maintain runoff water quality and often utilize temporary construction Best Management Practices (BMPs). If appropriate construction BMPs are not implemented, water quality can suffer from sediment-laden construction runoff. Regular inspection and enforcement could be via developer-funded 3rd Party reviewers when the County deems plans or implementation inadequate.

- **Revisions to Post Construction Storm Water Ordinance:**

  The Post Construction Storm Water Ordinance could be greatly strengthened by adding requirements for a Drainage Master Plan with loading, assessment and confirmation of BMPs to address load reductions, approval of a separate post construction BMP plan, owner certifications, Operation and Maintenance (O&M) plans, regular reporting and testing and cumulative impact assessment. Together these compulsory items would serve to refocus the ordinance from implementing measures to achieving the needed water quality outcomes using a suite of tools and techniques.

- **Low Impact Development requirement for development, redevelopment and improvement projects > 1 acre (State, County and private sector) to incorporate LID measures into design and construction**

  LID measures should be incorporated into project types, not just new development. Redevelopment and other improvements provide opportunities to improve storm water quality and should not be missed.

- **Require active BMP management plans and reporting for large scale users of pesticides and nutrients** on agricultural and urban lands.

  Both agricultural use and urban landscaping can involve large quantities of pesticides and fertilizers (nutrients) that impact water quality and ecosystems. A Best Management Practices (BMP) management plan can provide many practices and procedures to reduce potential entry of chemicals into surface and ground waters. Regular updates should also be required to capture changes in land use and management.

- **Participation in a comprehensive water quality monitoring program (Chapter 8).**

  A comprehensive water quality monitoring program assesses current conditions to assist in identifying problem pollutants and sources. Major landowners and lessees, residential developments and resorts should be required to participate in a comprehensive water quality

[1] These policy measures are highly recommended based on their estimated *Potential Impact on Pollutant Load Reduction* (in Tables 3.2 to 3.4)

monitoring program. This can involve monitoring their own activities and nearby water quality of streams, outfalls, or nearshore waters to provide an instantaneous feedback of current conditions to identify possible contributors to poor water quality that can be acted upon to improve water quality.

- **Agricultural Conservation Plan Requirement**

  Agricultural practices can impact water quality on a large scale via various inputs used in farming. All agricultural lands should be required to provide a conservation plan that includes the following elements:

  - Erosion and Sediment Controls
  - Nutrient Management
  - Pesticide Management
  - Irrigation Management

  There should also be a requirement for an Agricultural **Conservation Plan Implementation Verification Program** with penalties for non-compliance and renewal every 5 years.

  This policy measure could be mandated for properties with agricultural tax rates.

- **Storm Water Fees Establishment**

  Storm water fees could provide additional funding for system maintenance and improvements, storm water projects and retrofits and potential development of larger scale storm water capture and reuse infrastructure. Currently only limited funding is available through Department of Health Clean Water Act 319.

  In some jurisdictions fees have been based on the percent impervious surface with reductions for properties that provide storm water retention and treatment on site.

# 4.0 STREAM AND GULCH MANAGEMENT MEASURES

Streams and gulches are both sources and conduits of sediments. Stream is the term usually given to a naturally formed channel with water that flows year round (perennial) or did historically. A stream may be perennial in some sections such as the upper elevations and intermittent and/or ephemeral in other sections. Gulches refer to channels that flow for short periods of time (ephemeral) following rainfall events. Section 4.1 presents available information on stream flows, instream flow standards and effects on watershed and coral reef ecosystem health.

Sediments originate from ongoing erosion in the stream and gulch channels and from human or animal activities that occur in or above the channels that have exposed and eroded soils, leading to deposits into streams and gulches. While some erosion is natural, erosion caused by human and introduced animal activities is the focus for this chapter. Recent field work on instream sediment locations is summarized in Section 4.2. Potential management measure approaches to address sediments in streams and gulches are discussed in Section 4.3. Sections 4.4 and 4.5 discuss desilting and sediment basins.

This chapter focuses on sediments and corresponding management measures in the stream channel, and Chapter 5 focuses on agricultural and conservation management measures on the upper lands adjacent to the stream and gulch valleys. Priority management measures for Chapters 4 and 5 are at the end of Chapter 5.

## 4.1 Stream Flow

Stream flow is important to the watershed health as it can help in filtering pollutants, contributes to ground water recharge, and provides riparian and aquatic habitat for native stream species. Stream flow can also impact nearshore waters. While large amounts of freshwater can cause salinity levels to decrease and create conditions that are not conducive for coral growth, freshwater mixing from stream inputs has long been a part of the marine ecosystems of West Maui.

Stream flow is not transferred out of the three watersheds The Honolua Ditch brings in water diverted from Honokōhau Stream (to the north of the Honolua watershed). The ditch water is used by Kapalua golf courses and resorts for irrigation (about 2 million gallons per day [mgd]), and a small amount (0.25 mgd) is used for agricultural irrigation (CWRM, 2009-2012 average usage). The County of Maui also utilizes ditch surface water (with treatment) in addition to ground water sources for the West Maui drinking water supply. Honolua Stream does have a stream diversion; however, since 2004, the diverted water has been returned to the stream about 100 feet downstream from the diversion intake.

The State Commission on Water Resource Management (CWRM) is responsible for the setting of instream flow standards for Hawai'i's streams. CWRM commissioned the US Geological Survey (USGS) Pacific Islands Water Science Center for a study of West Maui streams titled Low-Flow Characteristics of Streams in The Lahaina District, West Maui, Hawai'i (Cheng 2014) as the first step toward setting permanent instream flow standards. Figure 4.1 shows the identification of flows during natural median-flow conditions. Most stream reaches are dry under natural median conditions below about 800 feet elevation. Honolua Stream was estimated as flowing to the ocean

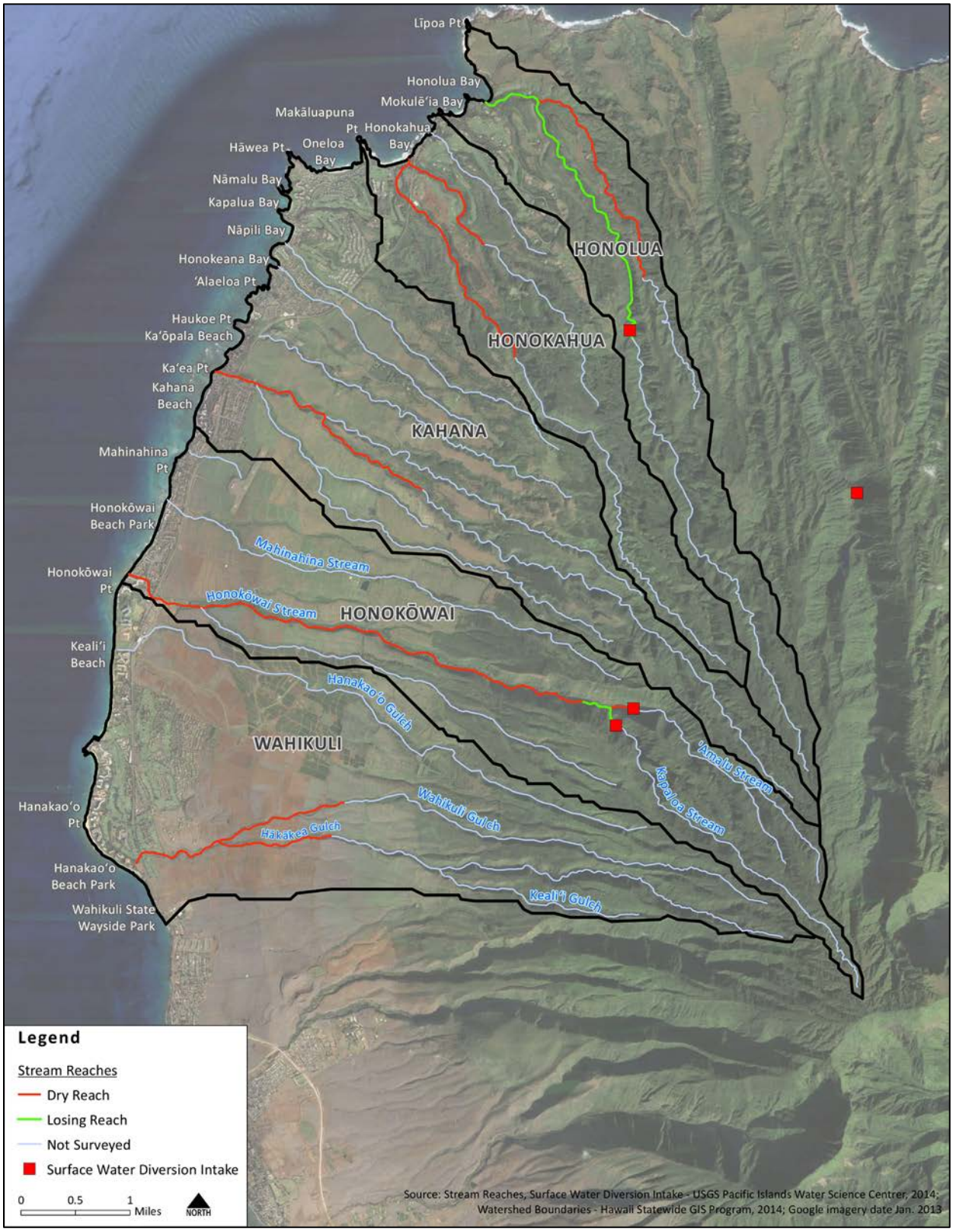



**Figure 4.1 Natural Median-flow Conditions in West Maui (Source: Cheng 2014)**

less than 80% of the time. Honokahua and Kahana Streams were observed to remain dry at least 50% of the time (Cheng 2014). However, during storm events, waters flow and carry sediments out into nearshore waters. In Kahana watershed, five desilting basins slow storm waters and allow for some settling of sediments before flowing to the ocean.

Honolua Stream was categorized as having "losing reaches" which means the stream flow is being lost to the ground water (Cheng 2014). The connection of streams to ground water is notable. The USGS Pacific Coastal and Marine Science Center is looking at the role that submarine groundwater discharge may have in buffering thermal stress (bleaching) (http://coralreefs.wr.usgs.gov/climatechg.html). Included in Chapter 5 is a discussion of ground water and opportunities to maintain and increase ground water recharge in the agricultural and conservation lands by protecting existing native ecosystems and restoring native landscapes.

Understanding stream flow can also be important in factoring the rate of sediment transport from streams and gulches.

## 4.2 Stream and Gulch Sediment Field Results

Stream sediment terraces were identified as significant suspended sediments sources in a USGS Western Geographic Science Center study in press (Stock et al, 2015). Sediments deposited over time have formed deep large terraces along stream and gulch banks (Figure 4.2).

**Figure 4.2 Sediment Terraces** *(courtesy of Michelle Haynes)*

The USGS study and anecdotal reports indicate that even during small storm events, sediments can be released into nearshore waters. Preliminary findings from follow-on USGS field work conducted in October of 2015 examined in greater detail the extent of sediment deposits along the stretches of Kaʻōpala Gulch and Pāpua Gulch (tributary of Honolua Stream). Sediment deposits or terraces were found along 50% of the bank length up to the ma uka conservation areas in these two gulches.

The report assumption, based on USGS findings, is that streams and gulches that border former agricultural lands will have sediment terraces from the past creation of fields and roads. The smaller gulches which only flow during storm events have terraces that are 1 to 3 meters deep.

The larger stream valleys have sediment terraces that are 3 to 7 meters deep. Because every subwatershed contained agricultural fields at one time, all are prioritized. Surveying additional streams and gulches is planned for 2016. Those findings, along with information about the likelihood of the sediments to erode (based on factors such as rainfall and streamflow) should be used to reassess subwatershed priorities.

The USGS field work also identified push piles, areas of dirt and sediment that were pushed to stream sides during road construction and fielding leveling. The push piles are found on the upper edges and slopes of the streams and valleys and are discussed in Chapter 5 as an ongoing contribution of sediments into streams and nearshore waters.

## 4.3 Stream and Gulch Bank Management Measures

Stream measures to stabilize and/or capture sediments eroding from sediment terraces need to be developed and tested simultaneously with mapping of sediment deposits. A stream restoration knowledge sharing is needed to identify restoration methodologies that are locally-specific, scientifically sound, culturally appropriate, and where possible, community driven. Landscape level restoration and replanting of the former agricultural fields should be considered in concert as a way to slow surface water flows to the streams and gulches (Section 5.3).

Listed below are streams and gulch management measure elements that need to be explored further.

### 4.3.1 Vegetation

One challenge is identifying plants suitable is that the plants species should be:

- Drought tolerant – able to survive seasons without little to no rainfall.
- Moisture tolerant – able to survive storm events.
- Low Maintenance – at a minimum, require little ongoing maintenance and will remain on the site either as a perennial or self-seeding annual.
- Easy to establish – if possible, plants or seeds that can be planted or timed with the rainy season to eliminate or minimize the need for irrigation.
- Ecologically appropriate – ideally, native to West Maui, and if not, are verified as non-invasive.

Table 4.1 lists potential native plants that meet the above criteria, are easy to propagate, and are readily available to install for stream management measures (Rick Barboza and Penny Levin, Pers. Comm.). Plants from the Pu‘u Kukui Preserve Plan must be used in conservation areas including the conservation area that stretches to the ocean in Honolua Watershed. There should be a preference for these plants in other areas. Buffer areas between the conservation and other areas should be maintained and to the extent possible have native plants to prevent introduction of invasive non-native plants. Seed stock from West Maui area should be used as much as possible.

**Table 4.1 Native Plants for Stream Management Measures**

| Hawaiian/ Common Name | Scientific Name | Sediment Capture | Slope Suitability | Ease of Propagation | NRCS recommended | Notes |
|---|---|---|---|---|---|---|
| kawelu | *Eragrostis variabilis* | Yes | Steep incl. vertical | Easy | X | |
| aheahea | *Chenopodium oahuense* | Yes | Steep | Easy | X | |
| ʻilieʻe | *Plumbago zeylanica* | Yes | Steep | Easy | | Shade tolerant; suitable for understory |
| kupukupu, fishbone fern | *Nephrolepis cordifolia* | Yes | Steep | Easy | | Shade tolerant; suitable for understory |
| Carex Grass/ Oʻahu sedge | *Carex wahuensis* | Yes | Steep | Easy | | Shade tolerant; suitable for understory |
| pili grass | *Heteropogon contortus* | Yes | Steep | Mod-erate | X | |
| Aeʻae, water hyssop | *Bacopa monnieri* | Yes | Steep | Easy | | Only suitable for very wet areas |
| mamaki | *Pipturus albidus* | | Steep | Easy/ Mod-erate | | Suitable for stream area restoration; some erosion control properties |
| Alaheʻe | *Psydrax odorata* | | Mod-erately Steep | Easy/ Mod-erate | | Suitable for stream area restoration; not specifically for erosion control |

### 4.3.2 Loʻi Kalo

Loʻi are paddies which pool water and collect sediments before water flows to the next loʻi and finally back out into the stream channel. Kalo, or taro (*Colocasia esculenta*), a staple of the Hawaiian diet, is grown in these paddies. Loʻi kalo was one of the agricultural techniques that allowed Hawaiians to provide abundant quantities of food as described in *Native Planters* (Handy, Handy, & Pukui 1972):

> *North of Lahaina are five valleys watered by stream draining the western slopes of the West Maui watershed: Honokōwai, Kahana, Honokahua, Honolua, and Honokōhau. The first four all had extensive loʻi lands in their valley bottoms, where terraces rose tier on tier in symmetrical stone-faced loʻi.*

Loʻi kalo can act as microbasins that collect sediments and reduce suspended sediments in the water. Recent research on kalo growing and mangroves in Palau demonstrated that Palauan methods can reduce sediments by 90% (Koshiba, 2013). On Oʻahu a partnership of The Nature Conservancy and local non-profit Kakoʻo ʻŌiwi is working to develop 200 acres loʻi kalo and is building the loʻi walls higher than usual to capture storm flows and trap sediments.

Loʻi kalo

One of the first steps to establishing kalo loʻi is to identify former kalo growing lands. Archived ML&P maps of loʻi kalo should be digitized and followed by field surveys to identify where terraces can still be found.

Loʻi kalo require active management and a steady supply of water. Restoration will be most appropriate where people can access the land, and where there is ample stream flow. Although Honolua Stream is categorized as a losing stream reach, the upper reaches may still have available water for loʻi kalo.

### 4.3.3 Kaʻōpala Gulch Opportunities

A potential location to trial stream bank measures is the lower portion of Kaʻōpala Gulch ma kai of the desilting basin and Honoapiʻilani Highway. This portion of the gulch is relatively wide and has sediment terraces with vertical faces (Figure 4.3). Kaʻōpala Bay turbidity measurements are the highest along the coastline.

Flooding is an issue in this area, and measures should serve to secure sediments and retain and slow the flow of water. Possible measures to test include bank reshaping and plantings to assess survival and soil and water retention.

Access may allow for equipment usage unlike upper gulch and stream areas. Landowner access and participation needs to be secured. Recently released coastal lidar data (created using pulsed laser to survey the earth's surface) can help to determine drainage patterns and opportunities. Available storm water system mapping would also be useful. Sediments have accumulated in the ocean outfalls, and these should be cleared to allow for monitoring and evaluation of trial measures.

**Figure 4.3** **Kaʻōpala Gulch**
*(courtesy of Tova Callender)*

### 4.3.4 Honolua Stream Diversion Removal

As part of stream restoration, the Honolua Stream diversion should be considered for removal. This would allow for restoration of 100 feet of the stream which currently lacks regular stream flow. It would also improve connectivity between the upper and lower portions of the stream. Removing the diversion would require permitting (Section 4.3.5) and should include a restoration plan for the adjacent area and should incorporate any plans for loʻi kalo restoration in the area.

### 4.3.5 Permitting Considerations

Work in a stream can trigger regulatory requirements listed in Appendix D, including HAR Section 13-169 Stream Channel Alteration Permit and Sections 410 and 404 of the Clean Waters Act. The agencies administering the regulatory requirements, State Department of Land and Natural Resources (DLNR) Commission on Water Resource Management (CWRM), State Department of Health (DOH) Clean Water Branch and US Army Corps of Engineers, should be consulted to determine whether or not a management measure will require these permits.

Manual planting of native plants typically do not require permits. If heavy machinery is used, and/or if sediment discharges into waters are anticipated, permits will be required. Loʻi kalo restoration and development requires agency consultation and permits. Obtaining permits can add upwards of 24 months to a project timeline and will entail additional costs.

## 4.4 Existing Desilting Basins

Desilting basins are management measures that reduce sediments coming through streams and gullies in runoff water. Constructed in streams or gulch channels, the basins slow the water and allow sediments to settle out. There are five desilting basins in the Kahana watershed shown in Figure 4.4. This map also identifies locations of smaller sediment basins that have small embankments to slow water and induce sediment settlement.

### 4.4.1 Monitoring Basin Efficacy

The efficiency of the desilting basins in removing sediments is not precisely known. Preliminary efficiency levels were assessed based on basin size for each drainage area. Kahana, Kaʻōpala and Nāpili 2-3 desilting basins are undersized relative to the catchment area and volume of storm water entering the basins. These basins do not hold or impound a significant volume of storm water and can overflow during rain events.

Nearshore turbidity in the vicinity of the basins was highest for Kaʻōpala and Kahana receiving waters. Sources of sediments can be from above and below the desilting basins. For Kaʻōpala Bay, there is a very small urban area and the source is likely from above, meaning stream, gulch, agricultural and conservation sources could be the contributors. Because the basin is constrained geographically, management measures that work to prevent sediments from entering the basin should be a priority. The high levels of turbidity rating (16 times the state standard of 0.5 NTU) provide an opportunity to monitor and test improvements to see which measures are most effective (Figure 4.4).

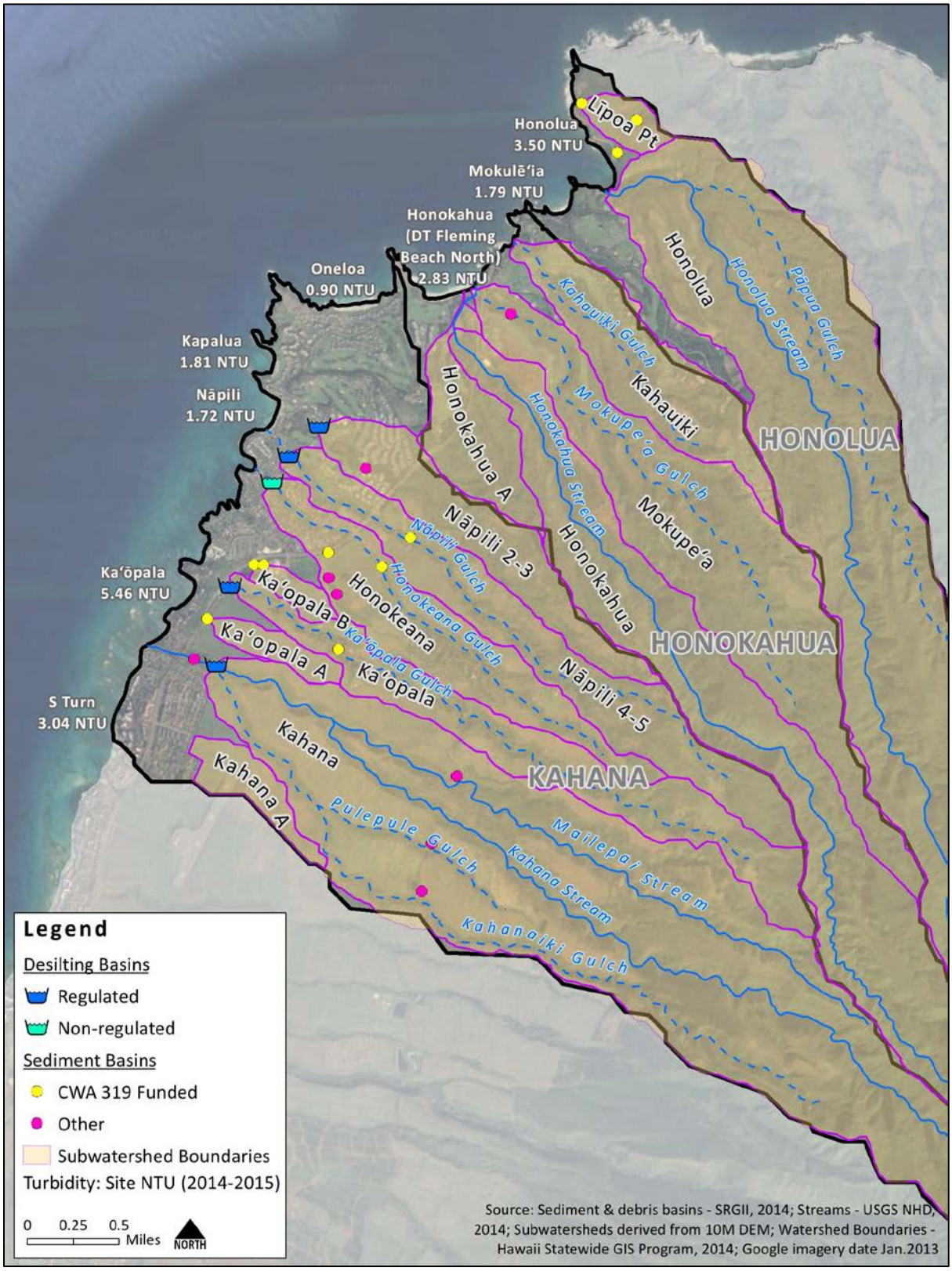



**Figure 4.4 Streams, Gulches, Desilting Basins and Turbidity**

### 4.4.2 Desilting Basin Maintenance

The County of Maui Public Works Department plays a critical role in maintaining desilting basins via mowing and sediment removal. The grassed areas of the desilting basins are mowed twice a month. Sediments are removed as they build up, on average about once every two years (see below for exceptions). One challenge faced by the County is finding locations to dispose of sediments removed from basins. A past practice of placing the sediments on the dam face is no longer allowable. Sediments should be placed in areas away from streams and gulches and hydro-seeded to prevent the sediments from re-entering a basin or being transported via other mechanisms to nearshore waters.

### 4.4.3 Potential Desilting Basin Retrofits

#### *4.4.3.1 Kahana Desilting Basin*

Currently the County is unable to bring in equipment to remove accumulated sediments from the dam because there is no mechanism that allows for completely draining the basin. Buried outlet pipes prevent complete drying of the basin. The pipes will need to be relocated and functionality tested and restored, or a new valve could be installed similar to the one reinstalled at the Nāpili 4-5 desilting basin dam. The Kahana basin capacity could be returned to a near design state by draining the basin, and its valve would remain closed for most storm events to maximize settling of sediments. For major storm events, the valve could be opened to allow water through and avoid a buildup of water or pressure behind the dam.

#### *4.4.3.2 Nāpili 2-3 Desilting Basin*

This basin currently contains standing water and functions primarily as a golf course water feature. As discussed in Chapter 6, if standing water is allowed to remain, the basin could have plant "living islands" installed to improve water quality. If the State DLNR Dam Safety Program determines standing water is not allowable, the basin will need to be drained and the water will need to be released. If the basin is drained, various measures could be installed to improve water quality.

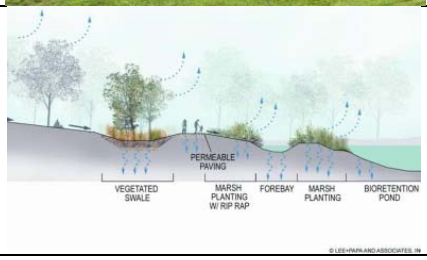
#### *4.4.3.3 Other Potential Retrofits*

At a minimum, all basins should have vegetative cover. In general, retrofits will focus effectiveness efforts at reducing sediments for small scale storm events. Some examples of management measures that might be implemented for a retrofit are found in Table 4.2. Low Impact Development measures such as lengthening flow paths, bioswales and utilizing vegetation for treatment can be additional retrofits to the basins to improve water quality and increase infiltration (Chapter 6). Retrofits can incorporate loʻi kalo techniques, where water flows from one sub-basin to another and creates a series of sediment settling areas. Retrofits for each basin are site specific and variables that should be considered are topography, hydrology, land cover, rainfall, etc.

### 4.4.4 New Desilting Basins

Desilting basins were not recommended for the Honokahua or Honolua watersheds in the initial 1970 assessment as it was based on the need for property protection. After the effectiveness of the desilting basins to trap sediments is better understood and loʻi kalo has been re-established, new desilting basins for Honokahua watershed may be considered.

**Table 4.2 Desilting Basin Retrofit Management Measures**

| Management Measure | Image | Description |
|---|---|---|
| ***Low / High Flow Channel Integration*** |  | Integrates low-flow channels where low-flow can be concentrated to increase channel velocities and ensure continuous flows through the basin. |
| ***Forebays*** |  | Serves as pretreatment storage area near the inlet of a storm water basin; traps and settles out sediments and pollutants before spilling out to the main basin. |
| ***Naturalized Basins*** |  | Replacement of turf grass with deeper rooted drought and moisture tolerant plants that may reduce mowing maintenance needs. |
| ***Treatment Trains*** |   | A series of treatment measures strategically placed for a sequential, multi-layered approach to treating storm water before reaching desilting basins. |

***Honokahua watershed*** had the least amount of pineapple cultivation of the other two watersheds and its fields were some of the first to cease operations. The future impacts to Honokahua watershed will likely stem from new development construction. Construction BMPs and post-construction BMPs also called Low Impact Development techniques (Chapter 6) should address sediment loads from those immediate sources. Upstream pollution prevention of feral ungulates, which cause soil erosion, (Chapter 5) should also be implemented. If these and other identified stream restoration management measures are not effective enough to protect nearshore waters, new desilting basins should be considered for Honokahua subwatersheds.

***Honolua watershed*** land use activities included pineapple cultivation for a longer period of time than Honokahua. Small sediment basins were installed to collect sediments contributing to areas outside of the stream and gulch channels. Honolua Bay has had high turbidly readings (6-7 times the water quality standard) which remain unchanged. However, given the conservation designation of most of the Honolua watershed and desires to have unaltered stream flow, an instream desilting basin is not a recommended measure.

### 4.4.5 Desilting Basin Analysis

Data Gap: To assess basin efficacy, systematic monitoring during storm events is essential. Regular data collection can track basin ability to capture water from different intensity events. A sample monitoring form is provided in Appendix E, and NRCS has the capability to analyze the data provided. Detailed data collection of basin performance along with plume monitoring after storm events would greatly assist in identification and prioritization areas and management measures.

Subwatersheds with high sediment loads and low basin efficacy to trap sediments (or no basin) may be higher priority than similar subwatersheds with high basin efficacy.

## 4.5 Sediment Basins

Sediment basins are smaller, simpler basin designs than desilting basins. A small embankment traps water to promote the settling of suspended sediments before it flows out or infiltrates into the ground. The sediment basins show in Figure 4.3 include basins funded using Clean Water Act Section 319 funding and those funded by landowners. The retrofits in Table 4.2 and LID techniques can be used to improve basin functioning.

## 4.6 Stream and Gulch Management Measures Priorities

Because stream banks, desilting basins and agricultural and conservation management measures are so interconnected, a joint summary and prioritization of Chapters 4 and 5 is provided at the end of Chapter 5.

# 5.0 AGRICULTURAL AND CONSERVATION MANAGEMENT MEASURES

The Kahana, Honokahua and Honolua watersheds agricultural and conservation lands have multiple issues including threats from wildfire, trespassing and feral ungulates, to address in order to protect and improve watershed health. West Maui Mountains Watershed Partnership and the Maui Land and Pineapple Pu'u Kukui Watershed Preserve have made significant progress in identifying issues and implementing projects on conservation lands. Yet, funding resources are greatly lacking to implement projects important to watershed and water quality health. Agriculture is no longer the region's economic driver, and with shifting land uses, new management measures are needed.

Presented in this chapter are pollution prevention strategies and management measures for agricultural and conservation lands in Section 5.1. Section 5.2 discusses the importance of conservation and agricultural lands for recharging ground water, along with management measures to maintain this functionality, and Section 5.3 presents landscape restoration benefits and opportunities that build on existing efforts. In the final section of the chapter, priority measures for streams and gulches (Chapter 4) and agricultural and conservation management (Chapter 5) are presented.

## 5.1 Agricultural and Conservation Management Measures

For each land use this section provides:

- A brief description of the types of pollutants generated.
- **Pollution prevention strategies** to reduce the amount of pollutants being generated and **management measures** to treat pollutant sources.
- Locations in the watersheds where there are **opportunities** to implement pollution prevention strategies/management measures as a starting place (not necessarily an exhaustive list).

### 5.1.1 Access Roads

Access roads, in addition to providing vehicle access, can consolidate runoff and direct it downslope into gulches, streams, and onto highways. The eroded soils and sediments carried by various waterways eventually make their way into nearshore waters. Dirt road stream crossings can bring sediments directly into streams especially with continued uses which disturb soils.

"Push piles" of dirt, sediments that have been pushed to the sides of the roadway from agricultural and conservation access road construction, can be found on the edges of roads and streams sides (Figure 5.1). If left bare, the sediments of these push piles will continue to erode and add sediments in to the stream or gulch below.

***Pollution Prevention***

The creation of future push piles should be prohibited via policy measures that promote stream valley buffers and enforcement of construction storm water BMPs. Road construction and maintenance should follow guidelines being developed that will direct push piles away from the stream valley edges. Existing push piles should be immediately seeded or planted to provide

vegetative cover and secure sediments to prevent any further soil erosion into stream and gulches. For push piles with very steep slopes where vegetation cannot be established other management measures to prevent soil loss should be implemented. These might include a combination of measures such as geotextile covers and seeding. Removal of the push piles could be considered; however, the act of soil removal is likely to cause some soil erosion.

Push pile locations need to be surveyed and assessed to determine locations that are actively contributing sediments to the stream or gulch below. These can be determined based on push pile location in relation to the valley wall, the path of runoff, and the amount of stabilizing vegetation. Push piles of concern can then be vegetated with more than grass and / or concentrated runoff redirected away from the push pile and valley edge.

Stream crossings using dirt roads should be discontinued or stabilized to prevent this source of sediments into stream and nearshore waters.

Another way to prevent access road pollution is to reduce the amount of access roads. Access roads that are no longer in use or needed can become "**decommissioned**" roads. Decommissioning would include tilling and vegetating roadways to prevent water from consolidating and flowing downslope to streams or other roadways, carrying sediments that have eroded from the water action.

***Management Measures***

For roads remaining in use, soil erosion and transport may be reduced by using management measures in Table 5.1 as applicable to the roadway segment.

***Opportunities***

The access roads are bare soil roads that provide access into the upper watersheds. There are over 73 miles of access roads and in some areas they follow or cross streams or gulches. Many of these roads are not well maintained or have been graded to facilitate water and sediment transport downslope instead of infiltrating nearby. Sediment laden waters drain to gulches and streams and later flow out to nearshore waters.

Table 5.2 lists the length of access roads in each subwatershed, the number of stream or gulch crossings for ML&P provided access road data, and those crossings from 2005 NOAA CCAP land cover data, which may include crossings that are no longer used and could be decommissioned.

**Figure 5.1 Road Push Pile on Side of Stream Bank**

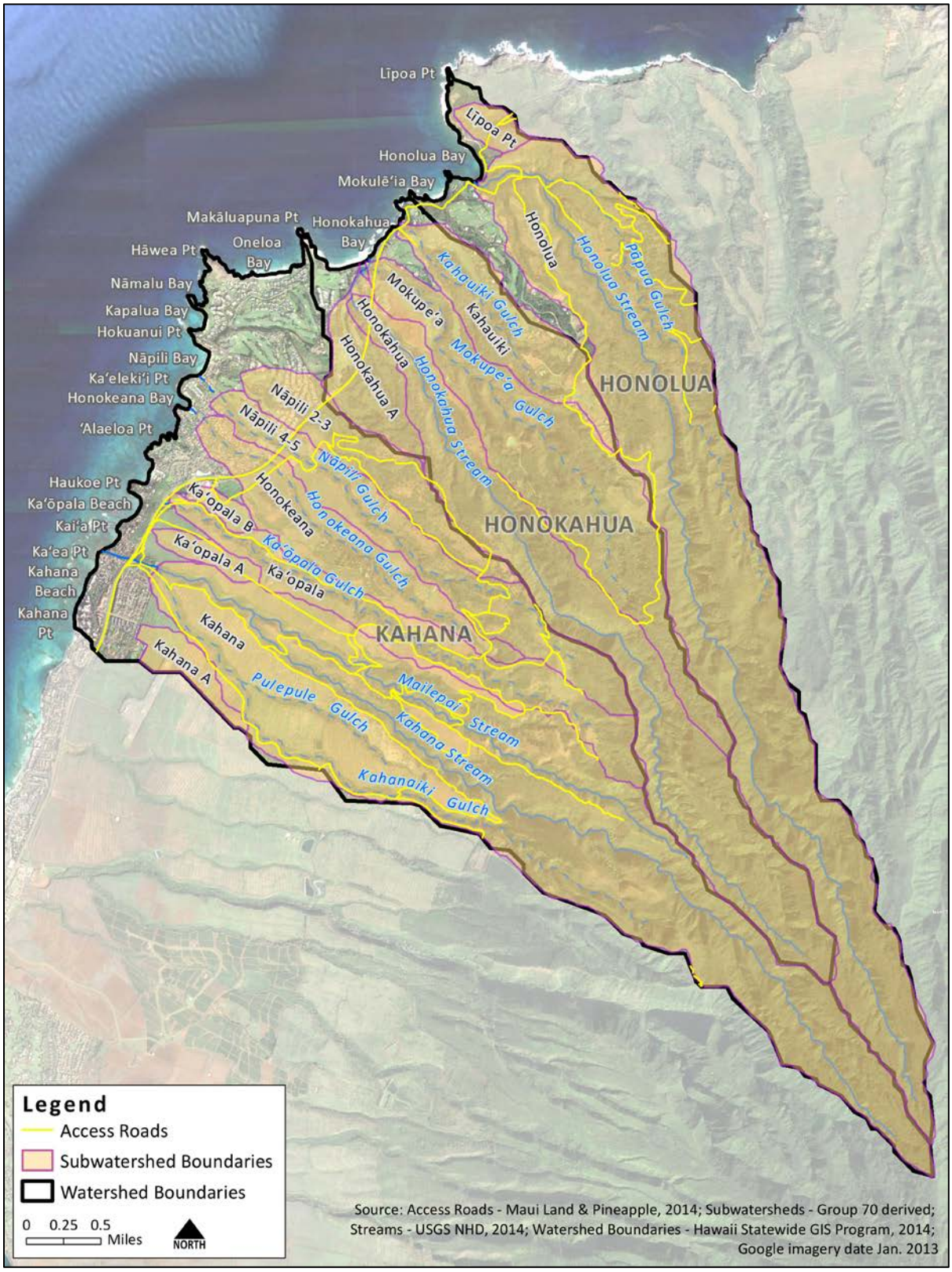



**Figure 5.2 Access Roads**

**Table 5.1 Access Road Management Measures**

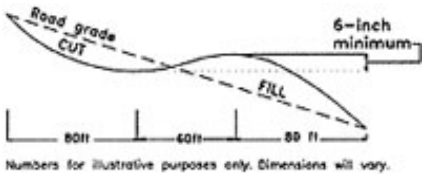
| Management Measure | | Note/Image |
|---|---|---|
| ***Stream crossing stabilization*** |  | Pave crossings to stabilize; where possible reorient to be perpendicular to stream/gulch edge. For high use crossings use appropriately sized culverts with stabilized sides to prevent road erosion. |
| ***Broad-based dips*** |  | Broad-based dips, similar to water bars, are gentle waves on the surface of roads to minimize erosion by directing water off roads. Water flows into the bottom of the dip and drains into stable, vegetated areas at the side of the road. |
| ***Spreader zones*** | | Vegetated areas are used to spread water drained off the roadway to increase infiltration. These are used where space permits. |
| ***Microbasins*** |  | Micro basins are small pools surrounded by stone walls and/or soil ridges to collect the rainwater and surface runoff. They are used where there is not space for spreader zones. |
| ***Bank stabilization*** |  | See Chapters 4 and 6 for bank stabilization options. Riprap might also be used. |

**Table 5.2 Access Road Lengths by Subwatershed**

| Subwatershed | Kahana | Ka'ōpala | Honokeana | Nāpili 4-5 | Nāpili 2-3 | Honokahua | Mokupe'a | Kahauiki | Honolua | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|
| **Access Roads** (miles)[1] | 26.8 | 12.2 | 0.7 | 6.5 | 2.9 | 3.6 | 6.8 | 0.8 | 12.7 | 73 |
| **ML&P Access Road Stream and Gulch Crossings** | 10 | 1 | 2 | 4 | 0 | 1 | 1 | 1 | 14 | 34 |
| **Impervious Surface Stream and Gulch Crossings** (not including Access Road stream & gulch crossings)[2] | 9 | 3 | 1 | 1 | 0 | 3 | 3 | 0 | 3 | 23 |

[1] GIS data provided by Maui Land and Pineapple
[2] Impervious surfaces are from the NOAA 2005 impervious surfaces data and are used to highlight areas where less frequently used dirt roads cross streams and gulches

Prioritization should be given to steeply sloped roads along gulches and streams – especially ones that cross streams or gulches. Roads with "kick-outs," areas that direct roadway runoff to adjacent gulches or streams, should have runoff redirected to adjacent fields for infiltration. Steeply-sloped roads that cross streams and gulches are also a concern. The Oleson Lab at University of Mānoa conducted an analysis of priority access roads that need repairs, and the findings are being submitted for publication.

Written procedures for future roadway maintenance are needed to guide the continued effectiveness of implemented management measures. To fund future maintenance, agricultural lessees or others with roadway access might be charged for their roadway usage or given maintenance responsibilities with appropriate guidance.

### 5.1.2 Feral Pigs and Deer

Feral pigs pose significant threats to soil stability on conservation and agricultural lands. The existing conservation land fencing and monitoring has helped to reduce this threat in the conservation lands. Funding is still needed to finish the **boundary fence** to prevent feral pig access, and to **retrofit existing low fences** to 8 feet in preparation for high jumping axis deer migrating northward (Table 5.3). **Ongoing monitoring and feral ungulate removal** inside the fenced area will also need to continue in order to fully achieve benefits.

**Table 5.3 Needed Conservation Fencing by Watershed**

| Subwatershed | Kahana | Honokahua | Honolua | Total |
|---|---|---|---|---|
| New 8-Foot Fence | 7,000 feet | 5,000 feet | - | 12,000 feet / 2.3 miles |
| 4-Foot Fence Retrofit to 8-Foot Fence | 1,800 feet | 13,000 feet | 8,500 feet | 23,300 feet / 4.4 miles |

Feral pigs and a future influx of axis deer are not confined to conservation lands and may pose a considerable threat to water quality on agricultural lands as well. These ungulates are commonly found along streams which provide protection and food sources. **Hunting programs** can help reduce feral ungulate populations. However, as residential development moves up in the watershed (Honolua Ridge, Mahana), hunting activities may become less compatible with increased residential and recreational uses. On O'ahu, DLNR has designated certain days for pig hunting on an as-needed basis to reduce influxes in the pig population. Announcements and posted signage can be used to avoid user conflicts particularly with hunting dogs. A monitoring program is an important component in adaptive management, as pig and deer populations are very mobile. Efforts to reduce the feral pig and deer populations must be equally nimble.

### 5.1.3 Wildfire

With fallow agricultural fields, volunteer alien species have established, providing cover and preventing further soil erosion from occurring. However, during dry periods this vegetative cover dries and becomes a potential fuel source.

***Pollution Prevention***

The best pollution prevention is reduction of fire risk by **reducing the fuel load**. The ML&P grazing lease is part of their plan to address this issue while putting the land to use.

**Green belt buffers** should be established between residential and agriculture areas to protect homes and fields from fire.

Anyone working in the dry areas with gas powered equipment should utilize **spark arrestors** to reduce the potential for ignition. **Community education** on fire risks, hazard levels, and prevention can also help to reduce the chances of fires being inadvertently set.

The Western Maui Community Wildfire Protection Plan (2014) and the Wahikuli-Honokōwai Wildfire Mitigation Plan (2014) represent extensive wildfire planning. The remaining item that needs to be completed is the development of a ***"Go Time" Wildfire Plan*** to addresses steps to take after a wildfire to ensure immediate and appropriate delivery of resources and project implementation for optimal post-fire recovery. This plan should include phone trees and detail immediate responsibilities for a timely and coordinated response.

### 5.1.4 Grazing

Grazing best management practices can prevent or reduce pollutants from the negative effects of overgrazing and improper stream access and crossings. High concentrations of cattle in areas especially near streams can increase nutrient releases.

**Grazing best management practices** include, but are not limited to:

- Herd and pasture management to prevent overgrazing and concentrated effects.
- Stream crossing stabilization & setbacks.
- Fencing to exclude cattle from stream areas.
- Hardened watering access areas.
- Provision of shade away from stream and gulches.

Agricultural conservation plans should be developed and implemented with assistance from National Resource Conservation Service (NRCS) and the West Maui Soil and Water Conservation District.

The Wahikuli-Honokōwai Wildfire Mitigation Plan contains resources on herd management that provide a foundation for implementing pollution prevention strategies. In addition, ML&P is seeking expert guidance regarding pasture capacity and the number of head of cattle that can be sustainably supported (Kaniaupio-Crozier Pers. Comm.). Clear lease provisions are recommended that detail required best management practices for cattle grazing to prevent sediments and nutrients from entering waterbodies.

### 5.1.5 Future Ag Uses / Solar Farms

Future agricultural uses might include forestry and cropland as well as possible solar farms on agricultural lands.

As noted for grazing, NRCS & the West Maui Soil and Water Conservation District should provide technical assistance in developing **agricultural conservation plans for forestry and croplands**. A proposed pollution prevention policy would require active BMP management plans for large-scale users of nutrients and pesticides.

For **solar farms**, or any other construction on agricultural lands, **temporary (construction) BMPs** should be followed to reduce soil erosion. These are especially important along sides of gulches and streams, where slopes and erodible soils can end up being eventually transported to nearshore waters. Solar panels are impervious surfaces and should be factored into a project's footprint when determining storm water volumes and necessary BMPs.

### 5.1.6 Dirt Biking / Trespassing

In order to prevent trespassing by dirt bikers, round-the-clock security across the watersheds at key points of entry would be required and would not likely be feasible. Potentially, with diversified land uses on agricultural lands, an increased presence of users to observe and monitor activity might reduce incidences of trespassing and illegal activities. Remote monitoring with cameras during off peak periods might serve as another option if problems persist.

Dirt bikers may be engaged in conservation programs to increase their understanding of their impacts on soil erosion, and perhaps increase their participation in conservation practices.

### 5.1.7 Invasive Species Monitoring

To prevent invasive species from becoming established on the land, there are many policies and regulations needed to minimize the threats from future introductions including monitoring and legislation at the State level. This discussion focuses on the need for monitoring to detect species that may pose a risk to the ecosystem.

The West Maui Mountains Watershed Partnership and the Pu ʻu Kukui Watershed Preserve work to monitor invasive species in the upper ma uka conservation area. The Maui Invasive Species Committee also helps to coordinate the monitoring of invasive species in urban and agricultural areas and have helped to control Ivy Gourd in the Kapalua area.

Invasive species pose potential threats to soil erosion through the establishment of monoculture stands and can increase fuel load and wildfire risks. After prevention, monitoring is the preferred method of treatment to avoid larger problems. Often once an invasive species becomes established, removal is no longer a feasible option.

## 5.2 Ground Water Recharge

The upper conservation areas of the watersheds with high rainfall provide for ground water recharge (Gingerich and Engott 2012). The formation of the West Maui Mountains Watershed Partnership and the Puʻu Kukui Preserve resulted from understanding the importance of the conservation lands for ground water recharge as well as the need to preserve the many native species found in these upper elevations.

Ground water travels from the recharge areas and ultimately flows out into nearshore waters. Submarine ground water discharge is hypothesized as having a buffering effect on thermal stress for coral reef ecosystems (Section 4.1). Continuing to manage the upper watershed for ground water recharge may result in increasing available drinking water supplies and as well as helping to maintain lower water temperatures for coral reef ecosystems.

Management measures that reduce or eliminate feral ungulates will help to maintain the ability of lands to recharge ground water. Wildfire prevention and mitigation plans will also protect the irreplaceable functions of these upper watersheds. The desilting basins also provide some ground water recharge, although they are ma kai of most wells.

## 5.3 Landscape Restoration

Landscape restoration is large scale improvements of degraded land to restore ecological integrity. More than 100 years of farming have impacted the streams and nearshore waters. Restoration to a multistory vegetated landscape will help to increase infiltration which can then reduce the volume of water draining into the streams and gulches. By reducing the direct storm inputs to the stream, the erosive power of the water is reduced. It also increases the ground water recharge and therefore submarine ground water discharge, which may buffer ocean temperatures. Restoring ecological functioning increases the long term viability of the land and its people.

A multi-story forest with ground plants, shrubs and trees can increase the ability of the forest to hold water and release it more slowly over time. Aquatic life is typically better able to deal with the lower magnitude shifts in temperatures and salinity than large pulse events when large quantities of storm water are released into streams and nearshore waters.

Pacific Regional Integrated Sciences and Assessments (RISA) recently conducted workshops with Maui stakeholders to envision future land use scenarios for assessing impacts on available ground water. The scenarios included more extensive forest conservation and explored the possibility of future tree plantations that might help to maintain or increase ground water availability.

The existing Honolua Wao Kele Forestry Stewardship project started in 2007 is one of ML&P's revegetation efforts. Thirty acres of former pineapple fields are being restored using native plants and active management. This project and other ML&P restoration efforts throughout the watershed in the coastal, lowland, mesic and upper conservation areas can literally help to seed other restoration efforts with seed collection and propagation efforts. The available resources, partnerships and lessons learned will be valuable to future efforts. For example, plantings are usually timed for the rainy season, although with climate shifts, planting seasons also shift. A wide range of plant species are propagated because the great variety through the three watersheds in rainfall (19 to 200 inches per year) and elevation differences (0 to nearly 4,500 feet above sea level).

## 5.4 Stream & Gulch and Agricultural & Conservation Management Measure and Data Gap Priorities

Priority management measures for stream and gulch areas (Chapter 4) and for agricultural and conservation lands (Chapter 5) were chosen for their ability to reduce pollutants and feasibility to implement measures. Priority management measures are management measures that:

1) **Stop sediment from entering streams and gulches**
   Ongoing sedimentation issues should be addressed.
   - ***Push Pile Assessment and Stabilization***
   - ***Stream Crossings Stabilization***
   - ***Access Road Improvements***

2) **Prevent future sedimentation sources**
   Best management practices can prevent sedimentation from future activities.
   - ***Construction Best Management Practices***
   - ***Grazing Best Management Practices***
   - ***"Go Time" Wildfire Plan***

3) **Keep existing in stream sediment deposits from moving down stream to the ocean**
   There are significant information gaps where sediments are located and types of management measures to best stabilize sediment terraces.
   - ***Identification of Sediment Terraces in Streams and Gulches***
   - ***Researching, Piloting and Implementation of Stream/Gulch Bank Management Measures***
   - ***Restoration of Traditional Loʻi Kalo***

4) **Address current instream sediment movement**
   It is preferable to address instream sediments where they exist. However, if there are limited management measures to stabilize sediments in place, downstream mitigation will also be necessary.
   - ***Kahana Desilting Basin Maintenance***
   - ***Desilting Basin Monitoring and Analysis***
   - ***Desilting Basin Retrofits***
   - ***Potential New Desilting / Sediment Basins***

5) **Increase ground water recharge and slow surface flows**
   Where the land is covered with trees and plants, rainfall can infiltrate into the ground and is slowly released into streams and nearshore waters. This can reduce the pulses of storm water in stream and decrease the forces that erode the sediment terraces.
   - ***Conservation Boundary Fencing***
   - ***Active Ungulate & Invasive Weed Management***
   - ***Landscape Restoration***

Ongoing research and filling of data gaps is especially important for stream sediments. The upcoming field work by USGS should help to further identify the extent of sediment terraces in the watersheds. Knowledge sharing and additional research to pilot promising measures is needed to secure sediment terraces in streams and gulches and reduce future erosion. Knowledge sharing and partnerships are also needed to implement landscape restoration to reduce the erosive power of water in streams and gulches.

# 6.0 URBAN MANAGEMENT MEASURES

This chapter provides a tool box of management measures to prevent and limit urban pollutant sources. Section 6.1 provides an overview of urban pollutant sources, known hydrology, Low Impact Development (LID) and descriptions of urban management measures. Section 6.2 matches the pollutant sources with urban management measures and lists implementation opportunities. In Section 6.3, opportunities for implementing urban management are summarized. The priority urban measures include policy measures (Chapter 3) and outreach initiatives for LID and construction BMPs (Chapter 7).

## 6.1 Overview

### 6.1.1 Urban Pollutant Sources

Urban pollutant sources from human development and activities contribute to the decline of stream and nearshore water quality. In the watersheds, urban area pollutant sources include roadways, residential and commercial development, landscaping, golf courses, and baseyards. Pollutants typically produced by these urban land uses are shown in Table 6.1.

**Table 6.1 Urban Land Uses and Potential Pollutant Generation**

| Urban Land Use | Potential Pollutant Generation | | | | | |
|---|---|---|---|---|---|---|
| | Hydrocarbons | Metals | Sediments | Nutrients | Other Chemicals (Pesticides, Cleaning, Pool Chemicals) | Pathogens |
| **Roadway** | X | X | | | | |
| Bare Shoulders | | | X | | | |
| Roadside Cuts | | | X | | | |
| Dirt Roads | X | X | X | | | |
| **Driveways and Roofs** | X | X | X | X | X | |
| **Parking Lots** | X | X | | X | X | |
| **Golf Courses & Landscaping** | | | | X | X | |
| **Baseyards/Property Management** | X | X | X | | X | |
| **Wastewater** | | | | X | X | X |
| **Construction** | | | X | | | |
| **New Development** | X | X | X | X | X | X |

X Pollutant of Concern

### 6.1.2 Natural Hydrology and Current Drainage

Prior to development, abundant native vegetation, which slowed and filtered water, allowed for infiltration into groundwater. Over decades, and even centuries, grazing, agriculture and residential and resort development have altered the West Maui landscape. These alterations have made it difficult to identify the location and nature of drainage patterns and how an individual area or project fits into the overall drainage system.

Limited information is available on the hydrology of the watersheds. In many cases the existing urban and agricultural drainage systems are unknown and are not mapped or inventoried. Ultimately, a ma uka to ma kai drainage plan and inventory is needed to map existing drainage systems to better understand water flows from the ma uka conservation and agricultural lands, and how the flow intersects with urban drainages and storm water systems before flowing to the ocean.

This information is needed to effectively identify opportunities to address runoff and inform prioritization of measures based on pollutant sources and drainage routes to nearshore waters. This information can be especially critical for siting retrofit projects. A thorough understanding of existing drainage systems and flow patterns may help to identify restoration opportunities.

Data Gap: Development of an asset management system for storm sewer system including outfall mapping is needed. The mapping of storm water inlets and outlets along roadways for this watershed report is a starting point. A regional drainage plan is also needed to understand where and how agricultural land runoff enters into urban storm water system.

### 6.1.3 Low Impact Development

> *Low Impact Development is an approach which aims to manage and restore site hydrology and natural and cultural resources of a project site through various design strategies, practices, and technologies.*

The LID concept is used in many of the management measures in this chapter. Selected LID techniques are shown in Figure 6.1.

Low Impact Development includes onsite storm water management by designing for infiltration, storage, and evaporation based upon the site's natural hydrology. Key LID principles include:

1) **avoiding disturbance** of existing vegetation, valuable soils and wetlands to the maximum extent possible; for West Maui coastal areas or streams and gulches should have buffer areas with vegetation to provide filter.

2) **reducing the amount of impervious cover**, and thus, storm water runoff generated on a site, through site planning and design techniques; and

3) **managing runoff** that is generated through structural and non-structural practices that filter, recharge, reuse or otherwise reduce runoff from the site.

Low Impact Development should be used to create multi-purpose features for managing storm water, e.g. features that provide storm water infiltration and treatment while also meeting aesthetic and recreational values. Single purpose storm water management designs are missed opportunities. Using LID also provides opportunities for entities to highlight their sustainability efforts via signage, self-guided tours, mobile apps, etc. Examples using LID measures in placemaking are shown in Figure 6.2.

Low Impact Development techniques are not limited to new development. Redevelopment and infrastructure improvements are excellent opportunities to install LID management measures such as the ones in this chapter.

Other LID Resources include:

*Stormwater Management in Pacific and Caribbean Islands: A Practitioner's Guide to Implementing LID*, February 2014.

*Stormwater Management the Natural Way: Low Impact Design & Development – An Overview for the Accommodations Industry in Hawaii*, September 2014.

### 6.1.4 Urban Management Measure Descriptions

Table 6.2 provides descriptions and illustrations of the various management measures presented in this chapter. Table 6.3 shows and lists the various management measures and the pollutants each measure is best suited to address. The urban management measures are then discussed further in Section 6.2.


**Figure 6.1 Low Impact Development Techniques**


**Figure 6.2 Placemaking that Integrates Low Impact Development Techniques**

## Table 6.2 Urban Management Measures

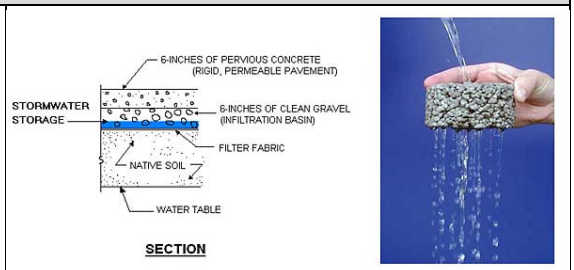
| Urban Management Measures | Description | Picture/Illustration |
|---|---|---|
| **Soil Stabilization** | | |
| **Gravel, Paved Gravel, Asphalt, Cement, Curbs & Gutters** | Used to stabilize bare soil and prevent soil erosion. |  |
| **Geotextiles and Plantings** | Permeable fabrics used to increase soil stability and provide erosion and drainage. |  |
| **Infiltration (& Soil Stabilization)** | | |
| **Pervious Concrete** | Concrete poured with reduced sand or fines that allows water to drain through it (usually over an aggregate storage bed). |    |
| **Porous Asphalt Pavement** | Standard hot-mix asphalt with reduced sand or fines that allows water to drain through it (usually over an aggregate storage bed). |  |

**Table 6.2 Urban Management Measures (Continued)**

| Urban Management Measures | Description | Picture/Illustration |
|---|---|---|
| **Permeable Pavers** | Permeable Interlocking concrete pavers allowing storm water to drain through them. |  |
| **Bioswales** | Vegetated, open-channel that slows and treats water with vegetation and via infiltration. |  |
| **Infiltration Basin** | A shallow impoundment designed to infiltrate storm water into the soil with high pollutant removal and recharge. |  |
| **Infiltration Trench** | A rock-filled trench where storm water is stored in the void spaces between the stones and infiltrates through the bottom into the soil. |  |

**Table 6.2 Urban Management Measures (Continued)**

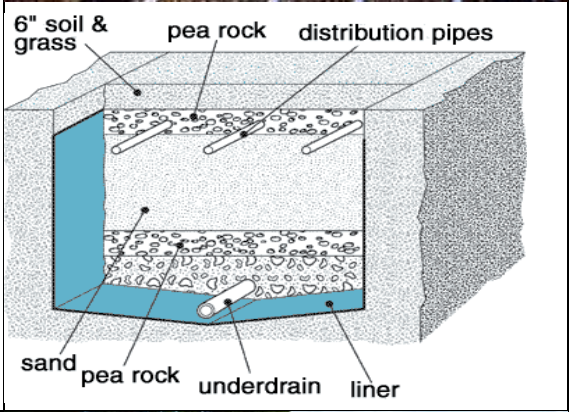
| Urban Management Measures | Description | Picture/Illustration |
|---|---|---|
| **Filtration** | | |
| **Vegetated Filter Strip** | Strips of vegetation that slow runoff and filter out sediments and other pollutants. |  |
| **Sand and Organic Filters** | Two-chambered measure for storm water with one for settling large particles and the second with a filter bed filled with sand or another filtering media for finer particles and other pollutants. |  <br>  |
| **Rain Gardens (Bioretention)** | Landscaping features that direct runoff from impervious surfaces to low areas and allow for infiltration. |  |

**Table 6.2 Urban Management Measures (Continued)**

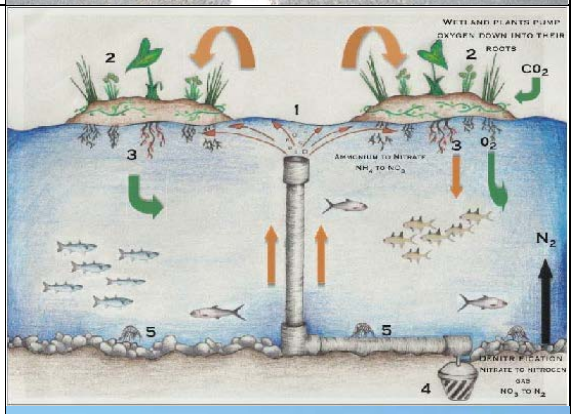
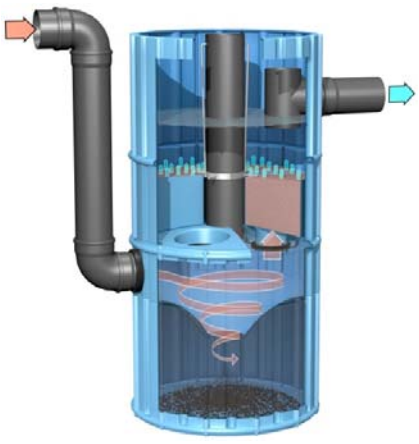
| Urban Management Measures | Description | Picture/Illustration |
|---|---|---|
| **Curb inlet baskets (Catch basin inserts)** | Inlets to the storm drain system that typically include a grate or curb inlet and a sump to capture sediment, debris, and pollutants. They capture floatables and settle some solids, and they act as pretreatment for other treatment practices by capturing large sediments. |  |
| **Restorer Living Islands** | "Living technology," floating islands of plants called "restorers" help to clean up the water. Bacteria and microorganisms can also be introduced into the gravel and root systems to assist with water filtration and pollutant and excess nutrient removal.<br><br>*Images: Roth Ecological Design International, LLC* |  <br>  |
| **Hydrodynamic Separator** | Device that treats storm water using gravity and rotational effects to separate solids and fluids. |  |

**Table 6.3 Urban Management Measures Comparative Evaluation**

| Urban Management Measures | Pollutant Reduction | | | Cost/Area | | | Considerations |
|---|---|---|---|---|---|---|---|
| | Sediments | Nutrients | Metals | Cost | Maintenance | Land Area Required | |
| | Low, Mid, High | Low, Mid, High | Low, Mid, High | $, $$, $$$ | Low, Mid, High | Low, Mid, High | |
| **Soil Stabilization** | | | | | | | |
| Gravel, asphalt, cement, curb & gutters | H | - | - | $ | NA | NA | Only effective for sediment reduction; does not have other storm water management benefits. |
| Geotextiles & Plantings | H | L | L | $$ | L | L | For slopes up to 1.5:1; allows for infiltration. |
| **Infiltration** | | | | | | | |
| Porous Paving* | H | L | H | $$-$$$ | L | NA | Should be protected from sediments with a curb. Maui batch sizes are fine for small jobs. Pervious pavements generally cost 10-15% more. |
| Permeable Pavers* | M/H | M | H | $$$ | L | NA | Should be protected from sediments with a curb. |
| Bioswales | H | L-M | M | $/$$ | L/M | H | Can require irrigation to maintain vegetation during dry periods. For slopes of 1-2%. |
| Infiltration Basin | H | M | H | $ / $$ land costs up to $$$ | H** | H | Challenging to apply on many sites due to soils requirements. Not for treating more than 5 acres (unless very sandy soil). Keep bottom or drainage basin 2-5 feet from high groundwater table. Mosquito issues with basins that take more than 4 days to drain. Some studies show relatively high failure rates. |
| Infiltration Trench | H | M | H | $/$$ | H** | M | Useful for select applications - see above for limitations. Should have pre-treatment as well. |

*Previous materials may not be appropriate in locations (e.g. baseyards) where chemicals might infiltrate into groundwater.
**High with low permeability soils

**Table 6.3 Urban Management Measures Comparative Evaluation (Continued)**

| Urban Management Measures | Pollutant Reduction | | | Cost/Area | | | Considerations |
|---|---|---|---|---|---|---|---|
| | Sediments | Nutrients | Metals | Cost | Maintenance | Land Area Required | |
| | Low, Mid, High | Low, Mid, High | Low, Mid, High | $, $$, $$$ | Low, Mid, High | Low, Mid, High | |
| **Filtration** | | | | | | | |
| Vegetated Filter Strip | M | L | L | $-$$ | L/M | M/H | Useful for small drainage areas; flow cannot be concentrated; require a wide area to be effective. For slopes of 2-6%. |
| Sand and Organic Filters | H | M | M/H | $-$$$ | M | L | Sand filters best for small areas (up to 10 acres but have been used on sites of 100 acres and more with measures to prevent clogging. Pretreatment is recommended. Modifications to the traditional surface sand filter are primarily to fit sand filters into more challenging design sites (e.g., underground) or to improve pollutant removal (e.g., organic media filter). |
| Rain Gardens (Bioretention) | L | M-H | H | $-$$$ | L/M | L/M | For slopes of up to 5%. |
| Curb inlet baskets (catch basin inserts) | L-M | L | L | $$-$$$ | H | L | The effectiveness of catch basins, their ability to remove sediments and other pollutants, depends on its design (e.g., the size of the sump) and on maintenance procedures to regularly remove accumulated sediments from its sump.<br>If not maintained, can become a pollutant source. Disposal of material can be an issue. Inserts designed to remove oil and grease, trash, debris, and sediment can improve the efficiency of catch basins. Some inserts are designed to drop directly into existing catch basins, while others may require retrofit construction. |
| Restorer Living Islands | L | H | M/H | $$$ | Mid | M | Requires standing water pond. |
| Hydrodynamic Separator | M/H | L | L/M | $$$ | M/H | L | Not effective at removing very fine sediments or dissolved pollutants; need to dispose of collected material. |

## 6.2 Pollutant Sources and Management Measures

For each of the urban land uses this section provides:

- A brief description of the types of pollutants generated.
- **Pollution prevention strategies** to reduce the amount of pollutants being generated. Often these are behavioral actions, such as washing cars on lawns for wash water to infiltrate instead or running off into the storm water system. Pollution prevention strategies are discussed throughout the chapter and summarized in Chapter 7 Public Outreach because affecting and sustaining these behaviors requires ongoing educational efforts. In some cases, pollution prevention includes physical management measures, such as securing bare soils to prevent further erosion and sedimentation.
- **Management measures** to address and treat each pollutant source.
- Locations in the watersheds where there are **opportunities** to implement management measures as a starting place (not necessarily an exhaustive list).

### 6.2.1 Roadways

Roadways are the primary conduits for pollutants such as hydrocarbons and heavy metals from vehicular traffic into near shore waters. Sediments from roadside shoulders or road cuts also contribute to runoff pollution. In addition, roadway runoff is also fed by storm water runoff from adjacent driveways, rooftops and parking lots (Sections 6.2.2 and 6.2.3).

***Pollution Prevention Strategies***
Ideally, vehicle pollutants would be minimized to reduce the pollutants in runoff. One strategy is to reduce the number of car trips through the availability of public transportation or walkable / bikeable communities. For West Maui this may include supporting the West Maui transit hub and park and ride in the Maui Island Plan 2014 and the future West Maui Greenway.

Efforts to place workforce housing near employment or to create more multimodal transit-friendly communities should be encouraged. Often these opportunities occur with new development and should be encouraged or mandated. Another strategy is to minimize the pollutants generated through car maintenance or through prohibitions of certain materials. For example, California and Washington States have banned brakes with asbestos, certain percentages of copper and other metals that impact fish, especially young salmon.

Pollution prevention strategies should be employed in the operation and maintenance of roads, highways and bridges. The State Department of Transportation has developed Best Management Practices (BMPs) in a Maintenance Activities Best Management Practices Field Manual (June 2006) that should be followed by State, County and contractors involved in operation and maintenance activities.

***Management Measures***
The permanent best management measures allow for some treatment of pollutants through biofiltration such as **roadside swales / filter strips**. Other options include various types of **pervious or porous paving** which can be installed where drainage areas have adequate depth above the ground water table and sufficient distance from shorelines or streams to allow for treatment of pollutants.

**Curb inlet baskets** are standard in many places with the primary purpose being the collection and separation of sediments and other litter from storm water. For areas with consolidated runoff from roadways, **hydrodynamic separators** could be used primarily for sediment reduction with minimal reduction of other pollutants. These tend to be more costly to install and require more frequent maintenance than biofiltration and pervious paving options.

***Opportunities***
Opportunities to reduce pollutants from roadways are greatest during new roadway construction. For example, roadside right-of-ways can be used for bioswales or other features which require considerable space not currently available along existing roadways. Porous asphalt or pervious concrete might also be used when constructing new roads.

For existing State, County and private roads curb cuts can be used and bioswales or infiltration ditches can be installed. Where space is limited, a hydrodynamic separator could be used to reduce sediments. Cooperation and partnerships with landowners adjacent to the roadway will increase opportunities for retrofitting.

*6.2.1.1 Bare Roadway Shoulders*

***Pollution Prevention Strategies / Management Measures***
To prevent road shoulders from eroding, soils should be stabilized to stop or minimize sediments from eroding and being transported via the roadway storm water system. Shoulder erosion is occurring along several areas of Lower Honoapi'ilani Road (Figure 6.14). The primary factor for determining which management measures should be installed is shoulder usage – parking, pedestrian path or open space.

**Shoulder stabilization with gravel, gavel paving or pavers –** Roadside shoulders used for parking can be stabilized with these materials to secure soil. If porous materials are used some infiltration will be provided.

**Shoulder stabilization with curb and gutters –** Where shoulders are used as a walkway, the shoulder should be graveled or have curb and gutters installed. Vegetation is not recommended as trampling from foot traffic will not allow for ample plant coverage. If there is room for a planter strip along the sidewalk, it should be at least 3-4 feet wide to allow for trees or drought tolerant shrubs. Smaller strips only support less hardy and smaller rooted plants that are susceptible to drought, which may result in bare soil that then easily erodes.

**Bioswales and shrubs –** If the street shoulder is not used for parking or as a walkway and there is adequate width, bioswales and shrubs can provide biofiltration. This is the most effective management measure for reducing roadside pollutant loading. Honoapi'ilani Highway shoulder right-of-ways may be wide enough to allow for bioswales and shrubs to provide some bio-filtration of runoff before entering the DOT storm water system. In some cases bioswales may need to be installed on, or in conjunction with, private lands.

For roadway shoulder soil erosion, the above prevention measures should be implemented before treatment options are pursued. The primary treatment option is curb inlet baskets with sediment filters to catch sediments once they have already eroded. Where there is consolidated runoff from the roadway and shoulders, a hydrodynamic separator may be needed. Soil stabilization should be addressed before resorting to these options to avoid high maintenance levels.

***Opportunities***

Lower Honoapi'ilani Road shoulders in selected locations (Figure 6.14) have serious erosion and sedimentation issues. The County of Maui is acquiring property along Lower Honoapi'ilani Road in preparation for future shoulder improvements. This project presents an opportunity to combine storm water management measures with traffic calming (Figure 6.3).

**Figure 6.3 Integration of Traffic Calming with Storm Water Treatment**

Landscaping elements that help minimize storm water runoff and serve as traffic calming devices. Traffic calming devices are used on roads to slow traffic down or reduce motor vehicle traffic and improve safety for pedestrians and cyclists. When redesigning streets, plants and trees can be included to filter runoff and manage storm water at the site. Traffic-calming elements like chicanes, islands, and curb extensions – all popular in creating Complete Streets – provide site opportunities for bioswales, street trees, and rain gardens. Other benefits include creating a more comfortable and visually interesting environment for all users. Traffic calming enhancements should be designed to retain emergency vehicle access, while still serving to slow general vehicle movement.

Sections of Honoapiʻilani Highway are also prone to soil erosion. Most of these shoulder issues are due to roadside cuts that bring soil onto the highway. These issues are discussed in Section 6.2.1.2 below.

*6.2.1.2 Roadside Cuts*

***Pollution Prevention Strategies / Management Measures***

Soil stabilization is needed to prevent continued soil erosion. The steep shoulders and embankments of Honoapiʻilani Highway would benefit from use of geotextile fabrics to hold soil and plantings in place. Hawaiʻi Department of Transportation used geotextile fabrics for a windward Oʻahu project (Figure 6.4).

**Figure 6.4 Geotextile Fabric for Soil Stabilization**

Where vegetation is used, low maintenance plants should be installed to control costs and reduce the likelihood of pesticide use as a maintenance mechanism which could introduce additional pollutants to runoff and enter nearshore waters.

***Opportunities***

Eroding shoulders and embankments of Honoapiʻilani Highway that would benefit from stabilization are shown in Figure 6.14.

*6.2.1.3 Dirt Roads*

***Pollution Prevention Strategies / Management Measures***

Dirt road stabilization can stop or minimize sediments from eroding and being transported into nearshore waters. Dirt roads are a priority for stabilization with an adequate non erodible gravel surface or pavement.

**Figure 6.5 Ala Hoku Subdivision Roadway**

***Opportunities***

Ala Hoku Subdivision contains a dirt road with soils that erode down toward the highway (Figure 6.5). Opportunities also exist to treat roadway pollutants by modifying the nearby underground sedimentation basin to increase its holding capacity and functionality. Ala Hoku subdivision road is identified in Figure 6.14.

### 6.2.2 Driveways and Rooftops

Driveway runoff can contain hydrocarbons and heavy metals from vehicle fluids and may contain metals from rooftop runoff. Soapy water from car washing and excess fertilizers and pesticides can also run offsite into the storm water system and be carried out into nearshore waters. The impervious nature of rooftops and driveways increases the amount of potentially contaminated runoff entering storm water systems and nearshore waters.

***Pollution Prevention Strategies***

A primary pollutant reduction strategy is to reduce the amount of impervious surfaces. A second strategy is to disconnect downspout connections to the roadway system. The latter can be accomplished via home rain gardens that provide vegetated areas for rain water to infiltrate. Rain barrels which collect rain water are another possibility. The impervious nature of driveways can be reduced by using pavers that allow some water to pass through to a base of sand. Implementing runoff reduction measures at individual sources is occurring across the US; however, they often require considerable technical assistance (Per Comm T. Cullison, 2015 and Crisostomo 2015).

Behavioral pollution prevention strategies are numerous. Cars can be washed on grassy areas or in a way that soapy water is routed to the sanitary sewer system (and is treated at the waste water treatment plant if this becomes allowable). Simple low-tech approaches to prevent wash water from entering the storm sewer system include either blocking the drain, or inserting a catch basin and using a pump to remove and redirect water to a vegetated area. Vehicles engines should be maintained to prevent oil and other fluids from leaking. The use of fertilizers and pesticides can be reduced with proper handing and application. In some instances, fertilizer and pesticide use can even be eliminated by choosing plants that do not require chemical inputs, and do not require irrigation water during dry periods. Recent surveys on Maui and Oʻahu found a decrease in homeowners use of fertilizers and pesticides in recent years; however, use by contracted landscapers may have remained the same (6.2.4 Golf Courses and Landscaping).

***Management Measures***

Existing developments can integrate management measure retrofits, including biofiltration and infiltration as well as detention basin retrofits. Existing developed areas usually face space and cost limitations when considering added management measures. Possibilities for "end of storm water pipe" treatment include vegetative filter strip and detention measures along streams and gulches, detention basin retrofits, and hydrodynamic separators.

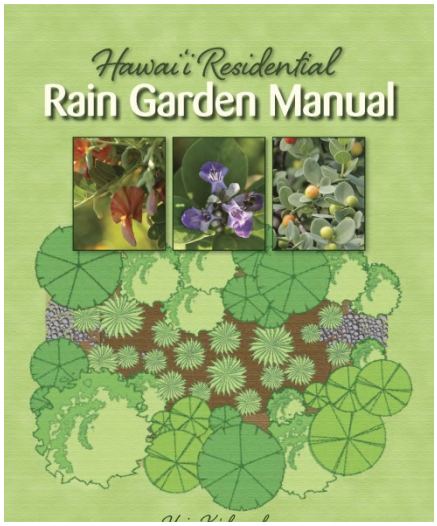



**Figure 6.6 Hawai'i Residential Rain Garden Manual**

**Biofiltration (Rain Garden)** – Vegetation provides filtration, slows water to increase soil infiltration, and decreases surface water conveyance. Rain gardens are strategically located to collect rain water near a runoff source or conveyance. An excellent reference for rain gardens in Hawai'i is the *Hawai'i Residential Rain Garden Manual* by Hui Koʻolaupoko (http://www.huihawaii.org) (Figure 6.6). Rain gardens for large areas or where soils have poor permeability may add sand and/or piping underground to decrease oversaturation and keep plants from drowning.

**Detention Basins Retrofits** – Where they exist, basins can be retrofitted using a suite of urban management measures to increase the treatment of the first flush, the storm water that first runs off during a storm event and carries the greatest pollutant load. Retrofits will add features that **slow** the water down, **spread** it out over the basin and allow more water to **soak** into the ground before running out. These include:

- Creating a forebay to initially settle some sediments
- Installing berms to slow and spread the water
- Forming curved edges to slow and spread the water flow
- Adding plantings to slow and spread the water, allowing it soak into the ground
- Rain garden pockets, or plantings that allow water to collect to increase infiltration

Agricultural desilting basins are basically detention basins. Where appropriate these management measures could be reviewed for applicability for the agricultural desilting basin retrofits.

**Hydrodynamic separator**, **filter boxes** and **curb inlet filters** may be used where there is not enough room to provide biofiltration and infiltration.

The County of Maui might consider limiting the types of management practices for roadways. Different technologies will have different maintenance requirements which can complicate upkeep and function of the management practices.

***Opportunities***

Depending on drainage patterns, or rerouting of drainage, the locations listed in Table 6.4 and shown in Figure 6.14 are opportunities for implementing the above management measures.

**Table 6.4 Residential Development Management Measure Opportunities**

| Management Measures / Opportunities | |
|---|---|
| **Biofiltration (Raingarden)** | |
| **A** | **Kahana Ridge Association** owns lands fronting Honoapiʻilani Highway including the common area at the northern ma kai end that might be suitable for biofiltration (Figure 6.7). |
| **B** | **Kahananui Park** (Omaikai Place and Lower Road) – this area is managed by County of Maui Parks and Recreation Department and is adjacent to the Kahana Dam spillway which is managed by County of Maui Public Works Department. The Park area might be suitable for treatment of nearby residential developments or at a minimum, convert to vegetation that does not require fertilizers or irrigation (Figure 6.8) |
| **C** | **Pineapple Ridge Development site** is owned by Pineapple Ridge LLC. The site has bare soil and incised lower Kaʻōpala gulch that is contributing sediments to nearshore waters. Erosion and sediment control should be implemented and efforts made to retain water which sometimes causes flooding. See also Section 4.3.4. |
| **D** | **Bay Golf Course has an area where drainage from Pineapple Estates** flows through and may be causing some erosion in addition to pollutant transport (Figure 6.9) |
| | There may also be residential development that drains into gulches or could be routed to provide space for biofiltration. Developments draining ma kai of desilting basin take precedence over developments draining to a desilting basin area. |
| **Detention Basins Retrofits** | |
| **E** | A detention basin located at Polohina Lane is associated with the Nāpili Villas Phase I Condos. Runoff may need to be rerouted into this basin for treatment (Figure 6.11). |
| **Hydrodynamic Separator or Filter Boxes** | |
| **F** | **Nāpilihau Street and Lower Road** open area appears to have drainage from adjacent development and is owned by Quam Properties Inc. (Figure 6.10). |

**Figure 6.7 Kahana Ridge Development Roadside Soil Erosion Reduction Opportunities**

**Figure 6.8 Kahananui Park off Lower Road Opportunity**

**Figure 6.9 Kapalua Bay Golf Course and Pineapple Estates Drainage Opportunity**

**Figure 6.10 Nāpilihau Street and Lower Road Opportunity**


**Figure 6.11 Detention Basin Retrofit Opportunity**

### 6.2.3 Parking Lots

Parking lots contain hydrocarbons and heavy metals from vehicle leakages. Hydrocarbons and heavy metals are pollutants of concern because they affect larval recruitment, survival and growth. The general rule of thumb is that larger parking lots have greater pollutant quantities that may flow off the lot.

***Pollution Prevention Strategies***
Pollution Prevention Strategies for large parking lots are similar to those for roadways in Section 6.2.1 that include minimizing car usage and promoting better vehicle maintenance to prevent engine fluid leakage.

***Management Measures***
Where space permits, **rain gardens** can provide biofiltration of storm water for parking lots. **Filter strips and bioswales** can be used to reconfigure flow paths and direct discharge to rain garden areas.

Where there is limited space, a mechanical **hydrodynamic separator, filter box** or **infiltration trench** would reduce pollutant loading to nearshore waters from parking lots.

**Pervious paving** can also be used to provide infiltration and treatment via the soil where there is adequate distance between the groundwater and the parking lot. This management measure is most feasible for new parking lots.

***Opportunities***
There are numerous large parking lots associated with businesses and resorts in West Maui (Table 6.5, Figure 6.14). The priority parking lots for management measures are large impervious parking areas that drain directly to or have a short path before storm water enters nearshore waters. The drainage paths are unknown for most locations.

Repaving and maintenance of parking lots provide opportunities for implementing management measures discussed above including pervious paving, rain gardens and mechanical devices.

**Table 6.5 Parking Lot Potential Management Measure Opportunities**

| | | |
|---|---|---|
| **Biofiltration (Rain Garden)** | | |
| **G** | Kapalua Golf Club Bay Course & Tennis Garden & Village Tennis Center | Existing grass area can be converted into filter strips (no fertilizing and consider changing plants if non-fertilized grass does not meet the desired aesthetic).<br>One low section (Figure 6.12) already functions as a rain garden and additional plants could be installed. |
| **Curb Inlet Filters** | | |
| **H** | Ritz-Carlton Parking Lot | Curb inlet filter installations with ongoing maintenance would be useful for this area. (Figure 6.13) |
| **Hydrodynamic Separator / Filter Box** | | |
| **I** | Nāpili Plaza | Constrained site with nearly all area paved. |

**Figure 6.12 Kapalua Pro Shop/Tennis Court Parking Lot Opportunity**

**Figure 6.13 Ritz Carlton Parking Lot**

### 6.2.4 Golf Courses and Landscaping

Fertilizers and pesticides used in landscaping maintenance of golf courses, resorts and residences can contribute nutrients and other contaminants to runoff which can eventually flow to streams and nearshore waters.

***Pollution Prevention Strategies***

Practices that reduce or eliminate the use of fertilizers and pesticides should be the first line of defense. For large scale users of pesticides and nutrients on agricultural and urban lands, one proposed policy measure is a requirement for active BMP management plans and reporting (Chapter 3). These plans determine appropriate amounts and timing of fertilizers and pesticides based upon soil conditions, soil type, pest types, plantings and rainfall amounts and seasonality.

The *West Maui Kumuwai Ocean-Friendly Landscaper* program incorporates a Pledge that includes a checklist of best practices such as selecting appropriate plants for local conditions and applying only necessary amounts of irrigation water, nutrients, and pesticides, aided by monitoring plant health and soil moisture levels. The *West Maui Kumuwai Ocean-Preferred Products* program is an effort to promote the use of more ocean-friendly alternatives of commercially-available lawn care and pest management products (characterized by low toxicity), through branding, labeling and outreach. These programs should continue to be expanded from the Wahikuli-Honokōwai watersheds into the Kahana, Honokahua and Honolua watersheds.

***Management Measures***

**Filter strips,** areas of vegetation between pollutant sources and the coast or stream, can trap sediments and slow water flow. Priority areas are landscaping along the coastline and irrigated landscaping along streams and gulches. Filter strips should not be fertilized, and communication with maintenance personnel will be critical to prevent plants from being fertilized like other landscaped areas. Filter strips can be used as stream side buffers to protect natural drainages.

**Rain gardens** take advantage of rainfall and storm water runoff and are designed to withstand the extremes of moisture and nutrient concentrations. Plantings can take up nutrients that are found in storm water runoff and, as with filter strips, should not be fertilized. In areas where there is not ample space for a filter strip, a rain garden can provide a higher level of filtration when situated between the pollutant source and nearshore or stream waters.

**Edge wetlands** can be constructed around ponds or other water ways to treat runoff before it enters the waterbody. These may use aerobic and anaerobic water treatment in a constructed wetland setting where the plants uptake nutrients and pollutants.


Kapalua Golf Course

**Living systems in a waterbody** are suitable for treating water quality in ponds or reservoirs with standing water. The existing Nāpili 2-3 reservoir could be an opportunity to implement a living system, if reservoir water is allowed to remain. Improved water quality might allow for fish

cultivation and provide supplemental income. This concept was implemented at Hualālai Resort's Punawai Lake. Continued sediment contributions from ma uka lands will reduce system longevity.

***Opportunities***

Opportunities exist for implementing management measures for golf courses and landscaping. The Kapalua and Bay golf courses are priority areas due to their larger acreages and potential for contributing pollutants to runoff. Other priorities are the expansive landscaping at Kapalua Resort as well as smaller resorts along the coastline. The second tier for priority would be residential areas below the desilting basins where storm water may have a short drainage path to nearshore waters. The large lot ma uka homes likely have biofiltration along the gulches and streams but should be considered potential opportunities. A requirement for active BMP management plans and reporting is also proposed (Chapter 3).

### 6.2.5 Baseyards / Property Management

Baseyards are places where vehicles, equipment and products for maintenance and operations are stored. They can also include areas for preparing materials and equipment for use on properties and facilities serviced by the baseyard. There can also be supporting office space. Baseyards may be located in urban areas or nearby in agricultural areas.

Condo and resort properties face many of the same management issues as baseyards in terms of storing chemicals and disposing vehicle wash water. In addition, condos and resorts must consider pool/hot tub water disposal methods. Best management practices for properly disposing of vehicle and pool wash water will depend upon possible County of Maui code updates regarding discharges to the sanitary sewer.

Vehicles parked on site can be sources of hydrocarbons and metals, products stored and used (such as fertilizers, pesticides, cleaning products and vehicle fluids) can be sources of nutrients and other chemicals. Often the baseyard is not paved or only partially paved and the bare ground can be a source of sediments.

***Pollution Prevention Strategies***

Listed below are strategies to prevent the potential pollutant sources from leaving baseyards and entering the ground or surface waters.

<u>Chemical and Materials Storage / Maintenance</u>

- Store chemicals under cover and in areas with proper containment.
- Fueling facilities should be under cover and raised.
- Have spill response materials and procedures in place.
- Dispose of wash water properly (per County of Maui guidance).
- Keep rubbish containers under cover and out of the rain.
- Cover bulk materials (soils, lumber) with tarps to prevent rainfall from carrying potential pollutants from the storage area.

Vehicles

- Maintain vehicles to prevent leakage of fluids.
- Store and maintain vehicles under cover or in an area with controlled runoff.
- Wash vehicles where wash water drains to treatment with filtering (biological or via the sanitary sewer, if allowed) or have a recycled water facility. Oil water separators may be needed.

Bare Dirt

- Stabilize baseyard surface with gravel or pavement.

***Management Measures***
Management measures can be used on the baseyard edges where runoff occurs. These include the use of vegetation filter strips, bioswales, filter boxes, etc.

A designated vehicle wash area with wash water treatment should be integrated.

***Opportunities***
The various baseyards in the watershed are opportunities to employ the above measures and are shown in Table 6.6 and Figure 6.14. Priorities areas are baseyards with direct connectivity to nearshore waters.

**Table 6.6 Baseyard Management Measures Opportunities**

| Base Yard Locations | |
|---|---|
| **J** | Kapalua resort baseyard |
| **K** | Troon Golf baseyard |
| **L** | Maui Land and Pineapple baseyard |

### 6.2.6 Pool and Vehicle Wash Water Disposal

Chlorinated water disposal from pools is detrimental to coral reef ecosystems. Many swimming pools are located in close proximity to the shoreline and discharges of chlorinated water are occurring directly to coastal waters. However, there is not guidance on allowable storm water system discharges, and pool water should not be discharged to the sanitary sewer per County of Maui code of ordinance.

On O'ahu the pool water should be dechlorinated (0.01 parts per million or less), and a City permit must be obtained prior to the discharge into the City storm drain system. The release of pool water to a landscaped area is allowed as long as the effluent remains on the property.

Vehicle wash water also has chemicals that are harmful to aquatic life and is not permitted for disposal in the sewer system.

The County of Maui needs to provide guidance on and enforcement of proper pool and vehicle wash water disposal (Table 3.2).

### 6.2.7 New Development

New developments must meet the County Rules for Design of Storm Water Treatment Best Management Practices. The Maui Code of Ordinances Chapter 15-111 requires infrastructure to reduce the average annual total suspended solid load by 80% for an average annual two year/twenty-four hour storm for developments. This requirement can be met with various storm water Best Management Practices (BMPs).

New development should strive not just to meet the standard but take a broader perspective to achieve the greatest benefits for both the environment and development.

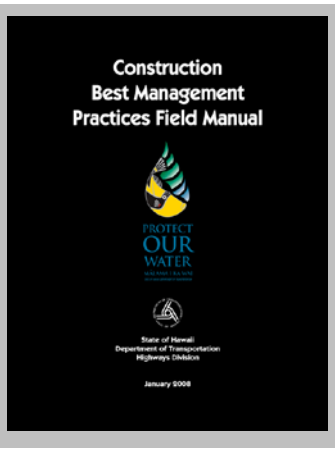
Pollution prevention measures should be used to the maximum extent and treatment options used where prevention measures are not feasible or additional pollutant management and treatment is needed.

Note: While rain water harvesting is possible for new developments, it can work at cross purposes with low impact development which aims to integrate the water at the site.

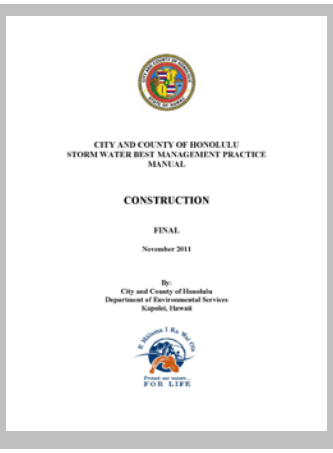
### 6.2.8 Construction

Policies and programs are critical for ensuring adequate construction BMPs are planned and implemented. Enforcement by County representatives and citizen monitoring is needed, as construction sites can change daily with grading, excavation, and building activities that have potential for releasing large sediment loads (see Chapter 3). The Kapalua Mauka development is of particular concern due to slope and extent of the acreage.

Information is readily available on construction best management practices but greater awareness and education is needed on the application and use of these practices. Two useful resources are Hawai'i Department of Transportation's Construction Best Management Practices Field Manual (January 2008) and the City and County of Honolulu Storm Water Best Management Practice Manual Construction November 2011 both of which are available on the agency websites. These cover Best Management Practices (BMPs) that address site management, erosion control, sediment control, non-storm water management and material management BMPs.




*Hawai'i Department of Transportation's Construction Best Management Practices Field Manual (January 2008)*




*City and County of Honolulu Storm Water Best Management Practice Manual Construction November 2011*

### 6.2.9 Wastewater

Treated and untreated wastewater effluent can make its way into nearshore waters. For the Kahana, Honokahua and Honolua watersheds, wastewater is treated one of two ways: pumped to the Lahaina Wastewater Reclamation Facility or via On Site Disposal Systems (OSDS) which include cesspools and septic systems. OSDS have varying levels of treatment to reduce pathogens and nutrients. Cesspools provide no treatment, and septic systems provide limited treatment before sewage is released into the ground and may be transported in groundwater.

***Pollution Prevention***

Wastewater quantity is largely dependent on population size and indoor water usage. Restricting growth can reduce the amount of wastewater produced. Another way to prevent pollution is to improve the water quality to the appropriate level for reuse. The Lahaina Waste Water Reclamation Plant is already producing water that can be used for water reuse. Due to the cost of piping and pumping to use this water it is most feasible to use it in close proximity to the plant. Reuse opportunities should be matched to local water needs. With limited agriculture in the vicinity of the treatment plant, potable water reuse should be considered similar to how it is utilized in San Diego, Texas and Arizona.

The recently constructed wastewater conveyance system experiences minimal infiltration via the pipes. Limited infiltration may occur via manholes and illicit connections, but is likely a relatively minor issue. Depending on the results of water quality sampling, this may need to be investigated more fully if elevated nitrogen levels are determined to be from waste water effluent.

***Treatment***

For cesspools, septic systems and other OSDSs, proper maintenance can decrease pollutants quantities from entering the ground water. Ultimately OSDSs conversion to more highly effective OSDSs (such absorption trenches or beds), or sewer connections, would greatly reduce pollutants. One reference in choosing a system is the State Department of Health *Onsite Wastewater Treatment Survey and Assessment* (March 2008). The extent of existing OSDSs is believed to be small but verification is needed via updated County records.

Cesspool conversion to more effective treatment systems is highly desirable for reducing potential pollutant effects on water quality. In July 2015 the governor signed a bill into law authorizing a tax credit of up to $10,000 to convert cesspools located within 200 feet from a shore, perennial stream or wetland, or within a source water assessment area.

***Opportunities***

The opportunities for cesspool conversion need to be identified. County sewer service locations would provide locations of sewer connections and unconnected properties could be targeted for cesspool conversion. This effort is in progress by the County of Maui without a targeted completion date. Door-to-door surveys of residences should be conducted to determine current waste water disposal mechanisms. The priority areas for conducting the survey are where properties are eligible for the tax credit. The surveys could also serve as an opportunity to educate and encourage owners to upgrade their cesspool or connect to County of Maui sewer system (if in the vicinity).

### 6.2.10 Honolua Bay and Līpoa Point

Honolua Bay is a popular destination for snorkeling and diving in the summer and surfing in the winter. There is little to no infrastructure for visitors driving to visit Honolua Bay. Parking occurs along the road shoulders and on a Līpoa Point dirt access road along the Bay with active erosion. The only bathrooms are three port-a-potties (pumped out three times per week) that are funded by the non-profit Save Honolua Coalition when funding is available. There is no regular trash collection and the Save Honolua Coalition also sponsors multiple clean-ups a year. Each cleanup results in a 20-foot dumpster full of rubbish and removal of hazardous waste such as car batteries.

Sunscreen with oxybenzone has been found to negatively impact corals. Visitors to Honolua Bay, and other beaches along the watersheds, may be negatively affecting water quality and coral with their choice of sunscreen.

***Pollution Prevention***

Appropriate bathroom and parking facilities to handle Honolua Bay visitors would provide lasting pollution prevention. Regularly maintaining roadway vegetation and maintaining lines of site could reduce the need for ongoing trash clean-ups. Līpoa Point, the road and parking areas should be stabilized roads and low-growing vegetation planted on the ma kai slopes of the roadways.

***Opportunities***

Līpoa Point was acquired by the State and a community planning process will likely begin in 2016. These measures should be incorporated into the management plan and be implemented to minimize sediments, trash and pathogens from entering Honolua Bay.

A ban on sunscreen containing oxybenzone is also a potential policy measure (Table 3.2).

## 6.3 Urban Management Measures Summary and Priority Measures and Data Gaps

The land uses and the toolbox of potential management measures suited for addressing the associated pollutants are listed below in Table 6.7. Figure 6.14 summarizes the various opportunities for implementation in the urban area that have been described previously in this chapter.

**Table 6.7 Potential Urban Management Measures by Land Uses**

| Land Use / Potential Management Measures (Storm water) | Soil Stabilization | | Infiltration (& Soil Stabilization) | | | | | | Filtration | | | | Other |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gravel & Paving | Geotextiles and plantings | Pervious Concrete | Porous Asphalt Pavement | Pavers | Grassed/Bio-swales | Infiltration Basin & Basin Retrofits | Infiltration Trench | Vegetated Filter Strips | Sand & Organic Filters | Rain Gardens (Bioretention) | Curb inlet baskets (Catch Basin Inserts) | Hydrodynamic Separator |
| **Paved Roads** | | | x | x | | | | | | | | | |
| **Roadway** | | | x | x | | | | | | | | x | x |
| Bare Shoulders | x | x | x | x | x | x | | | x | | | | |
| Roadside Cuts | | x | | | | | | | | | | | |
| Dirt Roads | x | | x | x | x | x | | | x | | | | |
| **Driveways & Rooftops** | x | | x | x | x | x | | | x | | x | | |
| **Parking Lots** | x | x | x | x | x | x | x | x | x | x | x | x | x |
| **Golf Courses & Landscaping** | | | | | | x | x | x | x | x | x | | |
| **Baseyards/Property Management** | x | | | | | x | x | x | x | x | x | | x |
| **New Development** | | x | x | x | x | x | x | x | x | x | x | x | x |

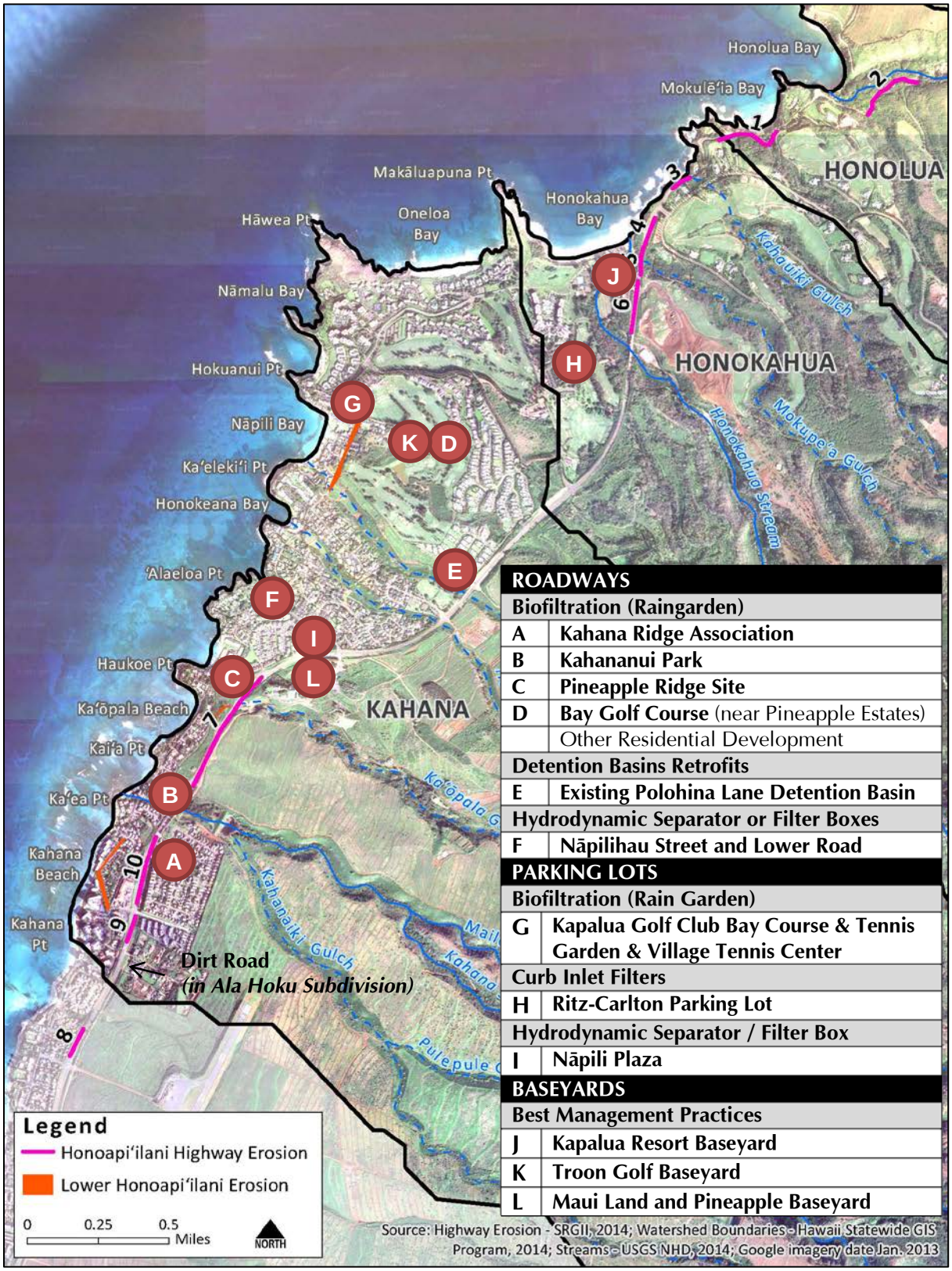



**Figure 6.14 Opportunities for Urban Management Measures**

The priority urban measures include management measures (Chapter 6), policy measures (Chapter 3) and outreach initiatives (Chapter 7). Priorities are based on the measures ability to have an overall positive impact on reducing pollutant contributions.

**Urban Policy Measure Priorities**

- ***Comprehensive Storm Water Management Plan***
- ***Low Impact Development (LID) requirement for development, redevelopment and improvement projects > 1 acre (State, County and private sector) to incorporate into design and construction***
- ***Increased Enforcement of Construction Storm water BMPs***
- ***Storm Water Fee Establishment***
- ***Golf Courses and Landscaping BMP Management Plans***
- ***Pool and Vehicle Wash Water Discharge Policy***
- ***Storm Water Management Asset Mapping***
- ***Regional Drainage Analysis***

**Urban Management Measures Priorities**

- ***Roadside Erosion*** (Honoapi'ilani Highway and Lower Road)
- ***Cesspool Identification and Conversion***
- ***Urban Storm Water Management Retrofits***

The urban outreach initiatives are discussed in Chapter 7.

Ongoing research (Appendix C) and information to fill data gaps are needed to better understand urban pollutants and their effects. The priority topics are nutrient sources and storm water drainage patterns and flow. For nutrient contributions, the ongoing DOH water quality data, results from submarine ground water discharge study in progress by Craig Glenn at UH, and the future testing nitrogen stable isotope ratios, future well testing for nitrogen and identification of homes with cesspools, will greatly assist in understanding nutrient sources and their relative contributions. The storm water system mapping and regional drainage analysis will aid in understanding pathways by which pollutant sources are entering nearshore waters.

Several other ongoing research studies will increase the understanding of pollutant impacts on coral. A study of biomarker expression in coral may contributed to the understanding of relative impacts of pollutants on corals, and a nutrient threshold study may provide target levels nutrient management. An ocean mapping project by NOAA may help identify problem areas for nutrient and sediments coming from land. Geo-chemical records of land-based sources of pollutants may highlight the impact and role of nutrients on coral degradation. In progress is water quality testing project by DOH, USGS and EPA to look for pollutants that can accumulate in fat tissue, and results may provide information on a new class of pollutants that need management measures to address.

# 7.0 PUBLIC EDUCATION PLAN

This chapter discusses and details ways in which the public can be empowered and supported in stewarding West Maui's natural resources during the implementation of the plan (Ongoing public engagement in the overall watershed planning process is discussed in Chapter 1).

The West Maui Ridge 2 Reef Initiative was formed in 2012 and through partnerships has led and participated in outreach that engages West Maui residents. To encourage greater public engagement in plan implementation, the West Maui Kumuwai Campaign was initiated in 2013. The ongoing development and expansion of this program is the primary conduit for the Kahana, Honokahua & Honolua Watersheds Public Education Plan.

Section 7.1 provides a look at the West Maui Kumuwai Campaign format and accomplishments to date. Section 7.2 lists behavioral pollution prevention strategies identified to address Kahana, Honokahua and Honolua watershed land uses and how they link to future Kumuwai outreach opportunities. Concluding sections discuss the benefits of public outreach and priority outreach initiatives.

## 7.1 Kumuwai Campaign

WEST MAUI
Kumuwai
A MOVEMENT FOR OCEAN HEALTH

The West Maui Kumuwai Campaign was developed as the spring board for future actions, and to persuade area residents to play a more critical role in ensuring watershed health. The campaign uses social marketing to achieve specific behavioral changes for social, political, and environmental good. Social marketing is the systematic application of social science and commercial marketing techniques (the same marketing tactics [e.g. peer pressure, social norms] used to sell products) coupled with social science and conservation psychology, to encourage and facilitate beneficial social and environmental behaviors. Strategies involve identifying and reducing barriers to action, enhancing benefits and incentives, and the use of social diffusion (or "peer pressure") to promote and change social norms surrounding the desired behavior.

Here are some West Maui Kumuwai Campaign hallmarks which are solid foundational components of existing efforts that address how effective outreach can be conducted:

- **Actionable requests** – People are often overwhelmed by the dire state of environmental problems and need to know what they *can* do. People can have a sense of accomplishment and connection.
- **Engaging** (e.g. gets people talking!) **and Fun**! – We need more fun in our lives, we want more fun, and we learn best when having fun. Engaging and fun events create connection between people in the community. Taking action in this manner can lead to further engagement and increase significant conservation action and outcomes.
- **Broad** – The groups engaged are beyond those typically seen as environmental supporters and reaches those who might not otherwise be reached.

- **Opportunistic** – If an opportunity arises with a willing partner, the team checks if it meets the overall strategy and goals of the campaign – and if so, the team engages. If another organization is hosting an event, and there is a meaningful and fun way to participate, West Maui Kumuwai Campaign engages.
- **Measurable Actions** – The requested actions should have measurable components to aid in estimating pollution reduction and assessing campaign effectiveness. Successful social marketing campaigns typically involve robust evaluation, including a pilot effort followed by broad-scale implementation in order to assess the effectiveness of the strategy and approach.

Activation points for Wahikuli-Honokōwai pilot campaign focused on lawn care practices, including: fertilizer, pesticide, and water use; planting *pono* and installing rain gardens; disposing of pet waste; car wash practices; and volunteering in the community. Through specific social marketing approaches, the campaign strategy is designed to generate not just individual actions in the short term, but a behavior change path that leads to greater, more complex and systemic actions and commitments (from individuals and the larger community) to sustainably manage West Maui reefs for the long term.

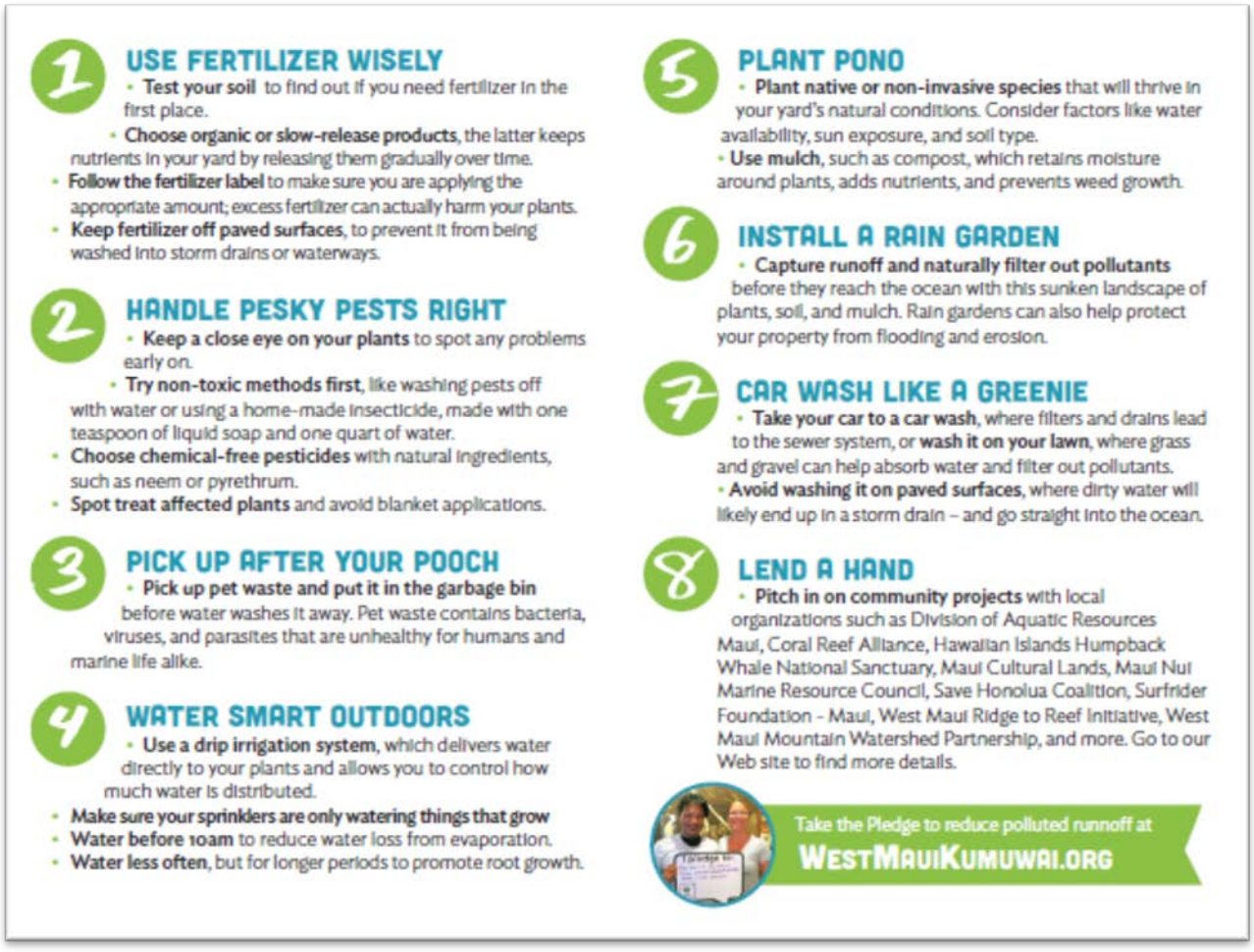



**Figure 7.1 Kumuwai Campaign Behavioral Targets**

Sustained support is needed to move these tactics through the pilot phase and into their final form. It will likely take several more years for this campaign to be fully realized and sustained by other partners in the community. Upon the campaign's establishment, not all components were fully developed, and capacity limitations prevented the undertaking of initial pilots involving robust evaluation and comparison with a control group. As such, this effort should not be considered a completed endeavor, but rather an undertaking that is off to a good start bolstered by excellent community engagement and partner feedback, and with strategies and tactics continually being evaluated and revised.

Currently the campaign team, comprised of eleven groups, is focused on further activating the target audiences to take individual action, and measuring those results. A part-time campaign manager has been contracted with grant funds to move the group's objectives forward; however, funding has only been secured through August of 2015. Figure 7.2 highlights the West Maui Kumuwai Campaign Initiatives in progress.

## 7.2 Future Opportunities

Future opportunities to expand the Kumuwai Campaign and other possible initiatives to increase public engagement and participation are presented in this section.

### 7.2.1 Pollution Prevention Behaviors

The pollution prevention behaviors were identified for Kahana, Honokahua, and Honolua watersheds throughout Chapter 6 Urban Management Measures. These matched with those targeted in the Kumuwai Campaign for resident behaviors. Additional focus and initiatives are listed below that broaden or introduce new initiatives.

#### *7.2.1.1 Proper Wash Water Disposal and Chemical Storage*

This initiative is particularly important where use and disposal of chemicals may be larger in quantities, such as those for condominiums, resorts or supporting baseyards. This should include proper disposal of pool and vehicle wash water after County code is clarified.

#### *7.2.1.2 Reduction in Fertilizer and Pesticide Applications and Watering Smart*

An expansion of the Ocean-Friendly Landscaper initiative would be working with area condominiums, resorts, and property managers in the three watersheds. County of Maui (Public Works, Parks and Recreation, Water Supply, Wastewater Reclamation) and State Department of Transportation employees working in these watersheds would also benefit from the outreach campaign.

Barriers, for both initiatives (7.2.1 and 7.2.2.), may include limited knowledge on correct behaviors and language/cultural barriers. Other barriers and benefits should be systematically identified and addressed through the campaign.

Possible motivators for the behaviors include:

A. cost savings by using less products
B. desire to do the right things
C. knowing their actions can be making a difference in the local environment
D. desire to have a positive public image

Several approaches or tactics were developed for the **West Maui Kumuwai Campaign** and are in pilot stages of determining which of these techniques will be most effective in changing the desired behaviors.

1. Pledges: Studies have shown that social norms can be quite powerful in behavior change campaigns. Pledges serve as a means for the community to make a public statement about a behavior they will adopt to reduce their personal polluted runoff. Pledges are collected at public events, following presentations, after beach clean ups, at watershed workshops and as the opportunity arises and is posted on the website and Facebook page.


**Figure 1 Voluntary Pledge**

**Figure 2 Joint Volunteer Event with Maui Cultural Lands**

2. Community events: The West Maui Kumuwai Campaign has partnered with numerous nonprofits and local agencies working to protect the watershed by promoting their events, and co-hosting activities. The aim is to showcase the many opportunities on West Maui to "lend a hand," which is one of the campaign asks, and to demonstrate that a cumulative effort is taking place to improve the health of the West Maui Watershed. These events are also used as a means to attract volunteers to maintain the four areas where the R2R has installed projects on public land.

3. Ocean friendly landscapers: This tactic was developed to allow homeowners who do not do their own landscaping to participate. Pledged landscapers are asked to commit to at least 10 of 14 ocean-friendly practices, and to involve homeowners by leaving them a letter of what they have pledged to do. Landscaper participants receive a suite of promotion items which include: company name on the WMK Web site, a digital "Ocean Friendly Landscaper" badge for their website, WMK stickers for their work trucks and for their clients, and an invitation to participate in community events.


**Figure 7.2 West Maui Kumuwai Campaign Initiatives**

4. Ocean Preferred Products: To eliminate the consumer's mind-numbing task of choosing which fertilizer and pesticide products are less harmful to marine resources, the branded point-of-purchase program called, "Ocean Preferred" was developed. Through a partnership with Ace Lahaina, staff label approved fertilizer and pesticide products with Ocean Preferred stickers and place marketing collateral, such as large shelf talkers, an end cap display, and a WMK video in aisles that sell such products.


**Figure 3 Ace Hardware Shelf Featuring Ocean Preferred Labeled Products**

5. Community stories: Recent examples of community volunteerism and contributions to Kumuwai goals were captured and shared about local people. The stories characterize multiple behavior change components: they encourage others to take action by modeling the desired behavior (social norms), they communicate to the audience that WMK actions are supported and should be investigated, and they create meaningful dialogue by allowing audiences to explore their own role in watershed health. This requires contacting, interviewing, photographing, writing and editing stories that are then shared through various media.

WEST MAUI Kumuwai

6. Media coverage: Stories covering West Maui Kumuwai are run regularly in the local paper. WMK has built strong partnerships with media outlets to promote programs and co-hosted events. Earned media additionally provides third-party validation of the campaign message, and helps direct residents to the WMK Web site.

***Source:*** *Wahikuli-Honokōwai Watershed Management Plan: 2014 Year End Progress and Adaptations*

**Figure 7.2 West Maui Kumuwai Campaign Initiatives (Continued)**

Having water quality data and monitoring as a component – and even enlisting the staff involved with water quality monitoring – could help to solidify the connection of their actions to the coral reef.

### *7.2.1.3 Proper Maintenance of Cesspools & Septic Systems*

As discussed, cesspools and septic systems provide limited treatment of household wastewater. The level of water treatment by these systems can even reduce over time without proper maintenance. While the locations of cesspools have not yet been verified, once they have, efforts can be made to provide information on cesspool and septic system best management practices to areas where they are located. Information with coupons to local providers could potentially be used as an additional outreach strategy, with coupon redemption used to track where cesspool and septic systems are, and are not, likely in use.

#### *7.2.1.4 Developer, Contractors, and County of Maui*

Outreach to developers and contractors should be continued, in addition to building upon outreach that has already occurred (workshops during US Coral Reef Task Force meeting). Contractors should understand construction temporary stormwater best management practices standards to prevent water quality and ecosystem declines.

Workshops on Low Impact Development (LID) should also be held for developers and contractors on these best management practices for new developments to assist them in meeting the County code of ordinance requirements (Chapter 15-111) and significantly improve runoff water quality (see also Chapter 6). The Coral Reef Alliance is conducting trainings with County of Maui staff on evaluation of SMA permits for effective LID and storm water GMP usages which should be continued as needed.

### 7.2.2 General Education

Additional public outreach needs and programs to be explored are discussed in the following sections.

#### *7.2.2.1 Community Stewardship Program*

Based on the County of Maui and State Department of Health's ability and capacity to address reported water quality related behaviors, a campaign could be created to educate the community on reporting potential water quality issues. The existing County of Maui mobile app "COMCONNECT" already contains reporting options which could be expanded and tailored for water quality issues. By providing information on what to report on the app, and through websites and other outreach means, citizens can play an important role as eyes on the environment to reduce pollutant source issues before they become larger problems. The policy measure to allow for anonymous reporting should be implemented prior to this program.

Community involvement can also be tied into water quality testing and research to help identify possible actions to mitigate and reverse impacts. A truly empowered and engaged community can help to check on pollutant sources and work with government entities and create synergistic effects.

#### *7.2.2.2 Seasonal Messages and Community Engagement*

A theme that might be utilized for schools or more general audiences is the remarkable life cycle of corals as well as the threats that coral reefs face, and how individuals can identify factors that indicate a general level of reef health. These observations can serve as the basis for community involvement, engagement, and citizen science activities. Community awareness of seasonal events such as coral spawning and bleaching can have longer lasting impacts on the watershed and nearshore waters, as people begin to connect their actions to the coral reef ecosystem. There might also be tie-ins to Native Hawaiian practices with kapu (taboo or prohibitions) put out by knowledgeable konohiki (Native Hawaiian land managers and cultural practitioners) at particular times of the year. These might include periods of coral, fish, and sea urchin spawning. Education and awareness alone may not shift the monitoring indicators, but they can be important foundations for later actions.

#### *7.2.2.3 Schools*

Schools are an opportune place to engage the next generation of children – and their parents – by sharing stories that highlight their connections to place. One upcoming opportunity for schools and students is via Honolulu Theater for Youth (HTY) which brings plays around the state. They are creating a play in collaboration with the City and County of Honolulu Storm Water Quality Branch that addresses storm water and impacts in fun and engaging event for kids and families. Collateral materials and information can be provided to the schools. Another opportunity is the annual Huilau Youth Environmental Film Festival on Maui.

#### *7.2.2.4 Public Demonstration Gardens*

As with the rain garden in Wahikuli, establishing public demonstration sites for management measures with appropriate interpretive signage and community engagement can help to create community connections and collective responsibility. Līpoa Point could serve as a place for highlighting and connecting projects with coral reef ecosystems as it attracts many recreational ocean users. Schools, parks, and commercial centers are other possible demonstration locations.

#### *7.2.2.5 Outreach Tools*

Outreach tools should be selected for targeted groups. Social media and expanded use of videos can help reach those with internet connections and individuals with schedules or issues that limit their ability to attend events. For other groups, such as kūpuna, farmers or decision-makers, meetings or tours may need to go directly to them to involve them more fully in the West Maui Watershed Plan process.

#### *7.2.2.6 Puʻu Kukui Watershed Preserve Public Outreach Campaign*

ML&P through the Puʻu Kukui Watershed Preserve public outreach connects with students and adults on conservation topics and efforts. Events include tree plantings of 5,000 to 10,000 trees per year, hosting hālau for traditional gathering, and boardwalk tours by lottery. Presentations are brought by Puʻu Kukui Watershed Preserve to schools, and over 100 interns were hosted in 2015.

### 7.2.3 Public Outreach Benefits

Benefits are often viewed primarily in terms of actions taken and behavior changes that help to reduce pollutant loading. These benefits alone are real and important outcomes. However, there are secondary benefits that may be just as important. Through public participation opportunities and increased awareness of the issues, a base of support for future projects is being built. It may take the form of volunteers ready to help do a stream side planting or run a workshop, or it may be in the form of support of County departments and Council members as they implement policies and programs to improve the health of watersheds.

## 7.3 Public Education Plan Priorities

The priorities for outreach are as follows:

1) The **West Maui Kumuwai Campaign** as the primary vehicle by which to empower and support community efforts (Chapter 1, Objective #2).
2) **Community Stewardship Program** which connects people with greater awareness of proper and improper water quality behaviors.
3) **Construction Industry Outreach on Storm Water Best Management Practices** to minimize potential large influxes of sediments from sites without proper stormwater management best practices.
4) **Low Impact Development Training** to increase understanding, promotion, and use of LID in existing and future development by landowners, developers, contractors, engineers, and county staff.
5) Expand outreach to **Landscapers and Property Managers** on best management practices with chemical and fertilizer usage, as well as proper disposal of pool and wash water.
6) **Pu'u Kukui Watershed Preserve Public Outreach Campaign** to continue connecting residents and others to conservation and the importance of preservation and restoration.

Guidance and information on how to positively impact the special West Maui environment will be needed into the foreseeable future. The makeup of people within a community reconfigures itself over time, and reinforcement of messages and behaviors will be required for continued levels of awareness and sustaining behavioral changes. Community educational campaigns may address certain issues and can provide opportunities to begin to address other behaviors.

The one recommendation that guides many others is to have at least one full-time outreach coordinator (in addition to a watershed coordinator) to extend public education within the watersheds. The outreach program will also need an ongoing support budget for print costs, media purchases and technical assistance (for instance with program evaluation) based on the proposed outreach programs. Because of the need to pilot and adapt programming, it is difficult to assign resources specifically to projects at this time.

# 8.0 MONITORING PLAN

The purpose of having a monitoring plan is to evaluate progress towards the West Maui Ridge to Reef end goal which is to "*restore and enhance the health and resiliency of West Maui coral reefs and nearshore waters through the reduction of land-based pollution threats.*"

A preliminary monitoring plan framework for this goal is presented along with a discussion of ways to measure the interim progress toward this goal. Three reasons to measure interim progress towards this goal are: 1) the coral reef ecosystem may take time to recover even after pollutant reductions, 2) other factors outside the reach of management measures (such as climate change and marine impacts) could be affecting coral reef health and 3) the monitoring of the various components of watershed health can direct adaptive management.

The monitoring framework in Section 8.1 includes indicators, proposed entities for conducting the monitoring, and potential funding sources. The discussion identifies the existing conditions data and missing components, many of which have been referenced in various sections of the document. The need for monitoring the effects of implementing specific measures is discussed in Section 8.2. Section 8.3 discusses next steps for the monitoring plan.

## 8.1 Monitoring Framework

A monitoring plan should include what to monitor as well as the location, frequency and monitoring methodology. This chapter begins by listing some of these parameters, which will be further developed for the five-watershed West Maui Watershed Plan.

Some of outcome and process indicators for monitoring coral reef community are taken from the draft Priority Ecological Measurements and Derived Indicators report developed by the US Coral Reef Task Force (US CRTF) Watersheds Working Group Metrics Subcommittee (2015). In addition to indicators, the document also includes details on data collection methods for many of the indicators in Section 8.1.2. Other process indicators were developed specifically for this *Kahana, Honokahua and Honolua Watersheds Strategies and Implementation Report.*

### 8.1.1 Outcome Indicators

The Priority Ecological Measurements and Derived Indicators document describes outcome indicators as measuring "how well your initiatives are accomplishing their intended goal. They compare the results of an intervention to the baseline beforehand." Table 8.1 lists outcome indicators which are those that characterize coral reef community conditions. These include benthic cover, coral recruitment, coral colony size structure, coral taxonomic richness and herbivore fish biomass. Not all coral decline is due to land-based sources of pollutants. Bleaching and climate impacts also impact these outcome indicators. Fish biomass is also affected by fishing activity.

Inherent in the definition of outcome indicators is comparison to a baseline or current conditions at a selected point in time. The lack of current conditions data for West Maui is significant, and efforts are under way to address this in part with identification of coral reef cover (Figure 2.2). A

comprehensive analysis of other cover including high relief pavement is needed to determine where coral has been lost and potential areas for recovery. Data for most of the other indicators are also lacking.

Due to the current understanding that regional circulation patterns may move nearshore waters from Kahana and Honokahua watersheds down south along the coastline, coral community indicators from Wahikuli-Honokōwai coral reef ecosystem should also be monitored.

### 8.1.2. Process Indicators

The Priority Ecological Measurements and Derived Indicators document describes *process indicators* as "important processes that contribute to the achievement of outcomes, but do not guarantee the achievement of outcomes." The proposed process indicators include those below with a description of their importance. These are listed with detailed components in Table 8.1 below.

#### *8.1.2.1 Sediment Quality*

The sediment quality is measured through two indicators, the first being *Sediment Constituent Accumulation*. This is a measurement of the percentage or ratio of the sediments derived from coral or carbonate sources versus those derived terrestrially due to watershed erosion. The terrestrial or terrigenous sediments tend to have smaller particle size, remain suspended in the water for longer periods of time, and cause more light reduction than the heavier coral derived sediments.

The second indicator of sediment quality is *Sediment Toxicity Testing*. This indicator uses standardized tests to measure the "lethal and sublethal effects of contaminants in sediment on specific test organisms." The results of this type of testing can help to identify priority sites for water quality contaminant testing. Water quality contaminant testing can be expensive and should therefore be used strategically.

There is no current data for these sediment quality indicators. This data could also help inform management measure prioritization.

#### *8.1.2.2 Water Quality – Nearshore Waters*

The indicators selected by the USCRTF Metrics Subcommittee included nutrients (*total nitrogen* and *total phosphorous*), *dissolved oxygen*, *chlorophyll a* and *turbidity*. In addition, *nitrate-nitrite* and *silica* have been added for Kahana, Honokahua and Honolua watersheds. These factors can affect corals, and human impacts can significantly alter the levels of nutrient loading into nearshore waters. Silica is included as it can serve to indicate amount of ground water mixing in the nearshore waters. The State of Hawai'i Department of Health Clean Water Branch will be developing a specific water quality monitoring framework that will be included in the West Maui Watershed Plan.

Until recently, available current conditions data for nearshore waters only included DOH turbidity data and bacteriological data. A more comprehensive sampling from a DOH study is in progress and is scheduled for March 2017 completion.

## Table 8.1 Proposed Monitoring Indicators, Units, Entities, and Proposed Funding

| Indicator | Unit of Measure | Monitoring Entity | Proposed Funder/ Funding | Current Data |
|---|---|---|---|---|
| **Coral Reef Community** (Outcome Indicators)[1] | | | | |
| Benthic Cover | Percentage of occurrences of biotic and abiotic elements occupying the benthos | CREP/DAR | CRCP/DOI | Yes but incomplete |
| Coral Recruitment | Density of juvenile corals (<5 cm) per $m^2$ | CREP | CRCP | No |
| Coral Colony Size Structure | Coral colony size frequency distribution for all coral species in a defined area | CREP | CRCP | No |
| Coral Taxonomic Richness | Number of species occurring in a defined area | CREP/DAR | CRCP/DOI | No |
| Herbivorous Fish Biomass | Total weight of herbivorous fish in $g/m^2$ | CREP/DAR | CRCP/DOI | No |
| **Sediment Quantity & Quality** (Process Indicators)[1] | | | | |
| Sediment Constituent Accumulation | % by mass by grain size; %weight of organic carbon, carbonate (coral derived) and terrigenous (land-based) sediment of a sediment sample | USGS | | No |
| Sediment Toxicity Testing | % Mortality | USGS | | No |
| **Water Quality – Nearshore Waters** (Process Indicators)[1,2] | | | | |
| Total Nitrogen[1] | mg/L N | Hui O Ka Wai Ola / DOH | DOH/EPA | No |
| Nitrate-Nitrite[2] | mg/L | Hui O Ka Wai Ola / DOH | DOH/EPA | No |
| Total Phosphorus[1] | mg/L P | Hui O Ka Wai Ola / DOH | DOH/EPA | No |
| Chlorophyll a[1] | µg/L | Hui O Wai Ola / DOH | DOH/EPA | No |
| Dissolved Oxygen[1] | mg/L DO | Hui O Ka Wai Ola / DOH | DOH/EPA | No |
| Turbidity[1] | NTU | Hui O Ka Wai Ola / DOH | DOH/EPA | Yes |
| Silica[2] | mg/L Si | Hui O Ka Wai Ola / DOH | DOH/EPA | No |
| Bacteriological testing[2] | | Hui O Ka Wai Ola / DOH | DOH/EPA | Limited |
| **Water Quality - Streams & Ground Water** (Process Indicators)[2] | | | | |
| Total Nitrogen | mg/L N | DOH | DOH/EPA | No |
| Total Phosphorus | mg/L P | DOH | DOH/EPA | No |
| Chlorophyll a | µg/L | DOH | DOH/EPA | No |
| Dissolved Oxygen | mg/L DO | DOH | DOH/EPA | No |
| Turbidity | NTU | DOH | DOH/EPA | No |
| Metals | µg/L | DOH | DOH/EPA | No |
| Other Contaminants | various | DOH | DOH/EPA | No |

**Table 8.1 Proposed Monitoring Indicators, Units, Entities, Proposed Funding (Continued)**

| Indicator | Unit of Measure[1] | Monitoring Entity | Proposed Funder/ Funding | Current Data |
|---|---|---|---|---|
| **Water Quantity** (Process Indicators) [2] | | | | |
| Streamflow | discharge measures in cubic feet per second (cfs) | CWRM/ USGS | DLNR | Yes |
| Ground Water Availability | water level in monitoring wells | CWRM/ USGS | DLNR | Yes |
| Submarine Ground Water Discharge | discharge measures in cubic feet per second (cfs) | CWRM/ USGS | DLNR | No |
| **Land Cover** (Landfire by USGS & CCAP by NOAA) (Process Indicators) [2] | | | | |
| Impervious Surfaces | acres | NOAA | NOAA | Yes |
| Development | acres | USGS/ NOAA | USGS/ NOAA | Yes |
| Forest Cover | acres | USGS/ NOAA | USGS/ NOAA | Yes |
| Fuel Load | | USGS | USGS | Yes |
| **Other** (Process Indicators) [2] | | | | |
| Feral Ungulates | feral ungulates per transect | PKWP & WMMWP | DLNR | Yes |
| Funding Received | $$/ Year, direct and indirect | WM R2R | WM R2R | Yes |

*1 USCRTF Watershed Partnership Initiative Priority Ecological Measurements and Derived Indicators; 28 April 2015 draft*

*2 Indicators proposed in this Kahana, Honokahua and Honolua Watersheds Strategies and Implementation Report*

A coalition of Maui Nui watershed/community groups, called Hui O Ka Wai Ola, has developed a coastal water-quality monitoring program. The Hui O Ka Wai Ola includes The Nature Conservancy, the Maui Nui Marine Resource Council, University of Hawai'i Maui College and West Maui Ridge to Reef Initiative. The goal is to augment the coastal monitoring program of the Department of Health Clean Water Branch, as limited staff availability and funding have affected the spatial extent and frequency of sampling. Through quality-assured sampling and testing, community-based monitoring can help fill the need for ongoing reliable data to improve assessment of coastal water-quality conditions and detection of trends. Reliable water-quality data depends upon well trained community team members following a comprehensive Quality Assurance Project Plan, and using a certified analytical laboratory for some analyses.

### *8.1.2.3 Water Quality – Streams & Ground Water*

Monitoring of the stream water quality and its contribution to nearshore waters tracks progress in reducing specific sources from watersheds, and serves as an important part of adaptive management. However, due to the lack of water flow for portions of the year, continuous stream water quality data may not be possible. Ground water monitoring is also pivotal in adaptive management and may provide a better understanding of the time it takes for ground water pollutants to reach nearshore waters, and their effects on coral. See Water Quality discussion in 8.1.2.4 below regarding a submarine ground water seepage study that may provide nutrient data.

#### *8.1.2.3 Water Quantity*

In the Hawaiian language, the word for water is wai, and the word for abundance is waiwai. These terms may stem from the understanding that abundant water is a measure of wealth, or that water provides wealth in its ability to provide for people through crops such as kalo. Wetland kalo, kalo grown in loʻi (or paddies), requires flowing water to grow abundantly in West Maui.

In terms of coral reefs, water quantities can help in assessing pollutant loading and establishing pollutant budgets. Water quantity data can also be used to track the amount of freshwater flushing as well as possible detrimental fresh water influxes to nearshore waters.

Two USGS studies provided data and analysis of ground water (Gingerich, 2012) and low flow stream characteristics (Cheng, 2014). However, ongoing monitoring of streamflow in the watersheds is not currently in place. The USGS study utilized a temporary streamflow gage and then tied flow to index streams on the other side of West Maui. CWRM is planning to set measurable interim instream flow standards for streams in the region. Upon adoption of revised standards, CWRM will implement a monitoring program to ensure the standards are not being violated. A study on submarine ground water discharge is in progress, but that data and analysis are not yet available (Appendix C).

#### *8.1.2.4 Land Cover*

Land cover data helps to monitor human impacts on the land and the extent of human settlement and vegetation changes. Pacific RISA and the Oleson Lab in the Department of Natural Resources and Environment Management at the University of Hawaiʻi Mānoa have both utilized available land cover data and provided additional details and ground truthing. The possibility of these entities maintaining and processing future data should be explored.

The existing conditions data is available and will be useful in tracking changes in the landscape, including those from climate change.

#### *8.1.2.5 Other*

Other process indicators may include quantities of feral ungulates to assess where the effects may be concentrated and guide ongoing management efforts.

Funding, both direct and indirect, should be tracked to show investment in actions in the watersheds.

Current data collection is limited for the conservation area, and no systematic data collection exists for agricultural lands.

### 8.1.3 Proposed Funding

Possible funders for the various monitoring indicators are listed. Discussion and confirmation of funding availability and level of commitment is still needed. Funding and a responsible entity for ongoing data analysis are also needed.

## 8.2 Monitoring for Impacts of Measures Implementation

Monitoring measures to determine their effectiveness is one of the most useful yet difficult components of watershed planning. The difficulties arise from factors which may include small project scale which makes changes hard to detect and budgets with limited funds for monitoring.

Identifying where meaningful data can be obtained and which measures are having a significant beneficial or negative impact, can be critical to an overall adaptive management approach.

The most basic monitoring is of which measures have been implemented. However, to yield information for adaptive management decision-making, quantitative information is preferred. Projects can be monitored via sediment pins in erosive areas which can track erosion rates pre and post measure implementation. Photo point monitoring of visual conditions to note sediment volumes or percent vegetative cover can also be used as a monitoring option. These types of monitoring will be required for any Clean Water Act Section 319 funded projects.

Monitoring of measures might also include evaluation of implementation through modeling approaches, monitoring at one site to determine efficiencies/effectiveness and applying this to broader practice implementation. This information is also critical for being able to attribute improvements in water quality to watershed implementation activities.

## 8.3 Monitoring Plan Next Steps

Monitoring plans require current conditions data in order to compare progress towards a goal. Current conditions data is limited for West Maui. For some elements, funding and commitments have been secured, while other indicators still need funding and commitments.

In addition to current data collection and securing funding support for ongoing data collection, it is also important to identify who will collect and analyze the data to chart progress towards goals. This will be detailed in the comprehensive West Maui Watershed Plan.

Having a well thought out, and ongoing monitoring plan with consistent data collection and analysis is one of the cornerstones of adaptive management discussed briefly in Chapter 9.

# 9.0 NEXT STEPS

## 9.1 West Maui Watershed Plan

The goal of the West Maui Watershed Plan is to identify land-based pollutant reduction strategies to restore coral reefs and protect the watershed (Chapter 1). Various reports are integral to the development of the overall West Maui Watershed Plan and will be incorporated by reference (Figure 9.1).

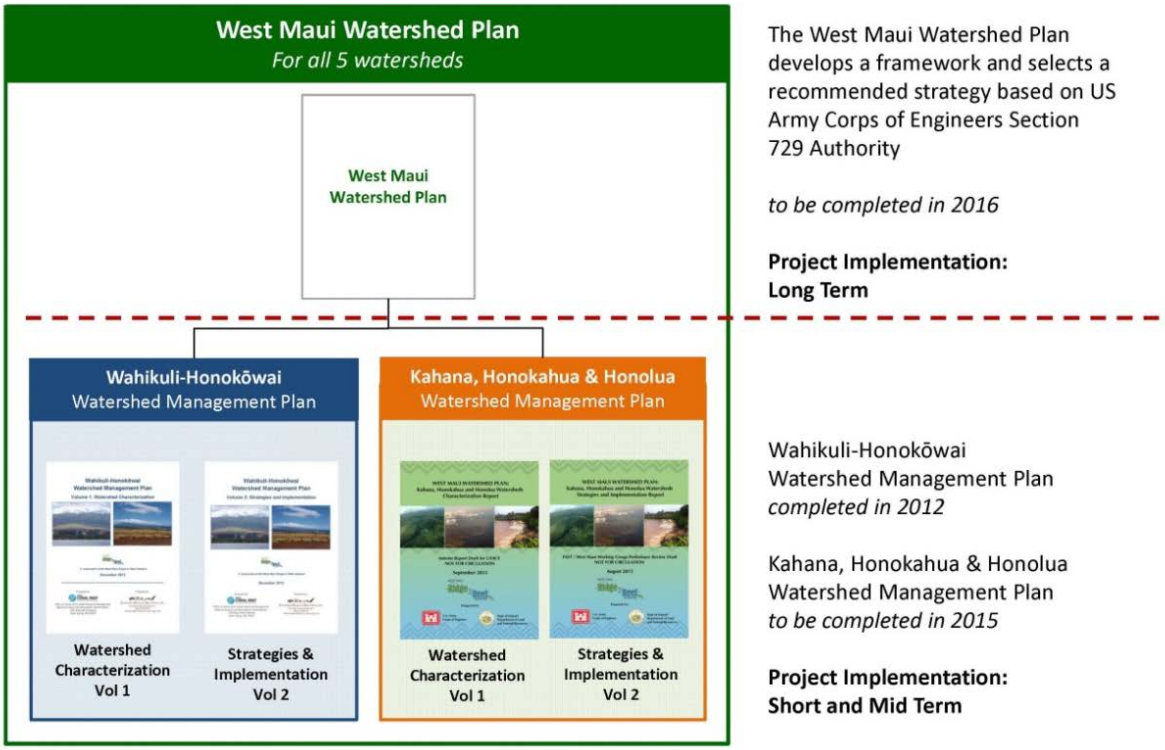



**Figure 9.1 West Maui Watershed Plan and Reports**

The next step in developing the overall five watershed West Maui Watershed Plan is formulating and evaluating alternatives that will best achieve the West Maui Watershed Plan goal. The alternatives will be comprised of policy and management measures from the Strategies and Implementation Reports for the Wahikuli and Honokōwai watersheds and the Kahana, Honokahua and Honolua watersheds (Figure 9.2).

Information from the Wahikuli and Honokōwai Watersheds and Kahana, Honokahua and Honolua Watersheds Characterization Reports will be used to inventory and forecast existing and future (over the next 50 years) conditions in the five watersheds – without management or policy measures (Figure 9.2).

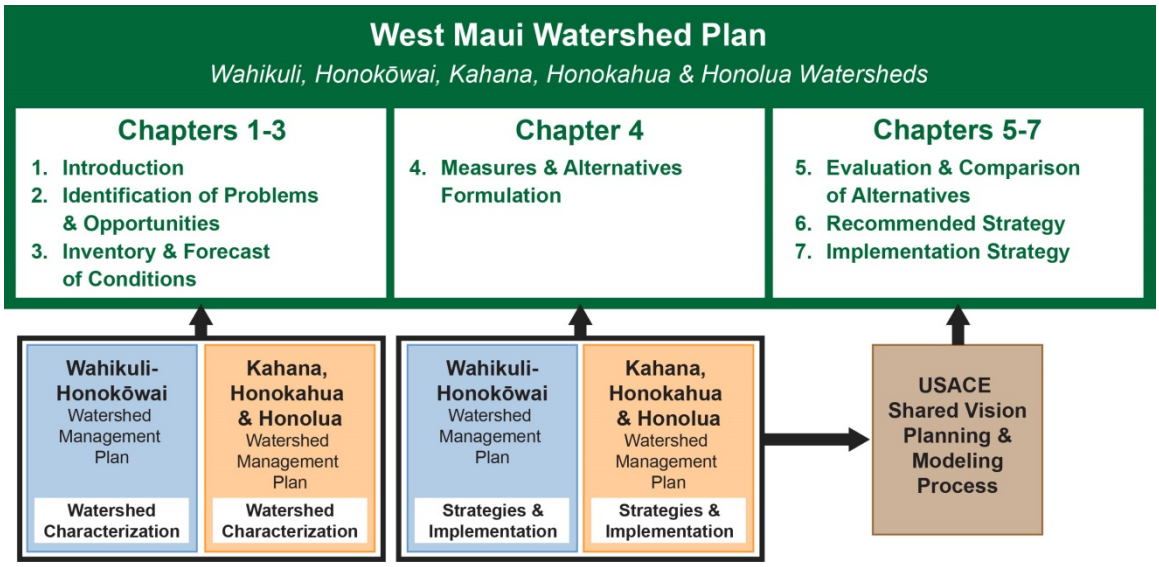



**Figure 9.2 West Maui Watershed Plan Report Integration**

A collaborative assessment will be used to evaluate what set of policy and management measures will provide the best outcomes for watersheds and people of West Maui using the US Army Corps of Engineers Shared Vision Planning and Modeling Process (http://sharedvisionplanning.us/).

Ultimately through the above steps with stakeholder collaboration, a recommended strategy will be selected for the Plan.

## 9.2 Adaptive Management and Structured Decision-making

While planning efforts will be based on available knowledge and stakeholder collaboration, ongoing efforts to gain greater understanding of the system and future decisions will need to incorporate future knowledge and lessons learned. Adaptive management and structured decision-making using an ecological model can support this effort going forward.

> *An adaptive approach involves exploring alternative ways to meet management objectives, predicting the outcomes of alternatives based on the current state of knowledge, implementing one or more of these alternatives, monitoring to learn about the impacts of management actions, and then using the results to update knowledge and adjust management actions. Adaptive management focuses on learning and adapting, through partnerships of managers, scientists, and other stakeholders who learn together how to create and maintain sustainable resource systems.*
>
> (Williams, B.K. et al, 2009)

The Adaptive Management Working Group (U.S. Department of the Interior) lists the conditions under which adaptive management is most useful:

1) management is required in spite of uncertainty
2) clear and measurable objectives guide decision making
3) there is an opportunity to apply learning to management
4) monitoring can reduce uncertainty
5) there is sustained commitment by stakeholders including decision makers

These conditions are clearly reflected in the West Maui Watershed Plan area and process.

Structured decision-making, which is grounded in values, is a key tool used concurrently with adaptive management. The clear and early identification of objectives that incorporate values then guides the analysis. The core steps in decision making steps 1-5 are displayed in Figure 9.3. This framework can set the stage for adaptive management in steps 6-9, which are used to assess the preferred alternative.

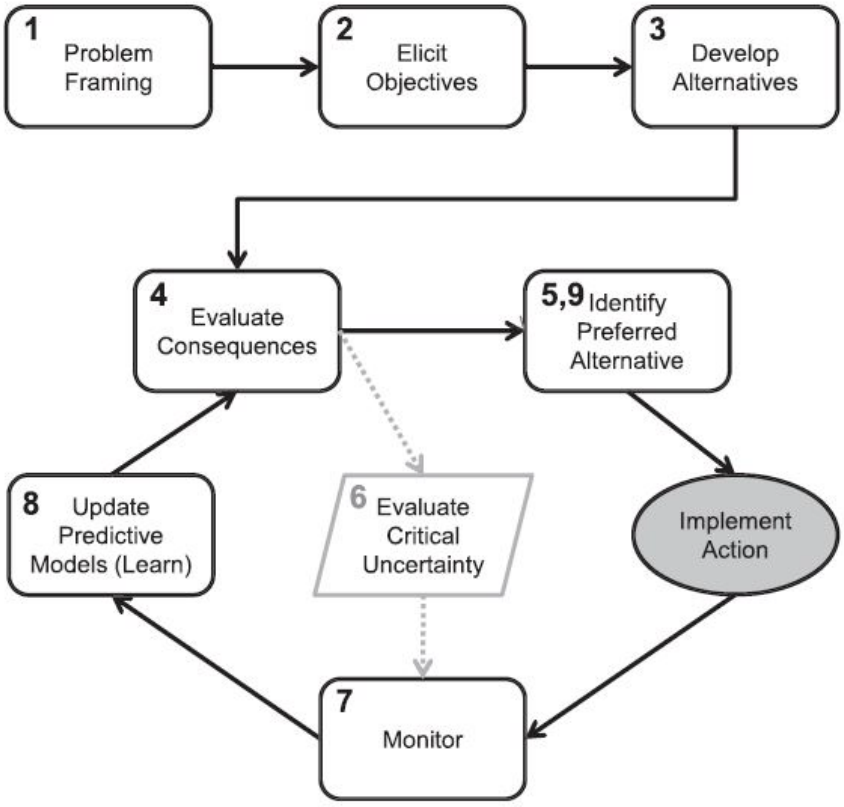



**Figure 9.3 Adaptive Management Schematic (Runge 2011)**

Adaptive management and structured decision-making use modeling and monitoring. Modeling is important in both predicting possible outcomes and in representing possible uncertainties about the system. Monitoring is critical for providing information for learning and evaluation of management effectiveness.

Adaptive management is more than monitoring, as learning must result from the monitoring; the learning is then used to decide at which point different actions are appropriate. The ability to adapt future decisions to new information is the hallmark of adaptive management (Runge 2011).

As noted in this report, research is ongoing to fill the identified data gaps. Research efforts are summarized in Appendix C along with potential implications for decision making. Information from the research efforts will be integrated into the modeling effort to develop the West Maui Watershed Plan. The researchers and related agencies will be consulted in the use of data. In particular, the ecosystem services mapping/modeling will be used for structured decision-making in the West Maui Watershed Plan process and will assist in implementing adaptive management in West Maui.

## 9.3 Adaptive Management Implementation

Adaptive management will be ongoing and may take many years and possibly decades to fully implement. Roles and responsibilities need to be identified, assigned and accepted by engaged organizations. A governance structure for decision-making and organizational interactions must be established including identification of a lead organization.

These issues and tasks will be part of the planning process to develop the West Maui Watershed Plan and to ensure implementation of adaptive management for West Maui.

# APPENDIX A: INFORMATION CITED

## A.1 References

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## A.2 List of Persons Consulted

The following individuals were consulted during the development of the Plan, either through personal communication, interviews, or attendance at meetings.

Barboza, Rick, Hui Kū Maoli Ola

Callender, Tova, West Maui Ridge to Reef Initiative

Cullison, Todd, Hui Koolaupoko

Ganske-Cerizo, Ranae, NRCS

Faliniski, Kim, UH

Foote, Liz, West Maui Kumuwai Campaign & S.E.A.-Link

Haynes, Michelle, IWR, USACE

Hood, Andy, SRGII

Johnson, Steve, USACE

Jorgensen, Mary, County of Maui Long Planning Department Range Planning Division

Kaniaupio-Crozier, Pomaika'i, Maui Land & Pineapple

Kurano, Matthew, State Department of Health

Levin, Penny

Lindquist, Pat, Nāpili Bay

Nohara, Wes, WMSWCD

Oleson, Kirsten, UH

Reed, Adam, NRCS Pacific Islands Area

Rollins, Scott, County of Maui, Environmental Management Wastewater Reclamation Division

Slay, Hudson, EPA

Smith, John, County of Maui, Department of Public Works

Sparks, Russell, DLNR DAR Maui

Storlazzi, Curt, USGS

Stock, John, USGS

Takeshima, Greg, State Department of Health

Tihada, Eugene (Mike), Maui County, Department of Public Works, Highways

# APPENDIX B: POLLUTANT DATA AND ESTIMATES

This table is a compilation of the available data and modelled estimations of pollutants that provides a snapshot of current understanding of pollutant sources and loading. Areas without data should not be interpreted as not being priority areas. As data becomes available, these areas may be prioritized for specific efforts.

**Table B.1 Water Quality Data and Existing Pollutant Sources Summary**

| Watersheds/Urban Sub-Areas[1] | KAHANA | | | | | HONOKAHUA | HONOLUA | |
|---|---|---|---|---|---|---|---|---|
| | Kahana | Kaʻōpala | Honokeana | Nāpili | Kapalua | | Honolua | Līpoa Point |
| **Water Quality Data**[2] | | | | | | | | |
| **Turbidity** (State standard = 0.2 NTU)[3] | | | | | | | | |
| Geometric Mean of 6 samples from 2014-2015 (NTU)[4] | 3.04 (S Turns/Pohaku as proxy) | 5.46 | No data | 1.72 | 1.81 Kapalua; 0.90 Oneloa | 2.83 DT Fleming Beach | 1.79 Mokulēʻia; 3.50 Honolua | na |
| **Nutrients**[5] | | | | | | | | |
| Available Data from after 2008 (post plantation era)[6] | No data | No data | No data | Significant Exceedances – Nitrate + Nitrite and Ammonia Nitrogen | No data; No data | No data | No data; No data | na |
| **Urban Pollutant Loading & Sources** | | | | | | | | |
| **Relative Annual Urban Loading** (Modeled using the Simple Method)[7] | | | | | | | | |
| ***Total Suspended Solids*** *(tons)* | *6* | *1* | *8* | *6* | *13* | *na* | *na* | *na* |
| ***Total Phosphorous*** *(lb)* | *68* | *11* | *92* | *74* | *153* | *na* | *na* | *na* |
| ***Total Nitrogen*** *(lb)* | *314* | *50* | *427* | *342* | *712* | *na* | *na* | *na* |
| **Related Information** | | | | | | | | |
| **Area** (acres) | 138 | 46 | 172 | 215 | 419 | na | na | na |
| **Impervious Surface** (acres)[8] | 77 | 9 | 77 | 57 | 105 | na | na | na |
| **Impervious Surface** (%)[8] | 56% | 20% | 45% | 27% | 25% | na | na | na |
| **Nutrient Sources (Potential)**[9] | Ala Hoku OSDS | OSDS? | OSDS? | OSDS? | Golf Course (54 acres) | Golf Course (128 acres) and Other Landscaping | Golf Course (95 acres) and Other Landscaping | |
| **Other Sources/Opportunities**[10] | • Hwy & Lower Rd Erosion<br>• Ala Hoku Area<br>• Illicit Discharges | • Coastal Erosion | • Nāpilihau Area Drainage | • Lower Road Erosion<br>• Illicit Discharges | | | • Hwy & Lower Rd Erosion | • Dirt Road |

| Watersheds/Subwatersheds[1] | KAHANA | | | | | HONOKAHUA | | | HONOLUA | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Kahana | Kaʻōpala | Honokeana | Nāpili 4-5 | Nāpili 2-3 | Honokahua | Mokupeʻa | Kahauiki | Honolua | Līpoa Point |
| **Existing Conservation and Ag Pollutant Loading and Sources** | | | | | | | | | | |
| **Potential Pollutant Losses, Annual** (modeled using NSPECT)[11] | | | | | | | | | | |
| ***Soil Loss*** *(tons)* | *48,453* | *16,131* | *24,581* | *24,010* | *12,826* | *27,202* | *11,351* | *7,110* | *31,978* | *5,629* |
| ***Phosphorous*** *(lb)* | *832* | *139* | *187* | *146* | *165* | *294* | *113* | *109* | *361* | *7* |
| ***Nitrogen*** *(lb)* | *12,480* | *1,110* | *1,272* | *1,161* | *1,129* | *5,837* | *1,640* | *798* | *8,001* | *44* |
| ***Suspended Load, USGS Study*** *(tons/year) modeled*[12] | *No data* | *No data* | *No data* | *No data* | *No data* | *No data* | *No data* | *No data* | *>345* | *No data* |
| **Related Information** | | | | | | | | | | |
| **Drainage Area** (acres) | 3,237 | 573 | 484 | 597 | 475 | 1,004 | 999 | 767 | 2,545 | 66 |
| **Fallow Crop Area/% of Total Area**[13] | 795/25% | 251/44% | 212/44% | 147/25% | 124/26% | 61/6% | 46/5% | 86/11% | 101/4% | 57/87% |
| **Access Roads**[14] (miles of roads / # of steam and gulch crossings) | 26.8 / 4 | 12.2 / 1 | 0.7 / 2 | 6.5 / 2 | 2.9 / 2 | 3.6 / 0 | 6.8 / 1 | 0.8 / 1 | 12.7 / 3 | |
| **Desilting Basin Assessment**[15] | Undersized | Undersized | Acceptable | Acceptable | Undersized | None | None | None | None | Sediment Basin only |

Notes: a) No data does not mean no priority. b) Darker fill denotes potentially higher loading or occurrence; brown is for sediment related data and green for nutrient related data; lack of data (and/or color) does not mean no priority. Additional nutrient and sediment data is forthcoming; c) data shown in normal font and modelling/estimations in italics; d) footnote references listed on following pages

## Footnotes for Table B.1 Water Quality Data and Existing Pollutant Sources Summary

[1] See Figure B.1 of watersheds, subwatershed drainages, and urban sub-areas.

[2] Hawai'i State Department of Health (DOH) Clean Water Branch (CWB) Monitoring and Analysis Section collects and analyzes water samples following quality assurance project plans (QAPP) approved by Environmental Protection Agency Region 9 (DOH 2012). Data from sample analyses are intended for use by Section personnel to assess coastal water quality. After internal data validation and quality assurance, the data is made is publically available on the website http://emdweb.doh.hawaii.gov/CleanWater Branch/WaterQualityData. Per the DOH QAPP uses of the data by other users for other purposes are not supported and the responsibility for determining the appropriateness of any such use lies solely with the user. Any conclusions in this Kahana, Honokahua and Honolua report utilizing DOH CWB data do not necessarily reflect findings of DOH.

[3] Water turbidity is one way to measure the amount of suspended sediments and other materials that block sunlight from reaching aquatic life. Turbidity is measured by nephelometric turbidity units (NTUs). Turbidity samples and measurements were taken during DOH CWB biological and chemical sampling from 2014 to 2015 is presented. Each sample for the seven sites within the Kahana, Honokahua, and Honolua watersheds were taken on the same day. The single day sampling consistency allows for comparison between sites because factors affecting turbidity, namely rainfall, are relatively constant. The State "dry" water quality standard for is 0.2 NTU. The more stringent "dry" standard is applied to West Maui because the definition of dry open coastal waters is as those receiving less than three million gallons per day of fresh water discharge per shoreline mile (from a 1977 report of the Technical Committee on Water Quality Standards.)

[4] The geometric mean is a special type of average used to characterize the central tendency of a set of numbers. It is calculated by taking the nth root of a product of n numbers. For most locations the State standard was exceeded by a magnitude of 3 to 40 times the criteria of 0.2 NTU.

[5,6] Nutrients refers to the following chemical constituents: Total nitrogen; ammonia nitrogen (NH4); nitrate + nitrite (NO3- + NO2-); total phosphorus; and chlorophyll *a*. These chemicals can act as nutrient inputs for plant life except for chlorophyll a which is an indicator of algal growth. The above chemical constituents were tested for in three coastal locations (Ka'ōpala Bay, Flemings Beach Out and Honolua Bay) between 2006 and 2008 during a period of pineapple cultivation. Nāpili Bay had testing after the close of pineapple operations (2009-2010). Phosphorous and total nitrogen levels exceeded the State standards only at sites sampled before pineapple closure. Ammonia and Nitrates/Nitrites were exceeded at sites both pre and post pineapple cessation and are shown for Nāpili Bay in the table.

[7] "The Simple Method" is a technique used to estimate storm water runoff pollutant loads for urban areas. The key inputs are subwatershed drainage area and impervious cover, storm water runoff pollutant concentrations, and annual precipitation. Because there are no storm water pollutant concentrations for West Maui, concentrations from O'ahu (NPDES Storm Water Monitoring Report for City and County of Honolulu by Oceanit Laboratories) for similar land uses were used for the calculations.

[8] National Oceanic Atmospheric Administration (NOAA) Coastal Change Analysis Program data from 2005 provides estimated impervious surfaces. The total of the impervious surface acreage is different than those for the total urban area as the urban subwatershed boundaries do not include the entire urban area.

[9] The State of Hawai'i Department of Health Safe Drinking Water Branch report entitled Human Health and Environmental Risk Ranking of On-site Sewage Disposal Systems for the Hawaiian Islands of I, I, Maui, and I was released in September 2014. The data includes locations of Onsite Sewage Disposal Systems (OSDS) of which cesspools are one type. However, over reporting has already been identified and greater review is needed. There are a number of areas that do not have County sewer lines and likely have OSDS including the Ala Hoku subdivision (in South Kahana ma uka of the Highway), Kapalua Plantation Estates and Honolua watershed area. The next step is to confirm the type of OSDS used in order to better identify sources and loading.

[10] Other sources such as sediments, and pool and wash water discharges are based on site visit observations by Sustainable Resources Group International, Inc. (SRGII) in May 2013.

[11] Nonpoint Source Pollution and Erosion Comparison Tool (NSPECT) which is applied over the three watersheds to compute estimates of soil loss from surficial erosion and to estimate nitrogen and phosphorus losses). The model does not estimate soil eroded or "lost" from concentrated flows such as along streams and gulches, nor does it compute sediment transport in streams and delivery to the ocean. The NSPECT estimates are best used as a comparative tool over subwatersheds within the project area in order to derive relative rates of erosion and soil loss. The model outputs have not been verified via ground truthing or empirical data.

[12] These are the preliminary results from the USGS July 2014 site visit (Stock 2014). A sediment budget was developed for the Honolua watershed that considers stream erosion and accumulated sediment deposition and estimates the portion of total sediment load which is from suspended sediments.

[13] National Oceanic Atmospheric Administration (NOAA) Coastal Change Analysis Program data from 2005 provides former cultivated crop fields.

[14] Access road lengths are from access road data provided by Maui Land and Pineapple (ML&P). Stream and gulch crossings are the total number of times the ML&P access road data intersects with a stream or gulch.

[15] The debris basins were assessed by SRGII based on a comparison of the subwatershed drainage area to the potential capacity of the basin to hold the water from the drainage area during a rain event. The capacity of the basin was considered based on both the stated basin size as well as visual inspection of the maintenance of the debris basin.

# APPENDIX C: RESEARCH IN PROGRESS

| Research Category | Research Description *(Researcher - Agency)* | Locations | Question To be Addressed | Management Implications | Timeline / Status |
|---|---|---|---|---|---|
| **Pollutant Impacts on Coral Health** | ***Geo-chemical Records of Land-based Sources of Pollutants and Climate Change (Storlazzi/Prouty- USGS)*** | | What are the historic water temperature variations, extent of bioerosion and nutrient loading? | Effect of nutrients and temperature on coral health is better understood and can shift prioritization of measures to address nutrients. | Field Work 2nd Qtr 2016 |
| | ***Setting Nutrient Thresholds to Coral Reef Health (Nelson, UH)*** | | What threshold of nutrients (Nitrogen and Phosphorous) stress W Maui coral? | Establishment of nutrient thresholds paired with coastal water quality monitoring will help with honing the priority level for nutrient management in hydrologically connected areas. | Results 3rd Qtr 2016 |
| | ***Biomarker Expression in Coral (Richmond- UH)*** | | Are West Maui corals showing a stress reaction to nutrients and sediment in nearshore waters? | As understanding of pollutant and effect on corals is refined, prioritization of projects should be adjusted. | Unknown |
| **Coral Connectivity** | **Maui Nui circulation models *(Storlazzi- USGS)*** | Maui Nui | What are the coral larval dispersal patterns in West Maui? | This may highlight the need for protecting larval sources outside of the five watersheds. | Report 2nd Qtr 2016 |
| **Coral Ecosystem Health** | **Annual monitoring and summary *(Williams/Vargas-Angel/White- NOAA/DAR)*** | All 5 | What are the trends in benthic and fish populations along select transects? | Critical monitoring: ability to show changes in the health of the marine ecosystem over time and understand long term impacts of management measures | Field Work (Mapping) 2nd Q 2016 |
| | **West Maui High-Resolution Benthic Habitat Mapping *(USGS)*** | Wahikuli, Honokōwai | What is the benthic character of the entire nearshore reef complex? | Monitoring: provide the base for all biotic and abiotic measurements on the reef | By 3rd Qtr 2016 |

| Research Category | Research Description *(Researcher - Agency)* | Locations | Question To be Addressed | Management Implications | Timeline / Status |
|---|---|---|---|---|---|
| | **Benthic habitat mapping the West Maui coral reef ecosystem *(Rooney- NOAA)*** | All 5 | What is the seafloor depth, structure and living cover to the boundary of state waters in West Maui? | Monitoring | By 3rd Qtr 2016 |
| | **Maui Nui Reef Geology and Oceanography GIS *(USGS)*** | Maui Nui | What are the best areas to put into Marine Protect Areas to sustain healthy reefs? | This may support the establishment of Marine Protected Areas that might be larval sources for West Maui. | Journal submission in 2016 |
| **Water Quality: Surface Waters** | ***Nearshore water quality sampling and testing (DOH)*** | All 5 | What are the trends in water quality across all standard parameters? | Critical monitoring: Will indicate the presence or absence of additional nutrient, sediment or microbiological pollutant concerns. | Data Collection Feb 2015 to Feb 2017 |
| | ***Urban water quality monitoring (Babcock- UH)*** | 4 urban areas in Wahikuli & Honokōwai | Are urban land uses a significant driver for nutrient export? | The level of prioritization of addressing residential landscaping or golf management will be adjusted according to the results. | Data Collection until June 2016 |
| | ***Semi-permeable membrane devices (DOH/ USGS /EPA)*** | | Are there contaminants present in the water column that can accumulate in fat tissue? | If contaminants are found and are of known toxicity to coral, this would introduce a new class of pollutants that need management measures to address. | Report by 3rd Q 2016 |
| **Water Quality: Ground Water** | ***Nutrient inputs through groundwater (Glenn- UH)*** | Honolua, Wahikuli Wayside Park | What are the groundwater discharge flows and nutrient loads at these locations? | If groundwater accounts for a known proportion of nutrient concerns, this will affect the approach taken to mitigate the balance of the nutrient load appearing in DOH water sample results. | By 2nd Qtr 2016 |

| Research Category | Research Description *(Researcher - Agency)* | Locations | Question To be Addressed | Management Implications | Timeline / Status |
|---|---|---|---|---|---|
| **Sediment Dynamics** | ***Sediment source mapping (Stock- USGS)*** | Select streams | Where and how much sediment is retained in the streams and gulches? | Will clarify where in-stream management measures should be placed to address the largest sediment loads. | Field Work 2nd Qtr 2016 |
| **System Modeling** | ***Ocean color mapping (Strong- NOAA)*** | West Maui | Can remote sensing help to identify the most problematic areas for nutrient and sediment export? | Can potentially validate sediment and nutrient models so that confidence can be adjusted accordingly. | Field Work 2nd Qtr 2016 |
| | ***Ecosystem service mapping, modeling, and valuation decision support tool (Oleson- UH)*** | All 5 | Can linked physical models guide decision making about management measures? | Tool for selecting highest merit measures where empirical data is missing. | 2017 |

# APPENDIX D: POLICIES, PROGRAMS AND REGULATIONS

Various policies, programs and regulations govern land uses and serve to prevent, limit and mitigate impact from pollutants to protect and improve water quality to inland and coastal water bodies and resources. The outline of existing policies and regulations in Tables D.1 to D.4 serves three purposes in this *Kahana, Honokahua and Honolua Strategies and Implementation Report*:

1. Provides the basis for potential additional or expanded policies, program or regulations (Tables D.2, D.3 & D.4).
2. Highlights opportunities to affect change in future land use (such as providing comments or requesting additional information on resource protection) before residential construction begins (Table D.1).
3. Addresses the possible regulations that may govern implementation of proposed management measures.

The regulations, policies and programs are presented in the following tables:

- Table D.1 – Existing Land Use Regulations
- Table D.2 – Existing Agricultural Policies, Programs and Regulations
- Table D.3 – Existing Construction and New Development Regulations
- Table D.4 – Stream / Water Regulations

**Table D.1 Existing Land Use Regulations**

| Regulation | Requirement/Applicability | Responsible Agency |
|---|---|---|
| **LAND USE DISTRICTS** | | |
| HAR 15-15 Land Use Commission Rules<br>HAR 11-200 Environmental Impact Statement Rules | This regulates land uses within a State Land Use District and lists permissible uses for the district (Urban, Agricultural, Conservation & Rural)<br>If proposed actions would be non-conforming, boundary amendment must be obtained. Boundary amendment applications typically require an Environmental Assessment or an Environmental Impact Assessment | State of Hawai'i DBEDT - State Land Use Commission |
| HRS 183C and HAR 13-5 Conservation District | Land uses in the conservation zone are regulated and conservation subzones permissible uses are defined.<br>Permit processes for applicable conservation land uses vary by conservation subzone | State of Hawai'i Department of Land and Natural Resources - Office of Conservation and Coastal Lands |
| **ZONING** | | |
| Maui County Code of Ordinances – Chapter 19 Zoning | Permitted uses and development standards for zoning are governed in this Chapter of the Maui County Code.<br>For uses not specifically permitted by zoning, a conditional permit application may be submitted.<br>Provides for Planned Development on urban zoned lands greater than 3 acres or outside the urban district on lands greater than 10 acres, allowing for greater building densities but retaining not less than 20% of total area in common protected open space; rules specify allowed densities (19.32) | County of Maui Department of Planning |

**Table D.1 Existing Land Use Regulations (Continued)**

| Regulation | Requirement/Applicability | Responsible Agency |
|---|---|---|
| | Permits cluster housing developments in order to allow development of housing sites which would otherwise be difficult to develop under conventional county subdivision standards, to allow flexibility in housing types, to encourage innovative site design and efficient open space, and to minimize grading, among other things. Cluster housing may be constructed in all residential and apartment districts, provided minimum land area and density requirements are met.<br><br>Maui County limits conversion of areas susceptible to erosion and sediment loss through requirements of specific Project Districts (19.70 through 19.81). Most of these restrictions are with respect to steeply sloping lands. | |
| Title 18, MCC Subdivisions | Some examples: The planning director shall not approve any subdivision that does not conform to or is inconsistent with the county general plan, community plans, land use ordinances, the provisions of the MCC and other laws relating to the use of land (18.04.030)<br><br>Where a subdivision is traversed by a natural water course, drainage way, channel, or stream, a drainage easement or drainage right-of-way must be provided (18.16.190)<br><br>Provides general criteria for flexible design standards for developments with approved design guidelines and development plans pursuant to section 2.40.050 or Title 19, MCC (18.32.030) | County of Maui Department of Planning |

**Table D.1 Existing Land Use Regulations (Continued)**

| Regulation | Requirement/Applicability | Responsible Agency |
|---|---|---|
| **SHORELINE MANAGEMENT AREA** | | |
| HRS Chapter 205 Coastal Zone Management Special Management Area and Maui County Maui Planning Commission 12-202 | Regulates land uses including development up to $500,000 valuation or has significant or cumulative adverse environmental or ecological effect within the Special Management Area<br>A Special Management Area Permit is required for projects within the Special Management Area http://files.hawaii.gov/dbedt/op/gis/maps/sma.pdf<br>Minor permit is for projects <$500K<br>Major permit is for projects >$500K<br>Properties abutting or within 150 feet of the shoreline may require a State Certified Shoreline Survey | Maui Planning Commission |
| HRS Chapter 205A Title MC-12 Subtitle 02, Chapter 203, Shoreline Rules for the Maui Planning Commission | Planning Department has allowable activities /structures and non-allowable uses may require a Shoreline Setback Area Variance | Maui Planning Commission |
| **COMMUNITY PLAN** | | |
| General Plan and West Maui Community Plan | The General Plan and the Community Plans are strategic planning documents which guide government action and decision-making. A Community Plan Amendment may be required and if so, it goes before County Planning Commission, County Council Land Use Committee and requires County Council approval | Maui Planning Commission & County Council |

**Table D.1 Existing Land Use Regulations (Continued)**

| Regulation | Requirement/Applicability | Responsible Agency |
|---|---|---|
| **HISTORIC RESOURCES** | | |
| HRS 6E Historic Preservation Review Process 8 & 42<br><br>HAR 13-275 Procedures for Historic Preservation Review for Governmental Projects<br><br>HAR 13-284 Procedures for Historic Preservation Review for 6E-42 Projects | A Determination Letter should be obtained for projects that may affect historic properties.<br><br>Review steps include: 1) Identification and inventory, 2) Evaluation of significance, 3) Effect determination, 4) Mitigation commitments, 5) Mitigation plan, 6) Verification of completion of mitigation plan. There are different rules for government and non-government projects but similar review steps.<br><br>Historic properties include buildings structures, objects, districts, areas and sites over 50 years old.<br><br>http://kipukadatabase.com/kipuka/ can provide a starting place of known historic sites in a potential project area. If an area has been previously unsurveyed, an archeological inventory and assessment may be required as part of the determination process. *Note: there are many sites at the mouth of Honolua Stream.* | State DLNR State Historic Preservation Division |
| **ENVIRONMENTAL IMPACT STATEMENTS** | | |
| HRS 343 Environmental Impact Statements<br><br>HAR 1-200 Environmental Impact Statement Rules | Requirement triggers for an EA/EIS include:<br><br>• Use of State or County funds or lands<br>• Within Conservation District<br>• Shoreline area<br>• Historic site<br>• Amendments to County General Plan<br>• Wastewater treatment unit (>50 single family dwelling units)<br>• State Land Use Change | State Office of Environmental Quality Control |

**Table D.1 Existing Land Use Regulations (Continued)**

| Regulation | Requirement/Applicability | Responsible Agency |
|---|---|---|
| **LAND USE ACTIVITIES** | | |
| Chapter 4-66, HAR Pesticides | Prohibits the use of any pesticide in a manner inconsistent with its label; use, storage, transportation, or discarding of any pesticide in a manner that would adversely affect the environment; use of application of restricted use pesticides unless by a certified pesticide applicator or under direct supervision of a certified pesticide applicator; any tank, implement, apparatus or equipment used to disperse pesticides that is not equipped with an air gap or a reduced pressure principle backflow device meeting the requirements under 340E-2, HRS.<br>Applicators for restricted use pesticides shall be certified as a commercial pesticide applicator or a private pesticide applicator. | State Department of Agriculture |
| Chapter 20.20, MCC Litter Control | It shall be the responsibility of owners or persons in control of any private property to maintain property free of litter at all times; provided that this chapter shall not prohibit the storage of litter in litter receptacles for collection. (20.20.040)<br>A person commits the offense of littering if the person discards litter upon a public place; discards litter upon private property; discards litter upon a public roadway; drives or moves any vehicle that causes litter to become deposited upon a public roadway; or permits an animal owned by such person or while in such person's custody to excrete litter upon public or private property (20.20.050) | Maui County |

**Table D.2 Existing Agricultural Policies, Programs & Regulations**

| Regulation | Requirement/Provision | Responsible Agency |
|---|---|---|
| **AGRICULTURE DISTRICT CONSERVATION PLANS** | | |
| NRCS Food Security Act Highly Erodible Lands and Wetland Conservation Compliance Provisions | Highly Erodible Land Conservation (HELC) and Wetland Conservation (WC) provisions aim to reduce soil loss on erosion-prone lands and to protect wetlands for the multiple benefits they provide. HELC and WC provisions apply to all land that is considered highly erodible or a wetland and that is owned or farmed by persons voluntarily participating in USDA programs, unless USDA determines an exemption applies.<br><br>Producers, and any affiliated individuals or entities who participate in most programs administered by the Farm Service Agency (FSA), the Natural Resources Conservation Service (NRCS), and the Risk Management Agency (RMA) are required to comply with these provisions. Non-compliance may affect the following types of USDA program benefits:<br>• FSA loans and disaster assistance payments<br>• NRCS and FSA conservation program benefits<br>• Federal crop insurance premium subsidies<br><br>NRCS agricultural conservation plans may be required for:<br>• NRCS grant funding or loans<br>• Agricultural leases<br><br>The West Maui Soil and Water Conservation District reviews drainage, engineering slope hazard report, and erosion control plans prior to the County making a determination of final approval or disapproval. | United States Department of Agriculture National Resource Conservation Service with West Maui Soil and Water Conservation District |
| HRS Chapter 180, Soil and Water Conservation Districts | Local soil and water conservation districts are charged with assisting in the development of plans for conservation of soil and water resources and control and prevention of erosion within the district (180-13) | West Maui Soil and Water Conservation District |

**Table D.2 Existing Agricultural Policies, Programs & Regulations (Continued)**

| Regulation | Requirement/Provision | Responsible Agency |
|---|---|---|
| **IMPORTANT AGRICULTURAL LANDS** | | |
| HAR 15-15 Land Use Commission Rules | Provision for Important Agricultural Lands (IAL) designation<br>Landowners and counties can seek designation of IAL.<br>Designation can be coupled with urban, rural or conservation reclassification | State of Hawai'i DBEDT State Land Use Commission |
| Chapter 179D HRS Dams and Reservoirs | Owners of dams and reservoir shall provide maintenance, operation and inspection of their dams and reservoirs and be responsible for any engineering investigations which may be required to insure public safety.<br>Dams with dam height over 25 feet and/or reservoir volume greater than 50 acre-feet are regulated by the Dam Safety Program.<br>Construction repair or alteration of dam or reservoir requires an application from the Board of Land and Natural Resources. | State Department of Land and Natural Resources Engineering Division |

**Table D.3 Existing Construction and New Development Regulations**

| Regulation | Requirement/Applicability | Responsible Agency |
|---|---|---|
| **GRUBBING AND GRADING** | | |
| HAR 11-55 Water Pollution Control | NPDES General Permits are required for project disturbed areas greater than one acre (if special types of discharges, an individual NPDES permit is required). Form C is for Construction Activities. The General Permit requires preparation of a Storm Water Pollution Prevention Plan, and a Notice of General Permit Coverage is required before a County grading permit can be obtained.<br><br>NPDES Individual Permit: For discharges of storm water associated with construction activities that result in the disturbance of one acre or more of total land area that do not qualify for a general permit because they affect "class 1, inland waters" or "class AA, marine waters," a NPDES Individual Permit is required (11-55-04; 11-55-15) | State of Hawai'i Department of Health Clean Water Branch |
| Maui County Code of Ordinances Chapter 20.08 | Grubbing and Grading Permits (projects with more than 500 cu yd require bonds)<br><br><u>Grading Permits:</u><br>Minor – < 1 acre or max height depth of 15 feet<br>Major - > 1 acre or more than 15 feet height or depth<br>Major grading permits require a grading plan, erosion control plan and a drainage plan and report and an engineer's soils report and engineering slope hazard report<br><br><u>Grubbing Permits</u>:<br>Required for greater than one acre with uprooted ground cover. A Grubbing Plan and a BMP Plan are required with additional requirements along the shoreline.<br>Land management to control soil and sediment must be in conformance with standards set by the Soil and Water Conservation District.<br><br>The West Maui Soil and Water Conservation District reviews drainage, engineering slope hazard report, and erosion control plans prior to the County making a determination of final approval or disapproval. | County of Maui Department of Public Works, Development Services Administration |

**Table D.3 Existing Construction and New Development Regulations (Continued)**

| Regulation | Requirement/Applicability | Responsible Agency |
|---|---|---|
| **NEW DEVELOPMENT STORM WATER TREATMENT BEST MANAGEMENT PRACTICES** | | |
| Maui County Code of Ordinances Chapter 15-111 | Sites with disturbed areas of greater than one acre must have a civil engineer prepared plan. (Sites less than one acre of disturbance require plans for director approval)<br>The ordinance requires infrastructure to reduce the average annual total suspended solid load by 80% for an average annual two year/twenty-four hour storm for developments. This requirement can be met with various Storm water Best Management Practices (BMPs). | County of Maui Department of Public Works |
| **WATER CONSERVATION / WASTEWATER** | | |
| Chapter 16.20A, MCC Plumbing Code | The Code establishes maximum rates of water flow or discharge for plumbing fixtures and devices in order to promote water conservation (16.20A.680(a))<br>Only low flow plumbing fixtures and devices specified in this section shall be installed in the county of Maui. | County of Maui Department of Public Works |
| Chapter 14.25A Maui County Code of Ordinances | Vehicle wash water, swimming pool water or water from fountains or ponds may not have a connection to or discharged into the public owned treatment works. | County of Maui Environmental Management Department Water Reclamation Division |

**Table D.4 Existing Stream/Water Regulations**

| Regulation | Requirement | Responsible Agency |
|---|---|---|
| Chapter 174C, HRS Hawai'i Water Code | The state water code shall be liberally interpreted to obtain maximum beneficial use of the waters of the State for purposes such as domestic uses, aquaculture uses, irrigation and other agricultural uses, power development, and commercial and industrial uses. Adequate provision shall be made for the protection of traditional and customary Hawaiian rights, the protection and procreation of fish and wildlife, the maintenance of proper ecological balance and scenic beauty, and the preservation and enhancement of waters of the State for municipal uses, public recreation, public water supply, agriculture, and navigation. Such objectives are declared to be in the public interest. | |
| HAR 13-169 | Stream Channel Alteration Permits address "Any river, creek, slough, or natural water course that usually flows in a defined bed or channel."<br><br>Stream channels shall be protected from alteration whenever practicable to provide for fishery, wildlife, recreational, aesthetic, scenic, and other beneficial instream uses. No stream channel shall be altered until an application for a permit to undertake the work has been filed and a permit is issued by the commission; provided that routine streambed and drainage way maintenance activities and maintenance of existing facilities are exempt from obtaining a permit.<br><br>A Request for Determination (RFD) can be submitted to see if regulation applies. It is not required if planting vegetation manually. | Hawai'i State DLNR CWRM |

**Table D.4 Existing Stream / Water Regulations (Continued)**

| Regulation | Requirement | Responsible Agency |
|---|---|---|
| Section 404 of the Clean Water Act<br>Nationwide Permits | Permit required for discharging dredged or fill material into waters of the United States.<br>Nationwide Permits exist for many activities including nationwide Permit 13 for Bank stabilization may be used if specific criteria are met.<br>See the link below for 2012 Nationwide Permit Honolulu District Regional conditions for more information. | US Army Corps of Engineers |
| http://www.pod.usace.army.mil/Portals/6/docs/regulatory/nwp/POH_Regional%20Conditions%20Encl%201.pdf | | |
| Section 401 of the Clean Water Act | The State Department of Health (DOH) is authorized under Section 401 of the Federal Clean Water Act and §342D-53, HRS, to administer the Section 401 Water Quality Certification (WQC) program in Hawai'i.<br>Any owner applying for a Federal license or permit to conduct any activity including, but not limited to, the construction or operation of facilities, which may result in any "discharge" into navigable waters, is required to have a WQC issued by DOH. A 401 WQC certifies that the activity will not violate State water quality standards (Chapter 11-54, HAR).<br>The US Army Corps of Engineers administered Clean Water Act Section 404 permit process triggers a Section 401 WQC prior to issuance (see above). | State Department of Health Clean Water Branch |
| HAR 13-95-17 on Coral Damage | It is unlawful to take, break or damage, with any implement, any stony coral from the waters of Hawai'i, including any reef or mushroom coral. | Hawai'i State DLNR Division of Aquatic Resources (DAR) |

**WEST MAUI DESILTING BASIN DATA COLLECTION FORM**
**-Draft-**

Desilting Basin (circle one)
Honokōwai Mahinahina Kahana Nui Kaʻōpala Honokeana Nāpili 4-5 Nāpili 2-3

---

Date: _____ Time:_____ am/pm

Observations by: _____

Observing from: Dam Reservoir Spillway Circle One or Other_____

---

**Rainfall Observations:**

Quantity: None Misting Light Moderate Heavy Storming (circle one)

Duration: Just started 1-2 hours 3-6 hours 6-12 hours Multiple Days or _____

---

**Desilting Basin Status:**

Staff plate level: _____ (Installation of staff plates are needed)

Feet until reaching spillway _____

% of total capacity _____

---

**Nearshore Waters Observation:**

Water Coloration (Color and Intensity): _____

Plume Description (Size and Extent): _____

Turbidity (NTU) Reading: _____

# APPENDIX F. ADDENDUM TO THE WEST MAUI WATERSHED PLAN: KAHANA, HONOKAHUA AND HONOLUA WATERSHEDS STRATEGIES AND IMPLEMENTATION REPORT

**August 2025**

# Estimating Pollutant Load Reductions Resulting from Control and Removal of Invasive Plant and Animal Species and Establishment of Native Species

## Introduction

This addendum has been developed by the Hawaii Department of Health (HDOH) to address additional considerations and updates relevant to watershed management efforts. This addendum supplements the West Maui Watershed Plan: Kahana, Honokahua and Honolua Watersheds Strategies and Implementation Report to include activities and additional guidance related to the removal of invasive plants and animals, as well as the reintroduction of native species. In addition to including these activities in the menu of best management practices (BMPs) that are eligible for 319 funding, this addendum provides an approach for calculating the pollutant reductions associated with these restoration activities. These pollutant reductions can be used by project managers and sub-grantees to develop individual project plans and by HDOH to calculate annual pollutant reductions for the broader NPS program.

## Pollutant Loading from Invasive Species

Invasive plants and animals are an increasingly challenging source of pollution in many of Hawaii's watersheds. Invasive plants, such as miconia, have shallow root systems, which are unable to stabilize the soil and are susceptible to erosion and landslides during rainfall events. Invasive animals, such as feral hogs, are destructive grazers, uprooting plant material and exposing additional areas to erosion.

As a result, sediment is the primary pollutant of concern from invasive species, although other pollutants may also be transported during rainfall events (e.g., nutrients and bacteria). Sediment has been identified by HDOH as a pollutant of concern across the state and is a focus of water quality improvement efforts. This watershed-based plan already includes a discussion of pollutants of concern and the load reductions needed to return the impaired waters to attainment. This addendum supplements that discussion; invasive species are one of multiple pollutant sources to be addressed.

## Pollution Control Practices

Across Hawaii, many organizations (including federal, state and local government, as well as watershed groups) are working to mitigate these problems. In many cases, this involves removing the invasive species and replacing them with native species. Native plant species[1] are better adapted to the soils and climate and provide improved soil retention, among other benefits. Excluding invasive animals, such as using fencing to block access to an area, allows vegetation to recover and thrive.

Table F.1 below includes BMPs that can address pollutant loading caused by invasive species.[2] As shown by the large number of potential BMPs, vegetative plantings are a common element of many BMPs; ensuring that native species are used (and in the necessary quantities for establishment) will help to restore native plant communities. Managing invasive animal species is typically limited to exclusion or removal.

[1] See, for example, https://dlnr.hawaii.gov/forestry/plants/ for a discussion of native plant species.

[2] The table shows only a selection of BMPs. Other BMPs may also accomplish the goals of invasive removal and re-establishment of native species. Watershed planners should consult with HDOH when developing project plans to ensure BMP eligibility.

**Table F.1 Selection of BMPs to Address Invasive Species**

| Management Practice | Description |
|---|---|
| Bioretention Cell (Rain Garden) | Depression consisting of native plant species and soil mixtures that receives stormwater flow and infiltrates to treat pollutants. |
| Channel Maintenance and Restoration | Practices used to control sediment and plant pollution into waterways during earthwork such as stream bank stabilization or habitat enhancement. Examples include floating booms and silt curtains extended across river or stream banks downstream of work. |
| Constructed Wetlands | Creation of an artificial wetland ecosystem to improve the quality of stormwater runoff or other water flows. A constructed wetland provides biological treatment in areas where wetland function can be created or enhanced. Constructed wetlands also can be used to treat runoff from agricultural land uses and stormwater runoff and other contaminated flows from urban areas and other land uses. The practice involves establishment of inlet and outlet control structures for an impoundment designed to accumulate settleable solids, decayed plant matter, and microbial biomass and support propagation of hydrophytic vegetation. |
| Critical Area Planting | Establishment of permanent vegetation in areas with heavy erosion problems. Particularly useful for areas that need stabilization before/after flood events. |
| Grassed Waterway | A shaped or graded channel that is established with suitable vegetation to convey surface water at a non-erosive velocity using a broad and shallow cross section to a stable outlet. Used to convey runoff from terraces, diversions, or similar; to prevent gully formation; and to protect or improve water quality. |
| Herbaceous Weed Treatment/Invasive Species Removal | The removal or control of herbaceous weeds, including invasive, noxious, and prohibited plants. |
| Sediment Basin | Captures and retains stormwater runoff until sediments settle out; water is released through engineered outlet. |
| Feral Ungulate Fencing | A structural conservation practice that prevents movement of ungulates across a given boundary. Within areas impacted by feral ungulate presence, fences prevent their movement into the forested lands. Ungulate fencing prevents direct contact of fecal matter with waterways, allows for restoration of vegetation, and reduces bacteria and nitrogen loadings and sediment input into waterways. |
| Feral Ungulate Removal | Hunting or trapping wild goats, pigs, and other non-native hoofed mammals to reduce erosion caused by trampling and vegetation removal, as well as nutrient and bacterial impacts from defecation in and around water bodies. |

Through this addendum, these BMPs are now eligible for funding under Section 319 to address water quality concerns caused by invasive species (if the BMPs were not already identified in the original plan). Implementation of these BMPs will lead to a reduction in pollutant loading in the watershed. The original watershed-based plan may include information on specific locations or land use types that may be most appropriate for invasive species BMPs. Additional

information can be found in other resources, such as the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service's *Field Office Technical Guide* for Hawaii.[3]

## Calculating Pollutant Reductions

Accounting for the total pollutant reductions is an important step in tracking water quality improvements. HDOH and watershed stakeholders develop watershed-based plans under the state's nonpoint source pollution (NPS) program; these plans include a projected level of pollutant reduction for the proposed project.

There are various models that can be used to calculate the pollutant reductions associated with BMP implementation. HDOH researched the advantages and disadvantages of each model, including the ease of use for watershed project managers and evaluating the model's appropriateness for use in Hawaii. After reviewing several models, HDOH selected the Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) model.

## Description of the InVEST Model

InVEST is a suite of models focused on ecosystems and how they connect to downstream economics. This addendum is focused on the sediment delivery ratio model in the InVEST suite. The InVEST sediment delivery ratio model was chosen by HDOH because it is easy to use and its ability to estimate sediment loading both with current condition and with BMPs implemented. Additionally, the InVEST model can be modified to accommodate the unique geologic conditions in Hawaii.

The InVEST sediment delivery ratio model is focused on sediment loading and erosion. The model outputs a set of maps showing the sediment erosion, including the amount of sediment soil loss per pixel, and the amount of erosion that is prevented by the presence of vegetation per pixel. The effect of BMPs on sediment erosion can be measured by comparing model outputs ran under the current conditions against model outputs ran with BMPs implemented. To calculate the annual soil loss per pixel, the InVEST model uses the Revised Universal Soil Loss Equation (RUSLE; Renard et al., 1997). Along with the factors that are in the RUSLE equation (rainfall erosivity, soil erodibility, slope length gradient, cover management, and support practice), this addendum recommends including an additional terrain factor to accommodate for the geology of Hawaii. The inclusion of the terrain factor prevents the model from overestimating the soil loss in places with geologically new basaltic bedrock which has minimal soil cover (Falinski, 2016). The required data inputs for this model are integrated into the RUSLE equation. To determine the effects of BMPs on sediment load reduction and erosion, the model should be run with altered data inputs.

The required data inputs include GIS data, a table, and five additional values. These five inputs are described in detail in the Step-by-Step Procedure below. To measure the reduction in sediment load and erosion with BMP implementation, these inputs can be changed to integrate the increase in vegetation that would come along with BMP implementation. The Step-by-Step Procedure section of this addendum describes each of these required inputs in further detail along with recommended values and sources for GIS data inputs.

## Step-by-Step Procedure

The step-by-step procedure begins with collecting and creating the proper data inputs for the current conditions in the watershed and running the InVEST model with those data inputs. After

[3] https://efotg.sc.egov.usda.gov/#/state/HI/documents

the first model run, the next step is to use multiple lines of evidence, including model outputs and other information, to determine the most appropriate areas in the watershed to implement BMPs. Next, the model should be run again with inputs that incorporate the impacts that BMPs would have on the land cover or support practices. The reduction in pollutant loading is the difference between the two model output runs. The steps to compile each data input and descriptions of each required data input are shown in Table F.2. All GIS inputs must be the same coordinate reference system. The coordinate reference system must be projected and in linear units of meters.

**Table F.2 Required Data Inputs for the Invest Model**

| GIS Data Inputs | | |
|---|---|---|
| **Input Name and Description** | **Data Type** | **Suggested Sources** |
| **Digital Elevation Model**: A digital elevation map (DEM) showing elevation in meters. The map should be clipped beyond the watershed boundary. | Raster | The 3D Elevation Program (3DEP) from USGS.[4] The best available resolution for the state is 1/3 arc-second. |
| | | The Hawaii Statewide GIS Program's Digital Terrain Model.[5] Data is only available for portions of the state and as a JPEG or PNG, so it must be converted to a raster format. The resolution is 1 meter, and the elevation values are in meters. |
| **Erosivity**: A map of rainfall erosivity in units of MJ • mm/(h • ha • year). The map should illustrate both intensity and duration of rainfall. | Raster | For the island of Hawaii, NOAA's digitized version of the rainfall erosivity map from the Agriculture Handbook No. 703.[6] The units are US customary units, so the units must be converted by multiplying each value by 17.02 (Renard, et al., 1997). |
| | | For the island of Oahu, NOAA's digitized version of the rainfall erosivity map from the Agriculture Handbook No. 703.[7] The units are US customary units, so the units must be converted by multiplying each value by 17.02 (Renard, et al., 1997). |
| | | The rainfall erosivity map on page 57 of the Agriculture Handbook No. 703. This map must be digitized into raster data by a GIS specialist and units must be converted to SI by multiplying each value by 17.02 (Renard, et al., 1997). |
| | | A rainfall erosivity raster can be made using precipitation from the Hawaii Climate Data Portal.[8] Rainfall erosivity can be calculated using the Roose equation (Renard and Freimund, 1994): R = 0.5 x P x 17.02, where R is the rainfall erosivity value in the proper SI units and P is the annual rainfall in mm/year. |
| **Soil Erodibility**: A map showing the soil erodibility in the watershed. Soil erodibility, also called K factor, is the likelihood of soil particles to erode and be transported downstream by precipitation or | Raster | Soil data, including K factors, is available from the Soil Survey Geographic Database (SSURGO).[9] This database provides raster data of soil type in an area of interest, and a table showing the K factor of each soil type. Raster data of K factors in a projected coordinate |

[4] https://apps.nationalmap.gov/downloader/
[5] https://geoportal.hawaii.gov/datasets/HiStateGIS::hawaii-dtm-elevation/about
[6] https://www.fisheries.noaa.gov/inport/item/48225
[7] https://www.fisheries.noaa.gov/inport/item/48230
[8] https://www.hawaii.edu/climate-data-portal/data-portal/
[9] https://www.nrcs.usda.gov/resources/data-and-reports/soil-survey-geographic-database-ssurgo

| | | |
|---|---|---|
| runoff. The soil erodibility raster must be in units of t · h · ha / (ha · MJ · mm). | | system will have to be generated by combining the soil raster data and the K factor table. |
| **Land Use/Land Cover**: A map showing the land use and land cover within the watershed. The C-CAP raster described below must also be combined with geology data. Each pixel should be categorized by its land use/land cover and geologic origin from the geology dataset. Every combination of land use/land cover and geologic origin should be assigned a unique LULC code. | Raster | NOAA has C-CAP high resolution land cover raster data available for the entire state of Hawaii from 2021.[10] NOAA's land cover data has a resolution of 1-meter and includes up to 25 classifications including forests and urban development. |
| | | Geology data for the state of Hawaii is available for download from USGS.[11] This data is available as shapefiles, so it must be converted to raster data. |
| **Watersheds**: A map of the boundary of the watershed. | Vector (polygon/ multipolygon) | The USGS Watershed Boundary Dataset has vector watershed delineation data available at different hydrologic unit levels for the entire state of Hawaii.[12] |
| | | The Hawaii Statewide GIS Program has vector watershed delineation data available that was created by the Division of Aquatic Resources (DAR).[13] |
| | | The InVEST suite includes the DelineateIt tool, used for generating watersheds based on user inputs. This tool outputs a GeoPackage containing a vector with the model's estimated watershed delineations. More information on this tool can be found in the DelineateIt section of the InVEST suite.[14] |
| | | Watershed delineations can be generated using a USGS StreamStats's tool.[15] Delineations can be downloaded as vectors. |
| **Other Required Data Inputs** | | |
| **Input Name and Description** | **Data type** | **Suggested Input Value** |

[10] https://coast.noaa.gov/digitalcoast/data/
[11] https://pubs.usgs.gov/of/2007/1089/
[12] https://www.usgs.gov/national-hydrography/watershed-boundary-dataset
[13] https://geoportal.hawaii.gov/datasets/HiStateGIS::watersheds-dar-version/about
[14] https://storage.googleapis.com/releases.naturalcapitalproject.org/invest-userguide/latest/en/delineateit.html
[15] https://www.usgs.gov/streamstats

| | | |
|---|---|---|
| **Threshold Flow Accumulation**: The minimum number of pixels that flow into another pixel for it to be classified as a stream. | Number of pixels | This value should be determined by the user via trial and error. Users should test different values until the streams on the output maps resemble the streams in the watershed. |
| **Borselli k Parameter**: A calibration parameter in the sediment delivery ratio equation. | Number | This value is based on watershed location. Table F.3 shows the Borselli k Parameter by location. |
| **Maximum SDR Value**: The maximum sediment delivery ratio a pixel is allowed to have. | Number between 0 and 1 | For all watersheds in the state of Hawaii, the value should be 0.5 (Falinski, 2016). |
| **Borselli $IC_0$ Parameter**: A calibration parameter in the sediment delivery ratio equation. | Number | For all watersheds in the state of Hawaii, the value should be 0.1 (Falinski, 2016). |
| **Maximum L Value**: The maximum allowed slope value in the slope length-gradient factor. | Number | For all watershed in the state of Hawaii, the value should be 122 (Falinski, 2016). |
| **Biophysical Table**: A table mapping each LULC code to its cover-management factor (C) and support practice factor (P). One column should be named “lucode” and contain the LULC code from the land cover and land use raster. The other two columns should be named “usle_c” and “usle_p” and contain the associated C factor and P factor, respectively. The C factor indicates how much erosion is likely to occur at this land use/land cover type. The smaller the C factor value, the less erosion is expected to come from that type. To account for the terrain factor in the model run, the C factor in the biophysical table should be modified. The C factor for each LULC code should be the original C factor from Table F.4 multiped by the terrain factor from Table F.5 that is associated with the geologic origin under that LULC code. The P factor indicates whether erosion reduction practices are implemented in that area. A value of 1 means there are no erosion reduction practices implemented in that land cover/land use type and a smaller value indicates best management practices are implemented in that land cover/land use type. | .CSV file | Table F.4 shows the C factors for land use/land covers in Hawaii, and Table F.5 shows the terrain factor by geologic origin. |
| **Workspace**: The folder where outputs will be written. | Folder name | -- |

**Table F.3 Borselli k Parameter by Watershed Location (Falinski, 2016)**

| Watershed Location | Borselli k Parameter |
|---|---|
| Windward part of the island of Hawaii | 4 |
| Leeward part of the island of Hawaii | 2.5 |
| Oahu | 2.5 |
| Maui | 2 |
| Lanai | 2 |
| Molokai | 1.25 |
| Kahoolawe | 2.4 |
| Kauai | 1.6 |
| Niihau | 1.5 |

**Table F.4 C Factor Values for Land Use/Land Cover (Falinski, 2016)**

| **Land Use/Land Cover** | **C Factor** | **Land Use/Land Cover** | **C Factor** |
|---|---|---|---|
| Evergreen | 0.014[16] | Developed, Medium Intensity | 0.01 |
| Scrub Shrub | 0.014[17] | Impervious Surface | 0.001 |
| Bare Land | 0.7 | Palustrine Scrub Shrub Wetland | 0.003 |
| Pasture/Hay | 0.05 | Palustrine Emergent Wetland | 0.003 |
| Grassland | 0.05 | Unconsolidated Shore | 0.003 |
| Open Water | 0 | Estuarine Forested Wetland | 0.003 |
| Cultivated Land | 0.24[18] | Estuarine Scrub Shrub Wetland | 0.003 |
| Developed, Low Intensity | 0.03 | Estuarine Emergent Wetland | 0.003 |
| Palustrine Forested Wetland | 0.003 | Background | 0 |
| Open Space Developed | 0.05 | Palustrine Aquatic Bed | 0 |

**Table F.5 Terrain Factor by Geologic Origin (Falinski, 2016)**

| **Hawaii** | | **Oahu, Kauai and Niihau** | |
|---|---|---|---|
| **Geologic origin** | **Terrain factor** | **Geologic origin** | **Terrain factor** |
| Hamakua Volcanics | 1 | Honolulu Volcanics | 1 |
| Hawi Volcanics | 1 | Kolekole Volcanics | 1 |
| Hilina Basalt | 0.001 | Koolau Basalt | 1 |
| Hualalai Volcanics | 0.001 | Waianae Volcanics | 1 |
| Kahuku Basalt | 0.001 | Kiekie Volcanics | 1 |
| Kau Basalt | 0.001 | Koloa Volcanics | 1 |
| Laupahoehoe Volcanics | 0.1 | Paniau Basalt | 0.1 |
| Ninole Basalt | 1 | Waimea Canyon | 0.1 |
| Pololu Volcanics | 1 | -- | -- |
| Puna Basalt | 0.001 | -- | -- |
| **Maui, Molokai, Lanai and Kahoolawe** | | **All Islands** | |

[16] Evergreen forest: 0.035 for Hamakua and Kohala volcanoes

[17] Scrub/shrub: 0.05 for leeward volcanic units

[18] Cultivated land: 0.4 for pineapple (Lanai) or 0.51 for sugarcane crop (central Maui)

| Geologic Origin | Terrain factor | Geologic origin | Terrain factor |
|---|---|---|---|
| East Molokai Volcanics | 1 | Open water | 1 |
| Hana Volcanics | 0.001 | Fill | 1 |
| Honolua Volcanics | 1 | Alluvium | 1 |
| Honomanu Basalt | 1 | Landslide Deposits | 1 |
| Kalaupapa Volcanics | 1 | Slope Deposits | 0.001 |
| Kanapou Volcanics | 1 | Tephra Deposits | 0.1 |
| Kaupo Mud Flow | 1 | Beach Deposits | 0.1 |
| Kula Volcanics | 0.01 | Lagoon Deposits | 1 |
| Lahaina Volcanics | 1 | Older Dune Deposits | 1 |
| Lanai Basalt | 1 | Younger Dune Deposits | 0.1 |
| Wailuku Volcanics | 1 | Talus and Colluvium | 0.1 |
| West Molokai Volcanics | 1 | Marine Conglomerate and Breccia | 0.1 |
| -- | -- | Caldera Wall Rocks | 0.001 |

The most relevant output is the "sed_export.tif', showing the sediment exported from every pixel. Because of the geology of Hawaii, data on the pixel level from this raster may be inaccurate. The model tends to predict higher sediment export from areas with steeper slopes. In Hawaii, high slopes occur in high elevation areas where the sediment supply may be naturally limited by the unique geology of Hawaii. Therefore, the model overestimates the amount of sediment export in the mountains because it assumes unlimited sediment supply in steep areas with thin or little soil. For this reason, the sediment export raster data should not be used as the sole or main method for determining where BMPs should be implemented within the watershed.

The sediment export raster can be combined with land use/land cover data to determine which land use classes are disproportionately contributing to sediment loading. The amount of sediment mass exported per acre for each land use can be calculated by adding up the value of every pixel in the sediment export raster in each land use and dividing that sum by the number of acres that the land use covers.

It is crucial that multiple lines of evidence are considered when determining where BMPs should be implemented. The normalized difference vegetation index (NDVI)[19] is a satellite-based measurement that could be useful in identifying areas with minimal vegetation which may be susceptible to increased erosion. The NDVI quantifies vegetative health and density. NDVI values closer to positive 1 indicate the presence of abundant and healthy vegetation, and a value closer to 0 indicates there is less vegetation (NASA, 2025). Looking at NDVI data in a raster format would allow a user to visualize areas within the watershed that have little vegetation or unhealthy vegetation, indicating that the area could benefit from BMP implementation. If the resolution of the NDVI data is a lower resolution, it may be difficult to pinpoint areas where BMP implementation would be the most valuable. Therefore, further evidence should be used when selecting areas for BMP implementation. A high resolution and recent satellite image can supplement older land use/land cover data and lower resolution NDVI raster data. A satellite image can be used to more accurately identify areas with minimal vegetative cover which could benefit most from BMP implementation. Further useful evidence can be collected on-site in the watershed. If possible, a person can walk along streams in the

[19] One potential source of NDVI data is NOAA's Suomi National Polar-orbiting Partnership (Suomi NPP) Visible Infrared Imaging Radiometer Suite (VIIRS) Vegetation Indices (VNP13A2) Version 2 data product which can be queried using the 'modisfast' R package.

watershed and identify locations in the watershed where BMP implementation would be the most advantageous, such as locations with invasive plant species, minimal vegetation and/or the presence of feral ungulates. Each of the options listed above is important evidence that should be considered when the user is deciding on locations for BMP implementation.

After determining where BMPs will be implemented, the next step is to re-run the model with inputs that account for the BMPs that would be implemented to determine how they would affect sediment loading. The model inputs for the revised run should remain almost entirely the same. A different directory should be entered into the Workspace field or the results from the last model run will be overwritten. Additionally, either the support practice factors in the biophysical table or the land use/cover raster should be edited:

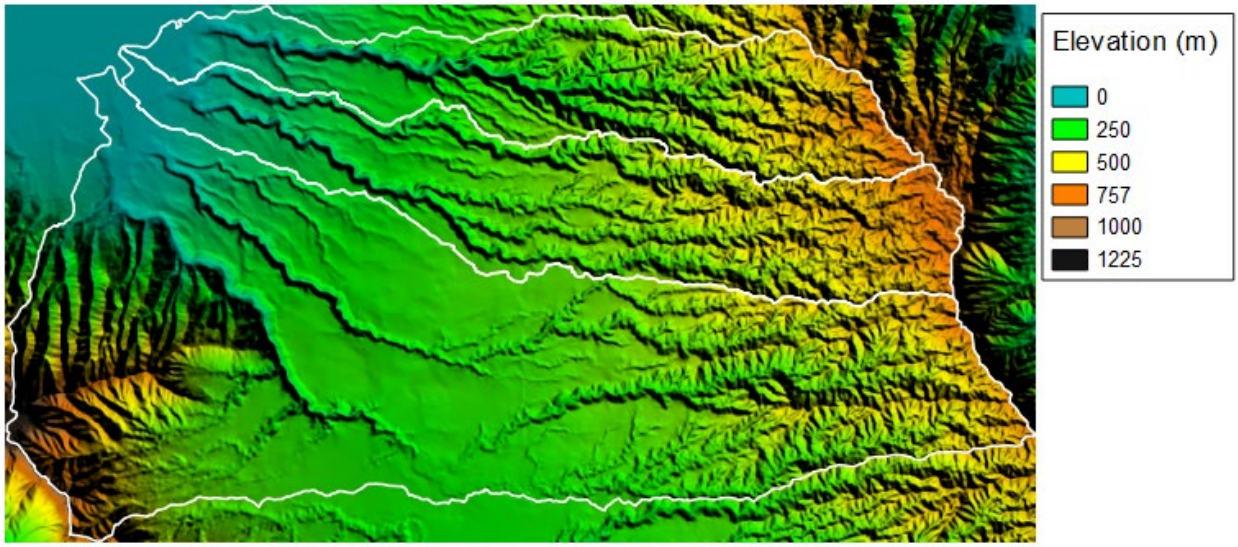
- The P factors in the biophysical table should be decreased for each land use/land cover type where an erosion reduction practice will be implemented.
- Alternatively, the land cover/land use raster should be edited to show how the land use/land cover would change with erosion reduction practices implemented. For example, bare land could be changed to a type of forest cover if a best management practice would be to plant native species on non-vegetated land.

To determine the effect that the implementation of best management practices would have on sediment exports, the outputs from both model runs can be compared. The sum across every pixel in “sed_export.tif” outputs illustrate how much sediment load reduction would occur with BMP implementation on the watershed level.

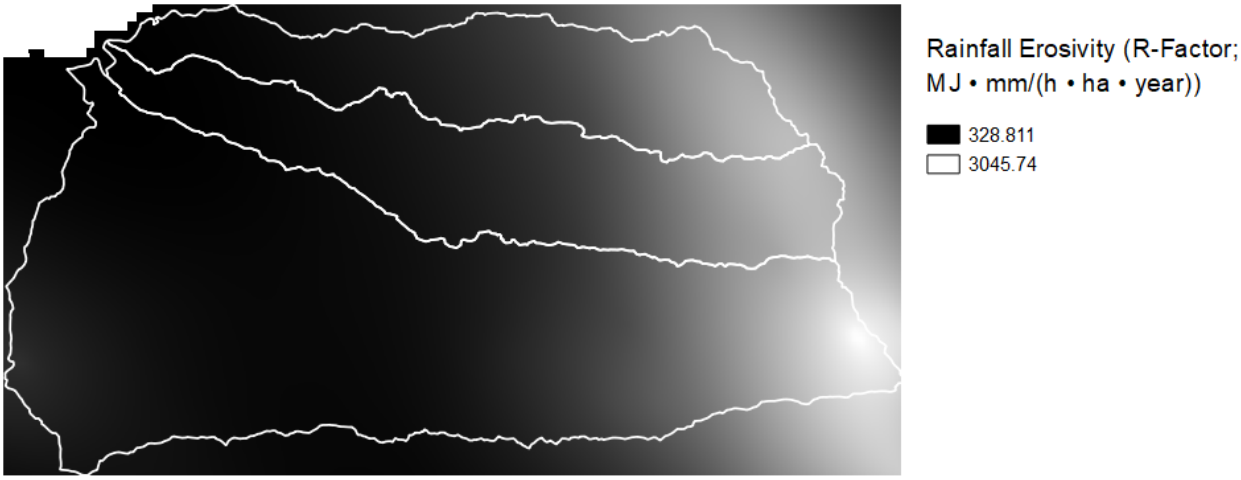
## Example Use of the Procedure

To illustrate the Step-by-Step Procedure, this section looks at an example watershed: Kaiaka Bay. The Kaiaka Bay watershed is on the coast of the island of Oahu. The Kaiaka Bay and several streams that drain into the bay are listed as impaired. Both invasive plant species and feral ungulates are thought to cause high levels of erosion in this watershed, making the Kaiaka Bay watershed a good example watershed for the procedure (AECOM et al., 2018). The GIS data inputs for the InVEST model must all be in the same projected coordinate reference system, so every GIS data input is in the NAD83 coordinate reference system. The data inputs used for running the model with current conditions are below:

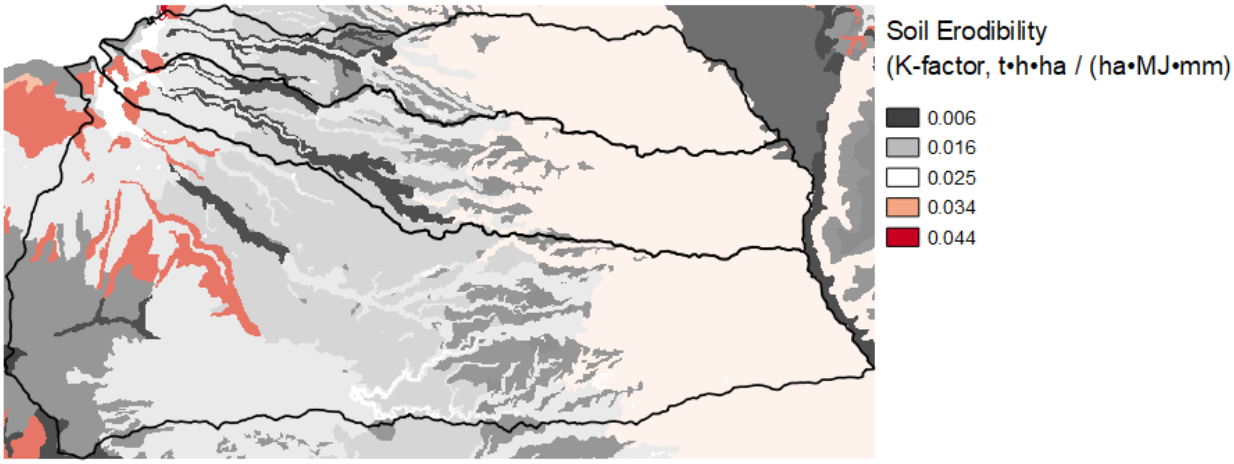
- Elevation Map: A DEM raster showing elevation in meters in the Kaiaka Bay and the surrounding area. This raster is a valid input for the InVEST model because the elevation is in meters and it extends beyond the Kaiaka Bay watershed boundary.



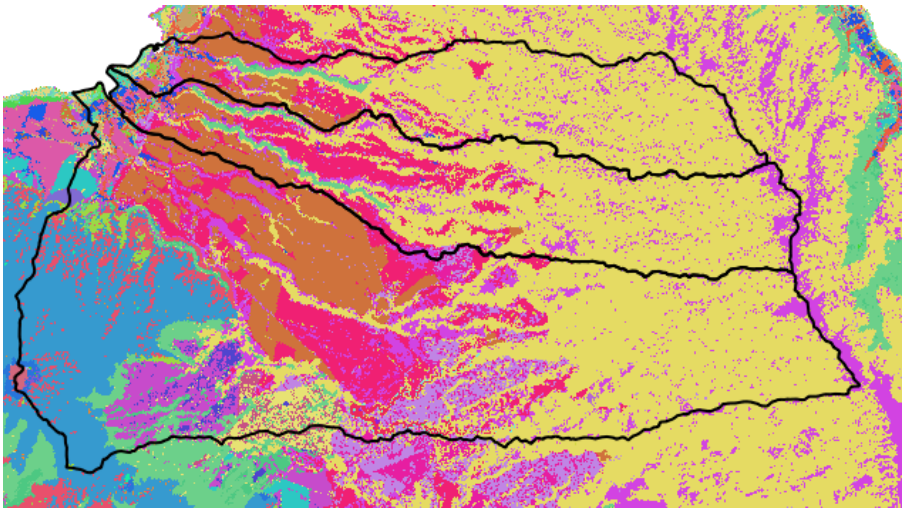

- Rainfall Erosivity: A rainfall erosivity map in raster format showing the rainfall erosivity throughout the Kaiaka Bay watershed in MJ • mm/(h • ha • year), the units required by the model.



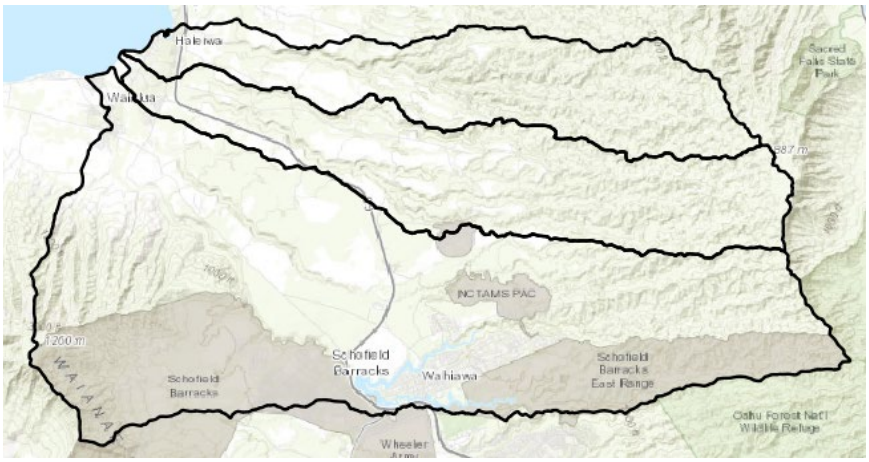

- Soil Erodibility: A map showing soil erodibility, or K factors, within the Kaiaka Bay watershed in raster format. The values in the raster format are in the proper units for the model, t • h • ha / (ha • MJ • mm).




- Land Use & Land Cover and Geologic Formation: A raster categorizing the land in Kaiaka Bay watershed by their land use/land cover and their geologic formation. This raster has over 1000 land cover/geologic formation categories, but not all categories have pixels that belong to them. Each land cover/geologic formation category has a unique LULC code so that this raster can be connected to the biophysical table.



- Watershed boundary: A vector outlining the Kaiaka Bay watershed.




- Threshold Flow Accumulation: 200. Value was derived through trial and error, and was identified when the delineated stream network approximately matched the “real” stream network for the watershed.

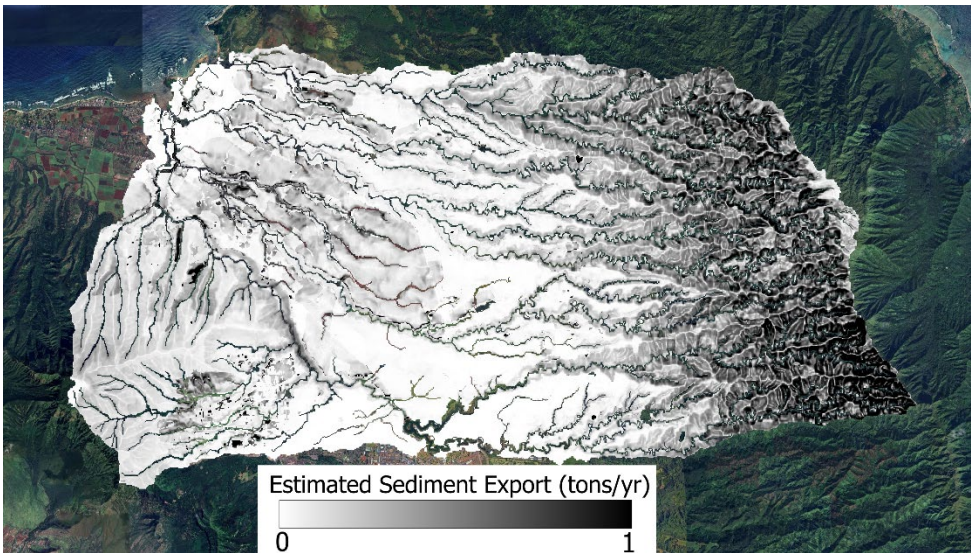
- Borselli k Parameter: The Borselli k parameter for this model run is 2.5, the value for all watersheds on Oahu.

- Maximum SDR Value: The maximum SDR value for this model run is 0.5, the value for all watersheds on the state of Hawaii.

- Maximum L Value: The maximum L value for this model run is 122, the value for all watersheds on the state of Hawaii.

- Biophysical Table: The biophysical table for this model run contains a column with each LULC code from the land use and land cover raster. Each LULC code is mapped to a modified C factor that is the original C factor from Table F.4 multiplied by the terrain factor from Table F.5 or the geologic origin associated with the LULC code. For example, a small piece of land in the Kaiaka Bay watershed is scrub shrub land (C factor = 0.014) with beach deposits as its geologic formation (terrain factor = 0.1), so the modified C factor in the biophysical table is 0.0014. The P factor for every LULC code is 1 because no support practices have been implemented in this watershed.

Once the inputs have been gathered, the baseline scenario is run. The model outputs suggest that a disproportionate amount of sediment export is occurring in the mountainous area of the Kaiaka Bay watershed. The sediment export raster is shown below:



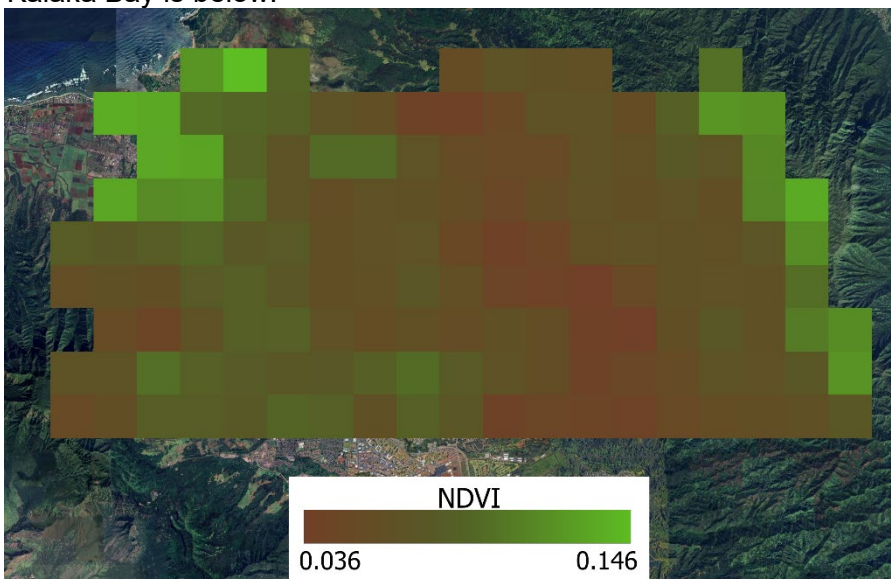

This raster indicates that the model expects the highest amount of sediment export to occur at the higher elevations of the watershed, but as discussed in the Step-by-Step Procedure section, the InVEST model tends to overestimate sediment export in high elevation areas. For this reason, multiple lines of evidence are considered when deciding on the locations for BMP implementation in this example. To determine the land class/land uses that contribute the most to sediment export relative to their area in the watershed, the pounds of sediment exported per acre is important evidence to evaluate as well. This value is calculated by adding the sediment export for every pixel in each land use/land cover and then dividing this sum by the acres each land use covers in the watershed. For example, bare land covers 405 acres of land in the Kaiaka Bay watershed and the model estimates that 1790.5 pounds of sediment are exported from bare land each year, so the pounds of sediment load per acre per year for bare land is 1790.5 divided by 405 which is 4.42. The sediment load per acre for each land use is shown in Table F.6.

**Table F.6 Pounds of Sediment Load Per Acre Per Year by Land Use**

| Class | Edge of Stream Sediment Load (lbs/acre/year) |
|---|---|
| Developed, High Intensity | 0.00 |
| Developed, Med Intensity | 0.00 |
| Developed, Low Intensity | 0.00 |
| Developed, Open Space | 0.11 |
| Cultivated Crops | 1.08 |
| Pasture/Hay | 0.26 |
| Grassland/Herbaceous | 0.44 |
| Evergreen Forest | 1.37 |
| Scrub/Shrub | 0.90 |
| Palustrine Emergent Wetland | 0.01 |
| Palustrine Forested Wetland | 0.01 |
| Palustrine Scrub/Shrub Wetland | 0.01 |
| Estuarine Forested Wetland | 0.03 |

| Class | Edge of Stream Sediment Load (lbs/acre/year) |
|---|---|
| Estuarine Scrub/Shrub Wetland | 0.23 |
| Unconsolidated Shore | 0.00 |
| Bare Land | 4.42 |
| Open Water | 0 |

This table indicates that bare land areas contribute the most sediment per acre in the Kaiaka Bay watershed, so bare land within the watershed may be a beneficial target for BMP implementation. Planting native plant species could minimize the sediment load coming from areas that are currently bare land by transforming it into vegetative cover (or evergreen forest in terms of land cover classes). Currently, bare land covers 405 acres of the watershed and the sediment export from this land is 1790.5 pounds. To calculate the amount of sediment load from this land after BMP implementation, assuming all the bare land becomes evergreen forest, the acres of bare land should be multiplied by the sediment load per acre for evergreen forest. This returns a value of 554.85 pounds of sediment load per year from this land, a 1235.65 pound decrease. These calculations should be considered when selecting locations for BMP implementation, but additional evidence should be evaluated as well. As discussed in the Step-by-Step Procedure section, NDVI data can be useful evidence as well. The NDVI data in raster format for the Kaiaka Bay is below:




The pixels with a lower NDVI index, which are shown in darker brown, are less vegetated areas. This image indicates that the middle section of the Kaiaka Bay watershed is less vegetated, so BMP implementation could be especially valuable in this area. However, the resolution of this raster data is low, so it is difficult to use it to precisely choose locations for BMP implementation. Therefore, other evidence such as high-resolution satellite images and drone footage can be used to pinpoint areas with minimal or invasive vegetation. As an additional line of evidence, people familiar with the Kaiaka Bay watershed can be interviewed to collect information on areas with minimal vegetation, invasive plants and/or feral ungulates. Furthermore, a person can walk along streams in the Kaiaka Bay watershed and document the most eroded areas. The information gathered from the InVEST model run, the NDVI index raster, satellite images, drone footage, interviews and documentation from someone on site should all be carefully considered when determining where BMPs should be implemented.

## Useful Resources and Materials

To supplement the information included in this addendum, more information on the InVEST model and using this model in the state of Hawaii is linked below:

- More information on the InVEST sediment ratio delivery model including background information, required data inputs, and guidance on interpreting outputs is here: SDR: Sediment Delivery Ratio — InVEST® documentation
- More information on the InVEST DelineateIt tool discussed in the Step-by-Step Procedure to create watershed boundaries: DelineateIt — InVEST® documentation
- Further details on the Kaiaka Bay watershed: Kaiaka Bay Watersheds Characterization
- For more information on running the InVEST model for watersheds in Hawaii, including the rationale for many of the non-GIS inputs see Predicting Sediment Export into Tropical Coastal Ecosystems to Support Ridge to Reef Management [dissertation], available for download here: (PDF) PREDICTING SEDIMENT EXPORT INTO TROPICAL COASTAL ECOSYSTEMS TO SUPPORT RIDGE TO REEF MANAGEMENT

## References

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National Aeronautics and Space Administration (NASA). 2025. Normalized Difference Vegetation Index (NDVI). https://www.earthdata.nasa.gov/topics/land-surface/normalized-difference-vegetation-index-ndvi

Renard, K.G., Foster, G.R., Weesies, G.A., McCool, D., Yoder, D. 1997. Predicting soil erosion by water: a guide to conservation planning with the revised universal soil loss equation (RUSLE). Agriculture Handbook, 703. USDA.

Renard, K.G., J.R. Freimund. 1994. Using monthly precipitation data to estimate the R-factor in the revised USLE. Journal of Hydrology, 157. Pp 287-306. https://www.tucson.ars.ag.gov/unit/Publications/PDFfiles/942.pdf

United States Geological Survey (USGS). 2025. 1/3rd arc-second Digital Elevation Models (DEMs) - USGS National Map 3DEP Downloadable Data Collection. https://data.usgs.gov/datacatalog/data/USGS:3a81321b-c153-416f-98b7-cc8e5f0e17c3