MĀ‘ILI‘ILI
WATERSHED MANAGEMENT PLAN

VOLUME I
Final Report
July 2014




Prepared for:
Hawai‘i State Department of Health
Clean Water Branch

Prepared by:
TOWNSCAPE, INC.
Environmental & Community Planning

MĀʻILIʻILI WATERSHED MANAGEMENT PLAN

VOLUME I.

- FINAL REPORT-

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This Project has been funded by a Supplemental Environmental Project settlement agreement between the City and County of Honolulu and the Hawai'i State Department of Health, Clean Water Branch. Although the information in this document has been funded wholly or in part by the City and County of Honolulu to the Hawai'i State Department of Health, it may not necessarily reflect the views of the City and County of Honolulu and the Hawai'i State Department of Health, and no official endorsement should be inferred.

This project was completed by TOWNSCAPE, INC. for the State of Hawai'i Department of Health, Clean Water Branch, under ASO LOG NO. 13-107 and MODIFICATION ORDER NO. 1.

<u>Subcontractors for this plan included:</u>

Mohala I Ka Wai – Community Outreach

Dr. Ross Cordy- Archaeology

AECOS – Water Quality Analysis

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ACRONYMS

AD	“Anno Domini” = All years since BC (“Before Christ”)
ALISH	Agricultural Lands of Importance to the State of Hawaiʻi
ATU	Aerobic Treatment Unit
BMP	Best Management Practice
BOD	Biological Oxygen Demand
BWS	Honolulu Board of Water Supply
C&C	City & County of Honolulu
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CFS	Cubic Feet per Second
CFU	Colony Forming Unit (bacteria measurement)
CPPE	Conservation Practice Physical Effects
CTAHR	College of Tropical Agriculture and Human Resources (UH Mānoa)
CWA	Clean Water Act
CWB	Clean Water Branch (DOH)
CWRM	Commission on Water Resources Management (DLNR)
DBEDT	Department of Business, Economic Development & Tourism
DHHL	Department of Hawaiian Homelands
DLNR	Department of Land and Natural Resources (State)
DNA	Deoxyribonucleic acid
DO	Dissolved Oxygen
DOFAW	Division of Forestry and Wildlife
DOH	Department of Health (State)
DWEL	Drinking Water Equivalent Level
EPA	U.S. Environmental Protection Agency
FDA	Food and Drug Administration
FEMA	Federal Emergency Management Agency
FOTG	Field Office Technical Guide (NRCS)
GIS	Geographic Information Systems
GPS	Global Positioning System
HAR	Hawaiʻi Administrative Rules
HOK	Hui o Koʻolaupoko

HRS	Hawaiʻi Revised Statutes
INRMP	Integrated Natural Resource Management Plan
IPM	Integrated Pest Management
IWS	Individual Wastewater System
LCC	Land Capability Classification
LHA	Lifetime Health Advisory
LID	Low Impact Development
MGD	Million Gallons per Day
MLRA	Major Land Resource Area
MS4	Municipal Separate Storm Sewer System
NAD83	North American Datum of 1983
NAVMAG	Naval Magazine Lualualei
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPS	Non Point Source (pollution)
NRCS	Natural Resources Conservation Service
NRTF	Naval Radio Transmitter Facility Lualualei
ORC&D	Oʻahu Resource Conservation and Development Council
PAH	Polycyclic OR Polynuclear Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
pH	Hydrogen Ion Concentration (measurement of acidity/alkalinity)
RAB	Restoration Advisory Board
RFP	Request for Proposals
RO	Revised Ordinances of Honolulu
ROV	Remotely Operated Underwater Vehicles
RTF	Radio Transmitter Facility
SCP	Sustainable Communities Plan
SCUBA	Self Contained Underwater Breathing Apparatus
SDWA	Safe Drinking Water Act
SDWB	Safe Drinking Water Branch (DOH)
SHPD	State Historic Preservation Division (DLNR)
SOP	Standard Operating Procedures
STEPL	Spreadsheet Tool for the Estimation of Pollutant Load
SWOT	Strengths, Weaknesses, Opportunities & Threats
TCRA	Time Critical Removal Action

TMDL	Total Maximum Daily Load
TMK	Tax Map Key
TPH	Total Petroleum Hydrocarbons
TSS	Total Suspended Solids
UH	University of Hawaiʻi
UIC	Underground Injection Control
USACE	U.S. Army Corps of Engineers
USDA	United States Department of Agriculture
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
UTM	Universal Transmercator (map projection)
VOC	Volatile Organic Compound
VSI	Vegetation Stiffness Index
WMP	Watershed Management Plan
WMWP	Waiʻanae Mountains Watershed Partnership
WPFPA	Watershed Protection and Flood Prevention Act
WSCP	Waiʻanae Sustainable Communities Plan
WWB	Wastewater Branch (DOH)
WWTP	Waiʻanae Wastewater Treatment Plant

EXECUTIVE SUMMARY

Introduction:

Māʻiliʻili Stream on the Waiʻanae coast of Oʻahu is an intermittent stream with several named and unnamed tributaries. The majority of the stream flows through military lands owned by the U.S. Navy. The lower reaches of the stream have been channelized with concrete to reduce flooding problems. In 2009, the City and County of Honolulu, Department of Facility Maintenance, Road Maintenance Divison, illegally placed 930 cubic yards of fill material in the Māʻiliʻili Stream Channel, prompting an investigation and lawsuit for violations of the federal Clean Water Act. This lawsuit resulted in a settlement agreement between the City and the State of Hawaiʻi Department of Health. The $1.4 million resulting from this settlement were allocated to several purposes, including the development of a watershed plan for the Māʻiliʻili Watershed and primarily for the implementation of projects recommended in the watershed plan to help address water quality issues from land-based pollution. This watershed plan, which follows the EPA "nine elements of watershed plans", was developed over the course of approximately 1.5 years between 2013 and 2014.

Methodology:

The plan and report are organized into four major sections following the introductory chapter: The Watershed Characterization (section 2), Watershed Management Strategies (section 3), Implementation Plan (section 4) and Monitoring Plan (section 5). The planning process and research were undertaken using a multi-disciplinary methodology that combined quantitative and qualitative science, geospatial analysis using Geographic Information Systems (GIS), and public participation and stakeholder outreach. Fieldwork and community outreach were a major component of the process, as well as consultation with experts in the field of archaeology and water quality science. Results of these consultations can be found in Volume 2. Appendices.

Watershed Description:

The Māʻiliʻili Watershed drains approximately 10,068 acres of land. Roughly 80% of this land is undeveloped in a relatively natural state and owned by the US Navy, therefore the overall watershed population is low. The remainder is primarily private/agricultural land. It is a very gently sloping valley with steep mountains in the background. The climate is hot and dry and streams in the watershed are intermittent. The soils in many parts of the watershed are highly suitable for agriculture and there are abundant Native Hawaiian cultural resources in the uplands.

Water Quality Problems:

Only very limited data are available on the water quality in this watershed and DOH has not done any baseline or long-term water quality monitoring. This watershed planning process included limited water quality sampling and modeling to help shed light on the pollutants of concern. Modeling and water quality sampling showed very high levels of nutrients coming from the agricultural areas, likely due to heavy fertilizer use. Low levels of pesticides were found coming from the Navy lands and future water quality sampling may reveal pesticide problems in the agricultural areas, which was a primary concern of community members who have witnessed and been personally affected by pesticide applications. Total suspended solids sampling data and modeling results also suggested a potential sediment problem. In general, trash and debris and illegal dumping are also of concern in this watershed.

Relationship to Land Uses:

Water quality problems and non point source pollution are related to land uses in a watershed. For example, an area with native forest and a healthy ecosystem will function in a natural way, infiltrating much of the rainwater, recharging aquifers and reducing runoff and flooding. Any land that has been converted by human development, including impervious surfaces and agriculture, changes the hydrology of this system and creates more runoff that carries any pollutants created by the land use or activity into nearby water bodies. Since the water quality problems in the Māʻiliʻili Watershed indicate agricultural inputs as a main source, it will be important to implement projects that address agricultural practices to reduce polluted runoff. Large-scale landscape management applications on Navy lands upstream of the agricultural areas will also provide long-term cumulative benefits.

Management Strategies:

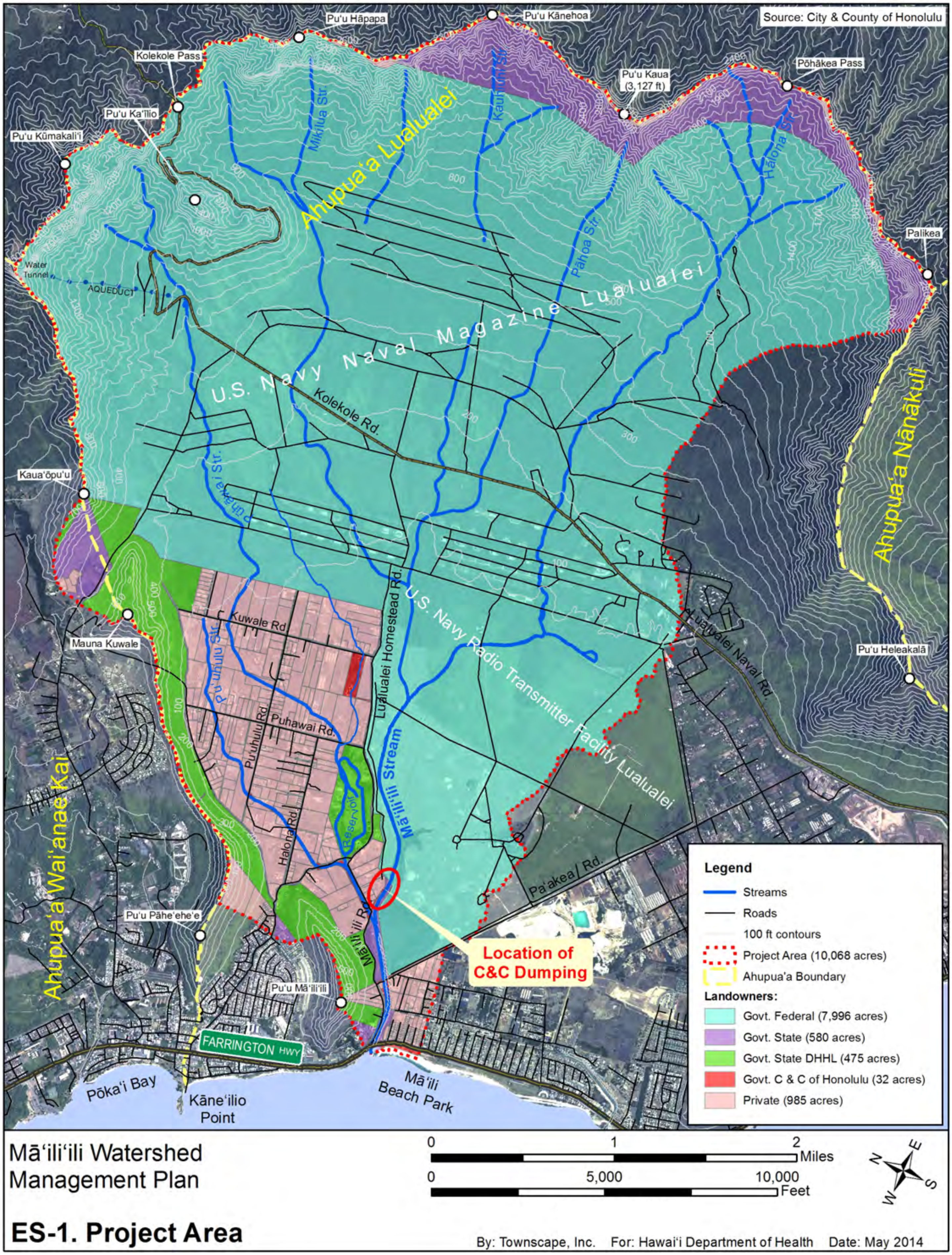
There are many different strategies and practices that can be applied at parcel and landscape levels to reduce runoff and pollutant loads. In Hawaiʻi, focus is typically on upland forest restoration and agricultural runoff reduction – these strategies apply to the Māʻiliʻili Watershed as well. Management strategies identified in this plan are listed by pollutant source or land use areas as used in our water quality modeling program. Strategies were identified for agriculture, forested areas, uplands, grasslands, riparian zone and residential areas.

Implementation:

The strategies selected will be implemented based on priority. Priority was given to projects that are expected to bring the most benefits and are relatively easy to implement using the settlement funds available for implementation, which is roughly $750,000. These funds will be allocated to the four identified priority projects, to be implemented over the next 3-5 years. DOH will issue RFPs for these projects which will be awarded through the state procurement process. Additional longer term projects were identified for the next 5-10 and 10-20 years. Funding for these future projects may be obtained from a variety of government and other programs. Implementation of the priority projects is expected to bring measurable water quality benefits to the watershed in the near future, while longer term projects will provide additional potentially highly effective benefits.

The priority projects were designed as "programs". Each implementation program addresses certain water quality issues and sources via the implementation of many discrete project types. The four priority projects (i.e. programs) are as follows:

1. **Community Watershed Projects -** $150,000 allocated for a program to implement a variety of projects, including ongoing community water quality monitoring, community stream clean-ups, rain garden installation and educational programs.
2. **Agricultural Education and BMP Implementation Program -** $200,000 allocated for a program to implement a variety of agricultural BMPs, including filter strips and field borders and an educational series on proper fertilizer and pesticide use.
3. **Streambank and Soil Stabilization Projects -** $235,000 allocated for the stabilization and planting of priority areas needing streambank and soil stabilization.
4. **Failing Cesspool Replacement Project -** $100,000 allocated for the replacement of failing cesspools



ES-1. Project Area

1. Introduction

1.1 Background:Setting the Context

Māʻiliʻili Stream on the Waiʻanae coast of Oʻahu is an intermittent stream with several named and unnamed tributaries. The majority of the stream flows through military lands owned by the U.S. Navy [(1)]. The lower portions of the stream have been channelized with concrete to reduce flooding problems. Sections of the channelized portions are owned by the City & County of Honolulu and the State of Hawaiʻi [(2)]. The stream is regulated under the Federal Clean Water Act (CWA).

In 2008 and 2009, the City & County of Honolulu, Department of Facility Maintenance, Road Maintenance Division, placed a total of 930 cubic yards of unauthorized fill material (including concrete rubble, metal debris, used asphalt and tires) in the Māʻiliʻili Stream channel, covering an area of over one acre approximately one mile inland from the shore, mauka of the first fork in the stream [(3)]. The area is frequented by several nesting pairs of the endangered Hawaiian Stilt. Unaware that this type of action is a violation of the CWA and would require a permit from the U.S. Army Corps of Engineers (USACE), the City placed the debris in the stream as part of an adjacent road maintenance project.

Upon discovery of the illegal activities, the environmental group EnviroWatch reported the violations to USACE, starting the legal process under the CWA [(4)]. In July 2009, the United States Environmental Protection Agency (EPA) issued a Finding of Violation against section 301 of the CWA and an Order of Compliance to the City & County of Honolulu, requiring the removal of the unauthorized material [(4)]. The ensuing lawsuit by the State of Hawaiʻi (plaintiff) vs. the City & County of Honolulu (defendant) resulted in a Settlement Agreement in May 2012. The settlement amount of $1.4 million was to be allocated for three different environmental protection activities with the goal of improving water quality on the Waiʻanae coast: 1. The development of a web-based tool for the public to track DOH permitted facilities; 2. The development of this Watershed Management Plan (WMP) for the Māʻiliʻili Watershed in accordance with section 319(d) of the CWA; 3. The implementation of some of the water quality improvement projects identified in the WMP [(5)].

While many WMPs in Hawaiʻi are developed for priority watersheds with specific identified water pollutants or TMDLs in mind, this WMP is a direct result of the mitigation efforts of the stream dumping case described above. There has been no ongoing water quality monitoring at Māʻiliʻili Stream and it is not listed on the State's 303(d) list of impaired waters, so the specific water quality issues remaining since the clean-up are not clearly understood. The research and planning process for this WMP sought to identify some of the specific water quality problems and employed a holistic approach to mitigating identified problems and preventing future issues via public education, management strategies and specific implementation projects [(6)].

1.2 Location and Geographic Scope

This WMP covers the roughly 10,068-acre drainage basin of Māʻiliʻili Stream on the Waiʻanae Coast of Oʻahu, outlined with a thick dotted line in the maps as “Project Area” (see Figure 1). The Māʻiliʻili Stream watershed is part of the ahupuaʻa of Lualualei (~15,374 acres), which also includes the drainage basins of Ulehawa Stream (2,850 acres) and Māʻili Stream (~1,800 acres) to the southeast [1]. The Māʻiliʻili Watershed is quite large compared to other Hawaiian watersheds, which are typically less than 5,000 acres in size.

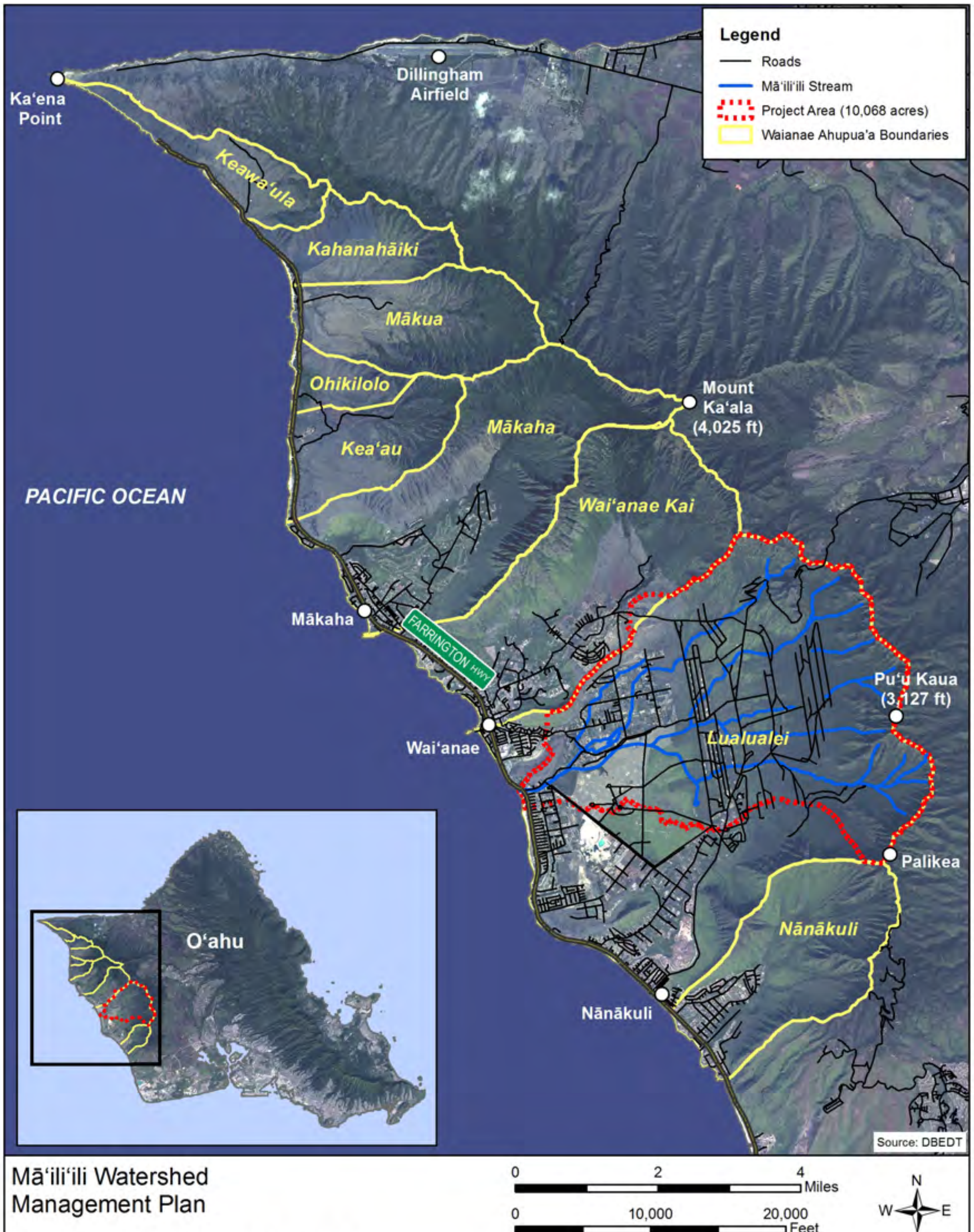


Figure 1. Project Location

1.3 Planning Process and Purpose of the Watershed Characterization

This WMP was developed in accordance with EPA's nine elements of watershed plans to ensure that projects proposed for implementation in this plan will qualify for funding under section 319(h) of the CWA [6] [7].

Table 1. EPA 9 Elements of Watershed Plans [6]

EPA's Nine Key Elements of Watershed Plans
a. Identification of causes of impairment and pollutant sources or groups of similar sources that need to be controlled to achieve needed load reductions and any other goals identified in the watershed plan.
b. An estimate of the load reductions expected from management measures.
c. A description of the non point source management measures that will need to be implemented to achieve load reductions and a description of the critical areas where those measures will be needed to implement this plan.
d. Estimate of the amounts of technical and financial assistance needed, associated costs, and the sources and authorities that will be relied on to implement this plan.
e. An information and education component used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing the non point source management measures that will be implemented.
f. Schedule for implementing the non point source management measures identified in this plan that is reasonably expeditious.
g. A description of interim measurable milestones for determining whether non point source management measures or other control actions are being implemented.
h. A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made toward attaining water quality standards.
i. A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under item h immediately above.

The Watershed Characterization (section 2) is the second step and the first document created as part of the watershed planning process outlined by the EPA in the “Handbook for Developing Watershed Plans to Restore and Protect Our Waters” (7). The planning and implementation process, further described in the “Hawaiʻi Watershed Guidance” (6) consists of six steps:

Step 1 – Build Partnerships

Step 2 – Characterize the Watershed

Step 3 – Set Goals and Identify Solutions

Step 4 – Design an Implementation Program

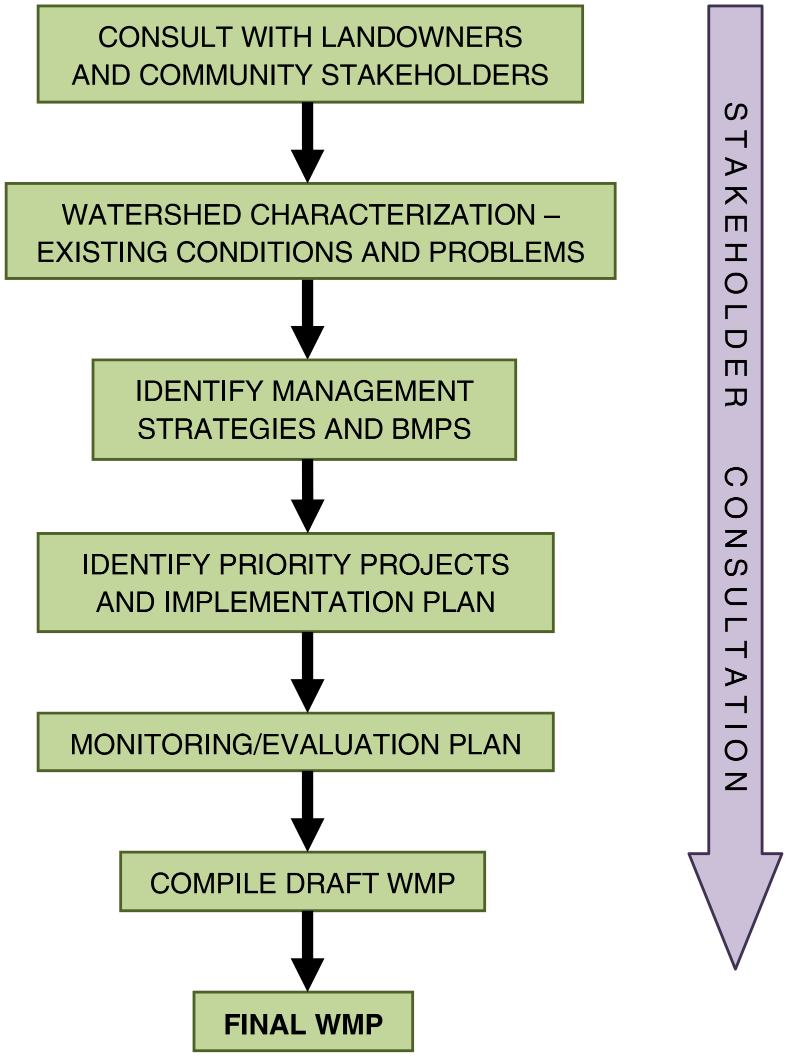
Step 5 – Implement the Watershed Plan

Step 6 – Measure Progress and Make Adjustments

For this WMP, steps 2, 3, 4, and 6 resulted in four separate documents that together comprise the Māʻiliʻili Watershed Management Plan. These four documents are the Watershed Characterization (step 2), the Watershed Management Strategies & BMPs Report (step 3), the Implementation Plan Report (step 4), and the Monitoring, Evaluation & Adjustment Plan Report (step 6).

The purpose of the Watershed Characterization is to provide an overview of the existing conditions in the watershed and identify problem areas. It provides a mechanism to assess natural and anthropogenic processes within the watershed and to determine which of them may be generating non point source pollution or causing other detrimental ecological impacts (6).

Figure 2. Planning Process Diagram



1.4 Summary of Research Methodology

Characterizing a watershed is performed via a multi-disciplinary approach that combines quantitative and qualitative science, geospatial analysis, and public participation and stakeholder outreach. This approach helps to blend science, regulatory issues, policies, people, and social/economic issues.

The first step was to create a "Watershed Inventory", i.e. gathering and analyzing existing data on the watershed. While creating the inventory, gaps in data and additional data collection needs were identified. Finally, possible causes of water quality impairments (point and non point source) are identified to provide a basis for the development of management solutions [6].

1.4.1 Data Compilation

Townscape Inc. gathered relevant reports, articles, government records and research described in section 1.5. There was a lack of scientific or research data on the watershed and its stream. Most of the literature covered the area in a general way or focused on specific issues such as flooding.

1.4.2 Geographic Information Systems

GIS (Geographic Information Systems) is a helpful tool used by planners and resource managers throughout the world to aid in analyzing and visualizing geographic areas and making management decisions. ArcGIS 10.1 [8] was used to analyze and depict spatial relationships among various features in the watershed such as land uses, land ownership, land cover, and other relevant features. The resulting outputs were the maps displayed throughout this document [1]. Townscape, Inc. compiled a database of GIS data from various sources as noted on each map. Most of the data layers can be obtained from the State Office of Planning, which hosts a web-based databank of GIS layers [1]. The watershed boundaries were defined via GIS-based modeling techniques that analyze topography and surface water flow [8]. Data layers obtained from various sources were later clipped to the project area boundary for analysis and computation of numbers found in tables throughout this report. The State does not guarantee accuracy of the data it provides. All maps were made using the North American Datum 1983, Universal Transmercator Zone 4 North projection (NAD83 UTM4N). Any data layers that were originally created in different projections, were re-projected to NAD83 UTM 4N. Some GIS data were produced by Townscape Inc. via GPS data collected during field work, which was later imported into ArcGIS. Satellite imagery used in most of the maps came from the “World View 2” satellite. Maps showing close-up areas at a smaller scale were made with USGS aerial photo imagery.

Note on place names identified in the maps: The place names seen in maps throughout this document are from a combination of historic records, modern books, GIS data and anecdotal information from the community. The spellings may vary from some old maps and were obtained from the book “Place Names of Hawaii” [9]. The only repeatedly named tributary to Māʻiliʻili Stream as seen in historic maps is Pūhāwai Stream. Puʻuhulu Stream to the north was labeled as such because of anecdotal descriptions from the community, probably due to proximity to Puʻuhulu Road. Modern maps have identified it as Lualualei Creek. The remaining tributary names up in the mountains are assumptions based on the land names of the surrounding areas as identified by our archaeologist (see Appendix B).

1.4.3 Field Work

Field work was conducted to get an overview of the on-the-ground conditions, to verify the accuracy of geospatial data, and to assess possible problem areas identified by stakeholders and the overall planning process. Field activities included windshield surveys of both military and non-military lands, a detailed tour of the Navy installations for the purposes of taking pictures of areas of concern, and a walk along the streambeds with State Civil Defense staff and community members in the non-military portions of the streams to assess areas of concern for pollutant contribution. Details on the observations recorded during these field visits can be found in section 2.4 “Pollutant Source Assessment”.

1.4.4 Stakeholder Participation

The EPA’s nine elements for watershed plans and the six-step process outlined in the Hawai‘i Watershed Guidance provide a framework for the public participation and stakeholder outreach process required for a WMP (6) (7). In order for a WMP to be more than just a document, it is important to find realistic and affordable management measures that are actually going to be implemented. Many of these types of management measures, e.g. stabilizing streambanks with native vegetation to avoid streambank erosion, are only implementable with the support of landowners and the local community since the streams don’t only flow through government-owned land and there is no legal requirement for landowners to participate in BMP implementation. Without a stakeholder outreach process, proposed activities typically don’t get much support and end up not being implemented, making such a WMP completely futile. By directly involving key stakeholders in the planning process, the management strategies and proposed projects can be developed with the input from the same people whose cooperation will be required for successful implementation. This maximizes the ultimate success of the WMP (6).

In order to achieve maximum stakeholder participation, Townscape Inc. partnered with Mohala I Ka Wai, a local community nonprofit organization that is well-known and respected on the Wai‘anae coast. A stakeholder outreach plan was developed as an initial deliverable to DOH, outlining the various outreach activities such as presentations to neighborhood board meetings, community meetings and one-on-one interviews (see Table 2). The major stakeholders were generally identified as follows:

Client: Department of Health Clean Water Branch (CWB)
Local kūpuna
Community leaders
Community/public
Public Agencies/elected officials
Landowners: U.S. Navy, State of Hawai‘i, Department of Hawaiian Homelands, City & County of Honolulu, Private landowners

Table 2. Stakeholder Outreach Plan

Planned activities	Stakeholders involved/ details	Timeline
Announcements	• Announcement of project to Waiʻanae Neighborhood Board at March 5 board meeting, request to give presentation at April 2 NB meeting. • Announcement of project to Nānākuli/Māʻili Neighborhood Board, request to give presentation at March 19 NB meeting.	Month 1-2
Presentations	• Project presentation at March 19 Nānākuli/Māʻili Neighborhood Board meeting. • Project presentation at April 2 Waiʻanae Neighborhood Board meeting.	
Meetings/phone calls	• Rotary Club • West Oʻahu Farm Bureau/Pūhāwai Farm Association • U.S. Navy (meetings + field recon) • Lualualei Hawaiian Civic Club • DHHL	
News media coverage	• Publish article about the project in "Westside Stories" • ʻŌlelo news coverage of project/ NB presentations	
Community meetings	• First community meeting ("speak-out" or "open house" style) at Kahumana Farms to introduce project and start making contacts for one-on-one interviews later	
Interview preparation	• Prepare questions for one-on-one interviews with kūpuna and Pūhāwai/Kuwale area residents • Prepare questions for one-on-one interviews with other stakeholders (gov't, ag, other residents)	
One-on-one interviews	Kūpuna/ residents: • Landis Ornellas • John DeSoto (explored via helicopter after '96 flood) • Albert Silva (former cattle rancher, knows old taro areas) • Walterbea Aldeguer • Vince Dodge • William Aila, Jr. • Waiʻanae Coast Comprehensive Health Center	Month 2-4
One-on-one interviews	Agriculture: • Kennard Hicks (taro, plumeria, corn farmer, ʻUilani Farms) • Father Phil (Kahumana Farms) • Harry Choy (West Oʻahu Farm Bureau)	

	• MAʻO Organic Farms	
One-on-one interviews	Government: • U.S. Navy • DHHL • Rep. Jo Jordan • Senator Maile Shimabukuro • C&C Department of Emergency Management • NRCS/ORC&D/West Oʻahu Soil and Water Cons. District	
Community meetings	• Community meeting to report findings from WS Characterization and Strategies/BMPs; receive community input on additional needs; identify management measures with the community (community vs. technical perspective)	Month 5-6
Follow-up meetings	• Key public agencies • Key landowners • Key community organizations	
Presentation	• Community presentation on findings, proposed projects; determine actual support for suggested strategies/BMPs	Month 7-8
Presentation(s)	• Draft Māʻiliʻili Watershed Management Plan (possibly at NB meeting and/or other event)	Month 11-12

1.5 Knowledge Base/Data Gaps

There is little scientific or other data available on the project watershed. There are some reports that cover certain aspects of the watershed and various permit information. Data gaps are primarily the lack of stream monitoring and water quality data. The most relevant reports available are summarized here. In addition, the major landowner is the U.S. Navy, which means some data and reports are not available to the public or are considered classified. Multiple data requests were sent out to the Navy for a variety of reports, GIS files and other data. Due to security procedures, the processing for these data requests is lengthy.

1.5.1 Watershed Workplan Waiʻanae Nui (1960) [10]

This work plan was written over five decades ago, not long after Hawaiʻi became a State, and before the enactment of major environmental laws such as the CWA. It was written in accordance with the Watershed Protection and Flood Prevention Act (WPFPA) of 1954 and primarily focuses on the issue of flood mitigation. This watershed plan provided the basis for the subsequent concrete channelization of streams in the Māʻiliʻili, Māʻili, and Nānākuli watersheds. Due to a lack of flood mitigation measures in the 1950s, this plan prescribes the structural improvements (concrete channels) later constructed and maintained to this day to prevent flood damage from rainfall events.

1.5.2 Lualualei Flood Study (2001) (2)

Despite the implementation of the flood control measures recommended in the 1960 work plan, flooding continued to be a problem in the Lualualei Valley during heavy rainfall events. In November of 1996, rainfall reported by the National Weather Service as being the heaviest in 50-100 years, resulted in extensive flooding in Leeward and Central Oʻahu. Lualualei Valley's topography makes it especially prone to flooding problems. The very steep slopes of the mountains can carry rainwater very quickly down into the very gently sloping valley, where it can build up if it is not properly drained.

The Lualualei Flood Study was conducted to assess the magnitude and location of flooding and drainage problems in each of the three drainage basins in Lualualei Valley. It included an analysis of the hydrology, hydraulics and environmental conditions with the goal of identifying infrastructure improvements to prevent future flooding. Hydrologic and hydraulic modeling were performed to assess peak flows and floodwater behavior. Based on these analyses, recommendations and cost estimates were made for infrastructure improvements.

Summary of findings: The proposed improvements were primarily in the area identified in the landowner map as "Private", i.e. the neighborhoods around Puhawai Road. The lack of maintenance of drainage structures such as culverts and channels prevented the water from draining, causing some residential areas to be inundated for up to seven days. The roads lack a proper stormwater drainage system, causing pooling of water in sump areas. The improvements made in the 60s and 70s were designed to meet the high peak flows, but there were some bridges and culverts that were not part of that flood control project and those were deemed inadequate. Overall, six of the nine bridges and culverts analyzed in this study (for the Māʻiliʻili basin) require extensive upgrading to handle stormwater (e.g. the culvert right above the Lualualei Reservoir is designed for a capacity of 200 cfs, but the 100-year peak flow is estimated at 6,074 cfs). Sump conditions exist in several locations due to the grade, allowing water to pool on roads. Some roadways need to be re-constructed with curbs and catch basins/drain lines. The concrete channel of Māʻiliʻili Stream is not designed to handle peak flows during a 100-year flood. Raising the banks of the channel was recommended. Costs for Māʻiliʻili improvements were estimated at $3.5 million. Some drainages and culverts were overgrown and even filled in by private landowners, causing more flooding and more debris/material to enter the stream. Maintaining the drainages could provide both flooding and water quality improvements. Some of the proposed infrastructure improvements could however reduce water quality, e.g. item D, to divert road runoff directly into the stream. For these types of developments, special permits are required [2].

1.5.3 Waiʻanae Watershed Management Plan (2009) [11]

The Waiʻanae Watershed Management Plan is one of eight regional water use and development plans that together constitute the Oʻahu Water Management Plan. In response to the State Water Code (HRS §12-174C), which requires the Counties to develop county-wide water management plans, the City & County of Honolulu developed an ordinance (RO §30) guiding the development of the county-wide plan by dividing it into eight planning areas. The resulting regional watershed plans focus on water use and quantity, but also on general sustainable watershed planning principles.

The Waiʻanae Watershed Management Plan gives an overview and analysis of the water resources present in nine watersheds in the Waiʻanae moku and provides a long-range plan (until 2030) for the *“protection, preservation, restoration, and balanced management of ground water, surface water, and related watershed resources.”* The management measures recommended for Māʻiliʻili are in alignment with the projects recommended by the Waiʻanae Watershed Management Plan.

1.5.4 Waiʻanae Sustainable Communities Plan (2010) [12]

The Waiʻanae Sustainable Communities Plan (WSCP) was developed in accordance with the City & County’s General Plan and is to be reviewed and updated every five years. It is one of eight regional plans for the Island of Oʻahu. Since the major growth and development on Oʻahu are planned for the ʻEwa and urban Honolulu areas, the regional plans for those areas are called “Development Plans”. As one of the relatively stable regions without large growth projections, Waiʻanae will receive development support to focus on supporting existing populations. These types of plans are called “Sustainable Community Plans”. The WSCP focuses heavily on sustainability principles and maintaining Waiʻanae’s rural character. With the increase in population from 7,000 in 1950 to almost 50,000 in 2010, as well as an increase in development, Waiʻanae is the most developed of Oʻahu’s rural districts. Retaining the rural character will be a challenge and strong City policies and actions will be required. The projects recommended for Māʻiliʻili in this watershed plan are in alignment with the WSCP.

1.5.5 AECOS Biological Reconnaissance Survey of Māʻiliʻili Stream (2009) (13)

This biological survey was conducted as part of the Environmental Assessment for the Māʻiliʻili restoration project after EPA issued the Order of Compliance to the City. The project area covered the site of the fill. In addition, basic water quality measurements were taken at four points between the Paʻakea Street bridge and the mauka end of the project area. The project area is described as a pond/wetland running down the center of the channel for a distance of about 500 feet, with a width of about 15-25 feet. Observations and measurements taken at the pond suggest that it is fed by brackish groundwater with an elevated nutrient content (possible agricultural fertilizer inputs) and is not receiving flow from mauka areas. The water does flow downstream towards the ocean. The lower regions that are subject to tidal influence are described as a "concrete-lined tidal estuary".

Water quality measurements included basic analyses of parameters that can be tested on site. These parameters include temperature, salinity, pH and dissolved oxygen. The State water quality standard for pH in streams was exceeded at 3 out of 4 testing locations. The flora is listed and described as "overwhelmingly dominated by non-native species, exceptions being the abundant widgeon grass and seaside heliotrope". There were not much fauna in the long shallow run down the concrete channel, but some in the pond/estuary area. Considering the high level of modification of this stream/estuary ecosystem, there was a high number of indigenous and endemic species found, including the endangered Hawaiian Stilt, ʻulili, āholehole, Samoan crab and others (13).

1.5.6 Ordnance Reef Study (2007) (14)

This study was completed over the course of several years to assess the potential danger of munitions dumped in the ocean after World War 2 to humans and the environment. The location of the munitions in an area referred to as "Ordnance Reef" is offshore and slightly north of the Māʻiliʻili Watershed. Since munitions are also being stored at NAVMAG, the community and various stakeholders have long been concerned about possible contamination coming from munitions storage areas on land, as munitions can contribute a variety of heavy metals and other contaminants. The ordnance reef study did not find significant ecosystem impairments resulting from the munitions discarded at sea. Therefore it is questionable whether there are any significant contributions of contaminants from munitions securely stored inside bunkers at NAVMAG.

The report provides a lengthy background section describing the environment and details of the research endeavors. The methods included GIS mapping, data collection via remote sensing, dive operations, and remotely operated underwater vehicles (ROV). Samples of water, sediments and fish found near the location of the munitions were analyzed for contamination with various trace elements found in military munitions, including arsenic, copper, iron, lead, etc. Some of the control samples were taken just offshore of the Māʻiliʻili Stream mouth near the sewage outfall pipe from the Waiʻanae Wastewater Treatment Plant so the researchers could compare the results of Ordnance Reef with other areas. Results of the study that are of relevance to this watershed plan are as follows:

- Ocean water sampled at two stations near the sewage outfall pipe was extremely clear, i.e. the levels of turbidity were very low, an indicator of good water quality.
- Sediment analysis for trace metals revealed that most were of volcanic origin, suggesting non marine and non-anthropogenic causes.
- Elevated levels of copper and zinc were associated with runoff from impervious surfaces as lab analysis suggested the source as “combined automotive” from tires and brakepads.
- Elevated levels of copper associated with discarded munitions were only found in samples collected very close to actual munitions.
- Elevated levels of lead were found near the sewage outfall pipe; detailed analysis attributed this lead to anthropogenic sources, although it was not able to identify a specific source. The report suggests that lead contributions come from the treated sewage as well as land runoff.
- Overall trace metal enrichment of sediments was very low.
- Fish tissue analysis revealed some detectable levels of metals, including Arsenic, Barium, Cadmium, Mercury and Zinc. The levels of these metals were lowest in the control area, which is offshore of the mouth of Māʻiliʻili Stream. Although there were “detectable levels” of these metals, they did not exceed Food and Drug Administration (FDA) standards for fish consumption anywhere. It should also be noted that arsenic and zinc detected was from natural sources, not munitions, as these elements are natural components of Hawaiian volcanic sediments.

1.6. Regulatory Environment

As a federal environmental law, the CWA (1972, further amended in the 1970s and 1980s), which regulates discharges of pollutants into U.S. waters and sets surface water quality standards, is administered by the EPA [15]. However, many of the administrative and enforcement aspects of the law have been delegated to the States. In Hawaiʻi, the agency responsible for pollutant discharges (NPDES permit system) and water quality regulation is the State Department of Health Clean Water Branch (CWB) through State regulations in the Hawaiʻi Administrative Rules Title 11. Groundwater is regulated separately by the Safe Drinking Water Act (SDWA, 1974 with amendments in the 1980s and 1990s). This law, administered by the EPA, regulates underground injection wells via the UIC program to prevent contamination of groundwater resources [16]. The regulatory relationships among the various federal, state and local laws are complex. The most relevant federal and state laws for this WMP are listed below in Table 3.

The most important aspect for watershed planning and implementation is: **Management practices or specific projects described in a watershed plan that is written in accordance with EPA guidelines (nine elements) qualify for grant funding as specified in section 319 (h) of the CWA** [6]**.** This mechanism helps to further maximize the success of WMPs by increasing access to funding for the implementation of projects. 319 funds are federal funds allocated by EPA to each State. The CWB administers and distributes 319 funding allocated to the State of Hawai‘i.

Table 3. Relevant Regulations

Regulation	Issues addressed by regulation	Responsible Agency
FEDERAL:		
Clean Water Act (CWA)	Surface Waters of the U.S.	EPA
Safe Drinking Water Act (SDWA)	Groundwater, Underground Injection	EPA
Coastal Zone Mgmt Act (CZMA)	Coastal Areas, nearshore waters, SMA	NOAA
U.S. Coral Reef Task Force (USCRTF)	Nearshore waters/coral reefs	NOAA
CFR §40 – Protection of Environment	Covers all EPA-regulated environmental programs, including water, sewage, pesticides, etc. Provides direction for the enactment of State and local laws.	EPA
CFR §33 – Navigation and Navigable Waters	Covers various aspects of Navigation and Navigable Waters as defined by the Army Corps of Engineers	USACE
STATE:		
HRS §12-174C	State Water Code- requires C&C to develop county water use and development plan (see RO §30)	DLNR- CWRM
HRS §12-180	Soil and Water Conservation Districts	DLNR
HRS §12-180C	Erosion and Sediment Control. Requires C&C to enact erosion/sediment ordinances	DLNR→ C&C
HAR §11-54	Surface water quality standards	DOH-CWB
HAR §11-55	Water Pollution Control (NPDES permits)	DOH-CWB
HAR §11-19	Emergency Plan for Safe Drinking Water	DOH-SDWB
HAR §11-20	Rules Relating to Public Water Systems	DOH-SDWB
HAR §11-21	Cross-connection & Backflow Control	DOH-SDWB
HAR §11-23/23A	Underground Injection Control (UIC program)	DOH-SDWB
HAR §11-25	Certification of Personnel at Water Treatment Plants	DOH-SDWB
HRS §19-340E	Drinking Water Regulations, Action Levels for Contaminants, Drinking Water Financing	DOH-SDWB
HAR §11-61 HRS §19-340F	Certification of Personnel at Wastewater Treatment Plants	DOH-WWB
HAR §11-62/62 appdx	Wastewater Systems (public treatment plants, on-site treatment such as septic tanks)	DOH-WWB
HRS §13-205A	Coastal Zone management, nearshore waters, SMA	DBEDT-Office of Planning
COUNTY:		
RO §14	Public Works Infrastructure- includes sewer/wastewater treatment systems, on-site wastewater treatment, storm sewer system	C&C-ENV, DDC (WWD)
RO §25	Special Management Area	C&C- DPP
RO §30	Water Management- based on State Water Code- 8 regional WMPs to make up the O‘ahu Water Management Plan	C&C- DPP, BWS

CFR = Code of Federal Regulations HAR = Hawai‘i Administrative Rules
HRS = Hawai‘i Revised Statutes RO = Revised Ordinances of Honolulu

2. Watershed Characterization

2.1. Physical and Natural Features

2.1.1 Watershed Boundaries

A watershed is a geographically defined area running from the mountains to the ocean, where all water, including rainfall and runoff drains to a common waterway, such as a stream or river [17]. In Hawaiʻi, each watershed eventually meets the ocean at the stream mouth. Watershed boundaries are defined by topographic features such as ridgelines and hills because rainfall on one side of a ridge will drain into a watershed on that side of the ridge, while the rain running down the other slope of the ridge will drain into an adjacent watershed. Often, each valley in Hawaiʻi is one watershed which can be subdivided into multiple sub-watersheds for each tributary feeding a stream. Any land-based activities with potential for polluting water, can potentially affect the waterways of that watershed and eventually its shoreline and beaches. Therefore, it makes sense to take a watershed-based approach to solving water quality/water flow and associated ecological problems [6]. The famous scientist and explorer John Wesley Powell once said:

> *"A watershed is that area of land, a bounded hydrologic system, within which all living things are inextricably linked by their common water course and where, as humans settled, simple logic demanded that they become part of a community."* [17]

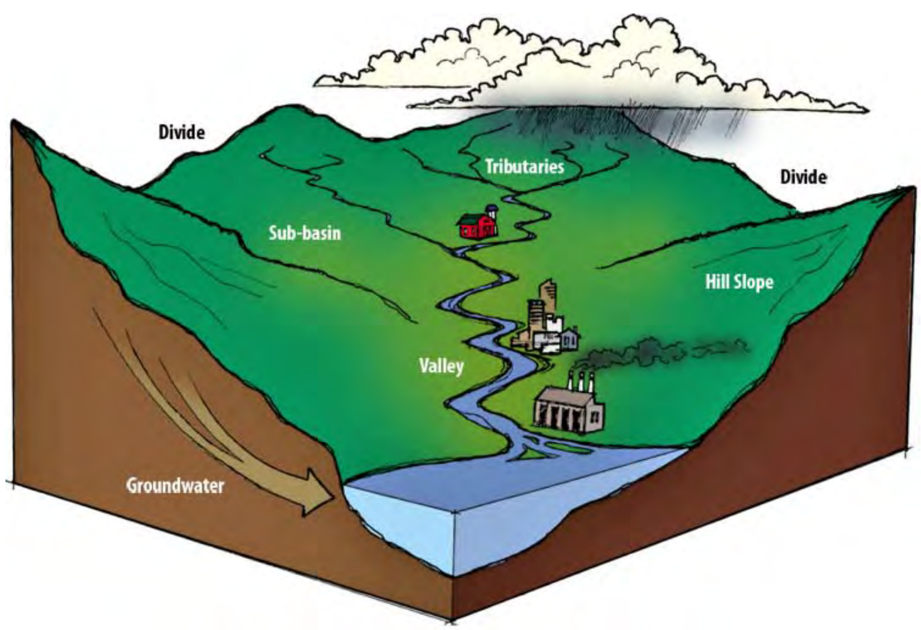


Figure 3. Watershed Conceptual Model. Source: University of Arizona [98]

This logic was already apparent to Native Hawaiians many centuries ago, where communities settled in a valley and engaged in agriculture, animal husbandry, aquaculture, fishing, and hunting/gathering. An ahupuaʻa is a subdivision of land usually running from the mountains to the ocean, where Native Hawaiians in ancient times practiced sustainable resource management on an ahupuaʻa level. In many cases, the ahupuaʻa boundaries were essentially the watershed boundaries because Hawaiians understood the connectedness between humans, land, and water. Some ahupuaʻa included several valleys or larger areas, but many ahupuaʻa boundaries are congruent with watershed boundaries [18].

Figure 4. Ahupuaʻa Illustration. Source: Deep Nature Connection [99]

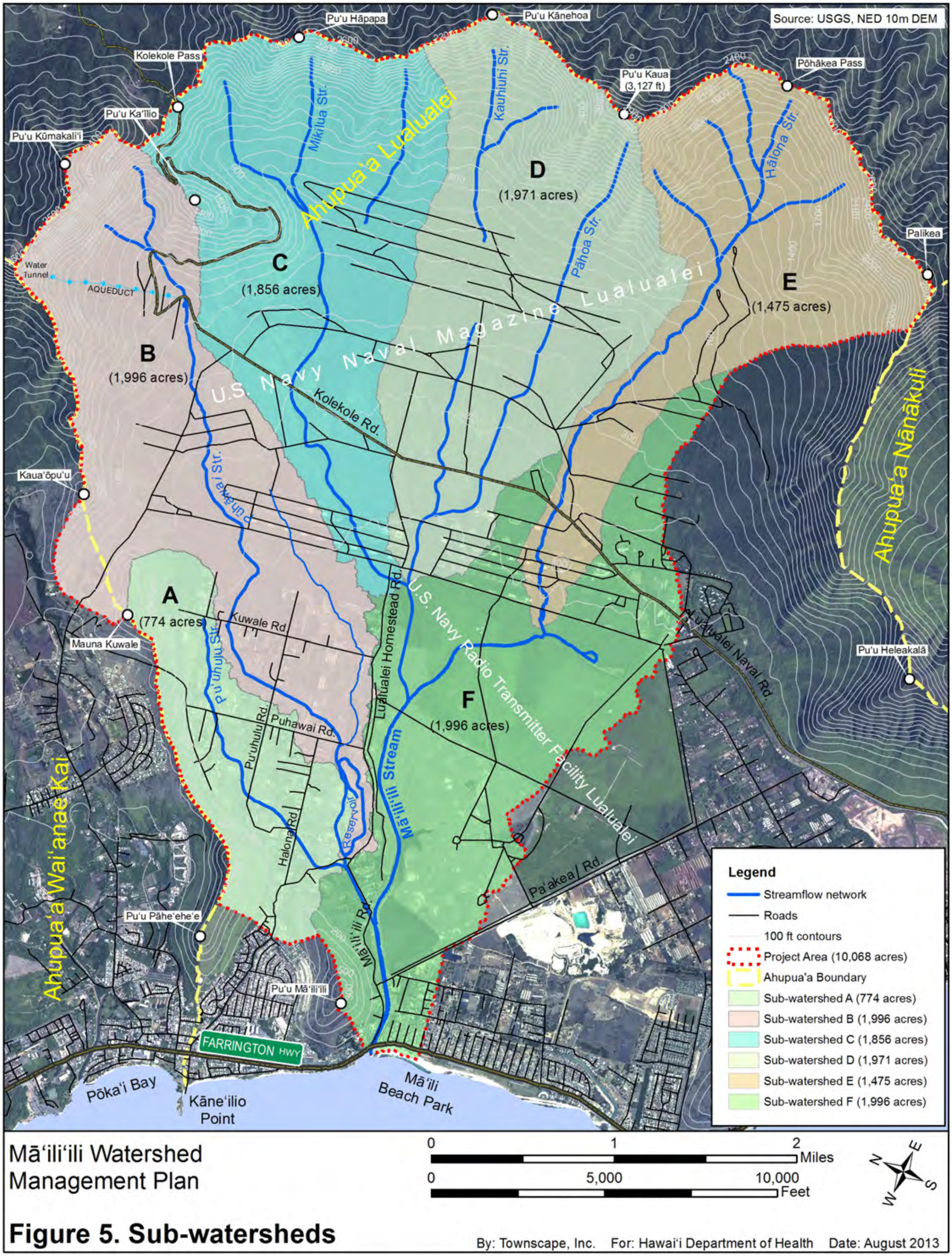


Figure 5. Sub-watersheds

2.1.2 Geology

The Hawaiian Islands emerged from volcanic eruptions in the Pacific Ocean with the movement of tectonic plates over an active hotspot. The only Hawaiian Island still over the hotspot is the Big Island, which is still growing due to the heavy volcanic activity from below. Oʻahu's two volcanoes (Waiʻanae and Koʻolau) started as two separate undersea volcanoes over 3 million years ago. With continued eruptions, the two mountains eventually joined to form the Island of Oʻahu [19]. The Waiʻanae mountains are the weathered remnants of the Waiʻanae shield volcano and contain the highest peak on the island, Mount Kaʻala (4,025 feet). Several million years of erosion created nine valleys in the Waiʻanae moku, characterized by steep valley walls and gently sloping valley floors and coastal plains [11]. The steep slopes of Lualualei Valley are part of the ancient caldera near Kolekole pass. This caldera was the center of volcanic activity, contributing lava flows through fissures several feet wide, which left behind many volcanic dikes. A large fault cliff protected the southwest slopes of the volcano from the lava flows, allowing streams to erode the valley walls, until the filled caldera overflowed into the valleys, creating several cinder cones. Therefore, the Waiʻanae landscape includes many prominent puʻu (peaks). The lava flows of the Waiʻanae Volcano are known as "Waiʻanae Volcanics" and contain different rock types, including icelandite and Mauna Kuwale rhyodacite. The multiple layers of lava flows make up the project area at higher elevations near the caldera and are approximately 2,000 feet thick. The lower elevations are made up of sedimentary rocks, mostly in the form of sand, mud and reef deposits from the ocean, including coral limestone close to the coast [1] [19] [20].

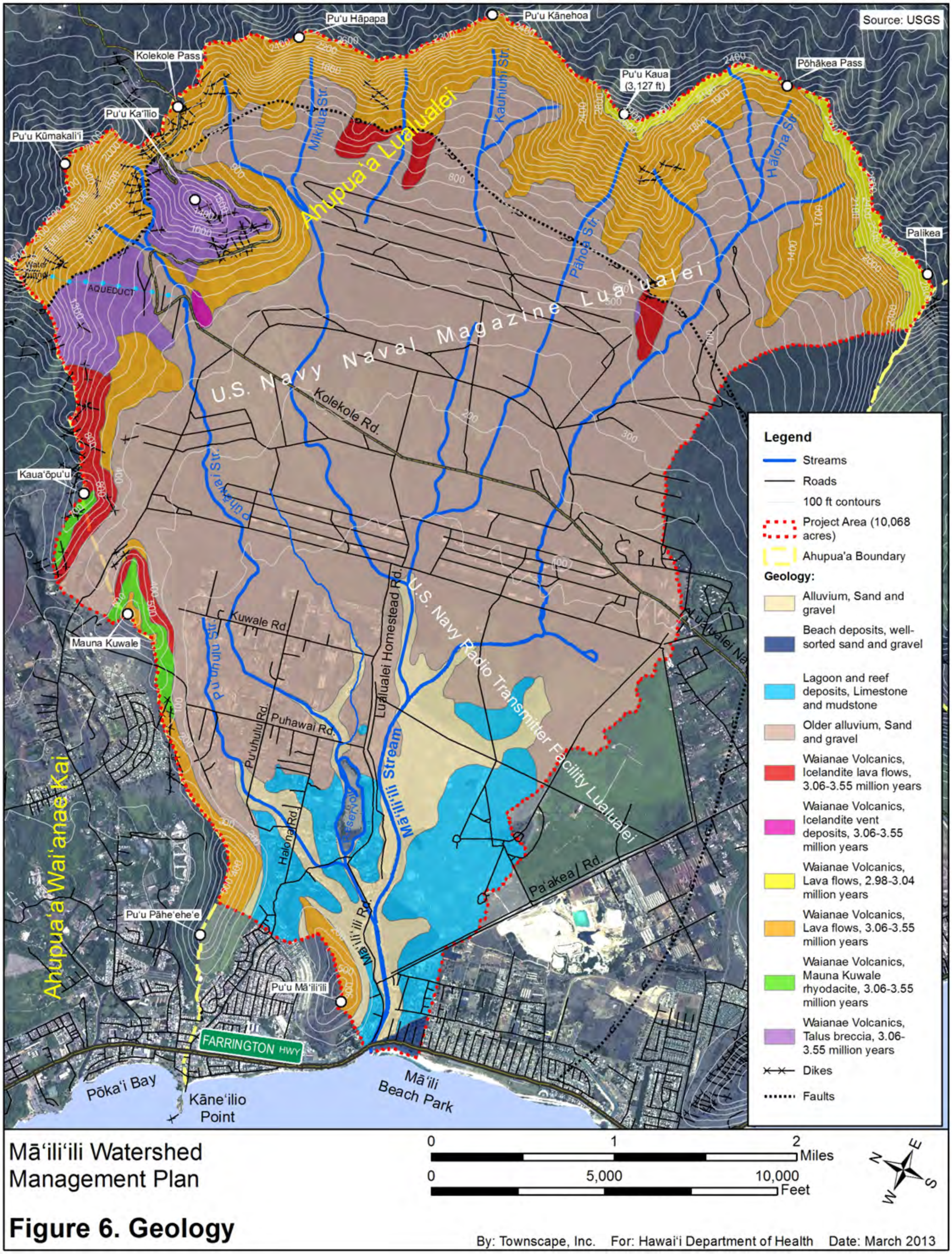


Figure 6. Geology

2.1.3 Soils [21] [22]

There are eight soil series throughout the Mā'ili'ili Watershed, which were formed from the volcanic processes (rocks and ash) described in the previous section. Approximately 3,197 acres of the project area are considered "Prime farmlands" by the Hawai'i Department of Agriculture, which designates "Agricultural Lands of Importance to the State of Hawai'i" (ALISH) [1]. Almost 80% of this prime farmland is located on Navy lands. The remainder is already under cultivation in the private neighborhood around Puhawai Road. Suitability for agriculture is further refined by the "Land Capability Classification" (LCC) provided by the USDA. The Major Land Resource Area (MLRA) designations from the Land Study Bureau (LSB) label areas from the shoreline to 500-700 foot elevation as "163- Alluvial Fans and Coastal Plains". The mauka areas are designated "166 – Very Stony Land and Rock Land". The soils in the project area are primarily clay soils and rock/stony land with low to moderate erodibility ratings. All soil types present in the watershed can be found in alphabetical order (of soil series) in Table 4. Colors correspond to the map. Notes on each soil type are found below the map.

Table 4. Soil Details

Symbol	Soil type	Slope	Erodibility	LCC *	Acreage	% of project area
	'Ewa series				**491**	**4.9**
EwA	'Ewa stony silty clay	0-2 %	Not highly erodible	2s/4s	12	0.1
EwC	'Ewa stony silty clay	6-12 %	Potentially highly erodible	3e/4e	479	4.8
	Hale'iwa series				**295**	**2.9**
HeA	Hale'iwa silty clay	0-2 %	Not highly erodible	2e/3e	176	1.7
HeB	Hale'iwa silty clay	2-6 %	Potentially highly erodible	2e/3e	119	1.2
	Kea'au series				**6**	**0.05**
KmaB	Kea'au stony silty clay	2-6 %	Potentially highly erodible	3w/5w	6	0.05
	Lualualei series				**4,379**	**43.5**
LuA	Lualualei clay	0-2 %	Not highly erodible	3s/6s	335	3.3
LuB	Lualualei clay	2-6 %	Potentially highly erodible	3e/6s	433	4.3
LvA	Lualualei stony clay	0-2 %	Not highly erodible	3s/6s	898	8.9
LvB	Lualualei stony clay	2-6 %	Not highly erodible	3e/6s	986	9.8
LPE	Lualualei extremely stony silty clay	3-35 %	Potentially highly erodible	NA/7s	1,727	17.2
	Mamala series				**446**	**4.4**
MnC	Mamala stony silty clay loam	0-12 %	Potentially highly erodible	3s/6s	446	4.4
	Mokulē'ia series				**56**	**0.5**
Mtb	Mokulē'ia clay	Level	Not highly erodible	3s/6s	56	0.5
	Pulehu series				**621**	**6.2**
PsA	Pulehu clay loam	0-3 %	Not highly erodible	1/4c	318	3.2
PuB	Pulehu stony clay loam	2-6 %	Potentially highly erodible	2e/4s	170	1.7
PvC	Pulehu very stony clay loam	0-12 %	Potentially highly erodible	NA/4s	133	1.3

Rock series					**3,757**	**37.3**
rRK	Rock land	All	Potentially highly erodible	NA/7s	2,532	25.2
rST	Stony land	5-40 %	Potentially highly erodible	NA/7s	1,140	11.3
rTP	Tropohumults Dystrandepts association	30-90 %	Highly erodible	NA/7e	85	0.8

*The listed land capability classifications (LCC) are listed as irrigated/non-irrigated

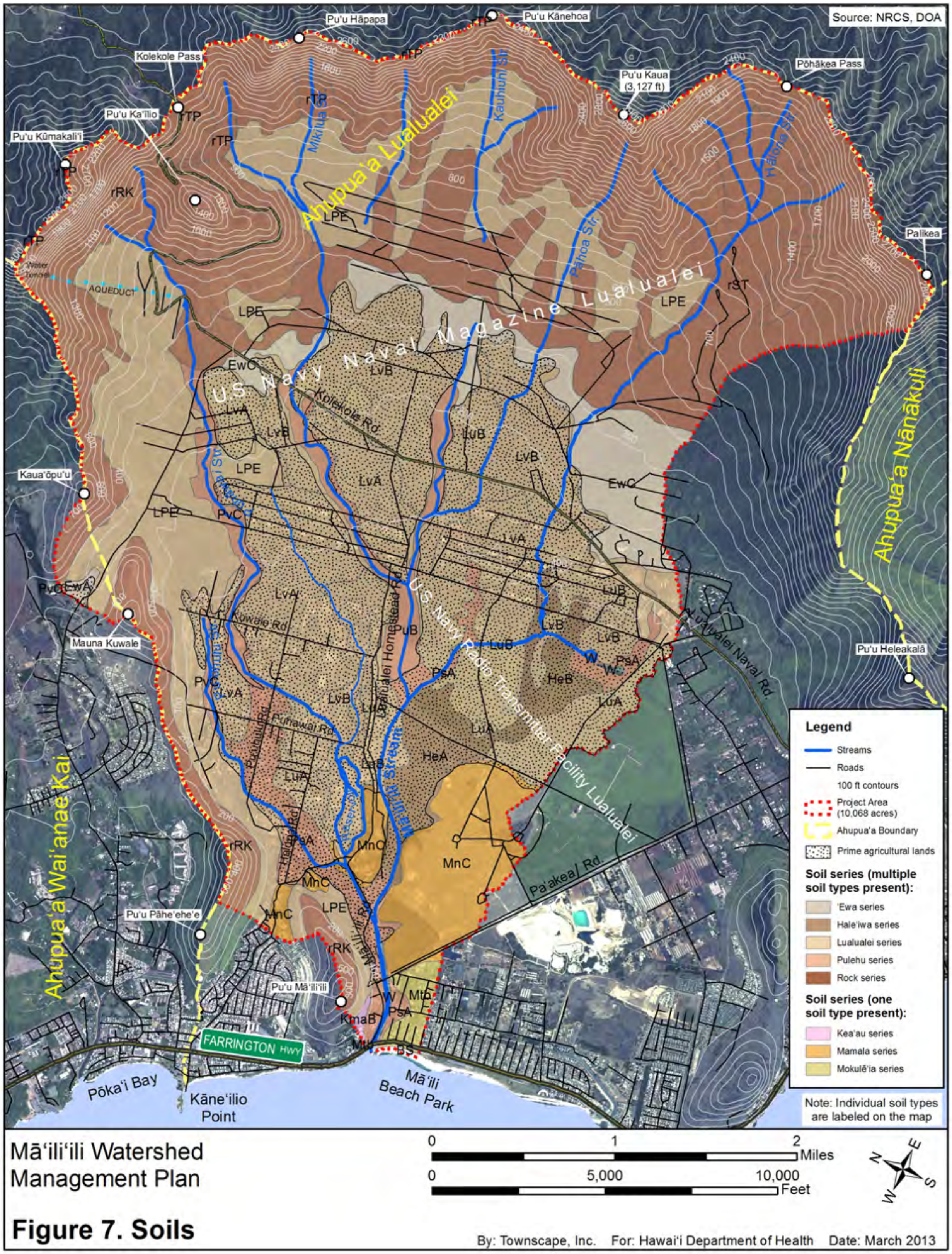


Figure 7. Soils

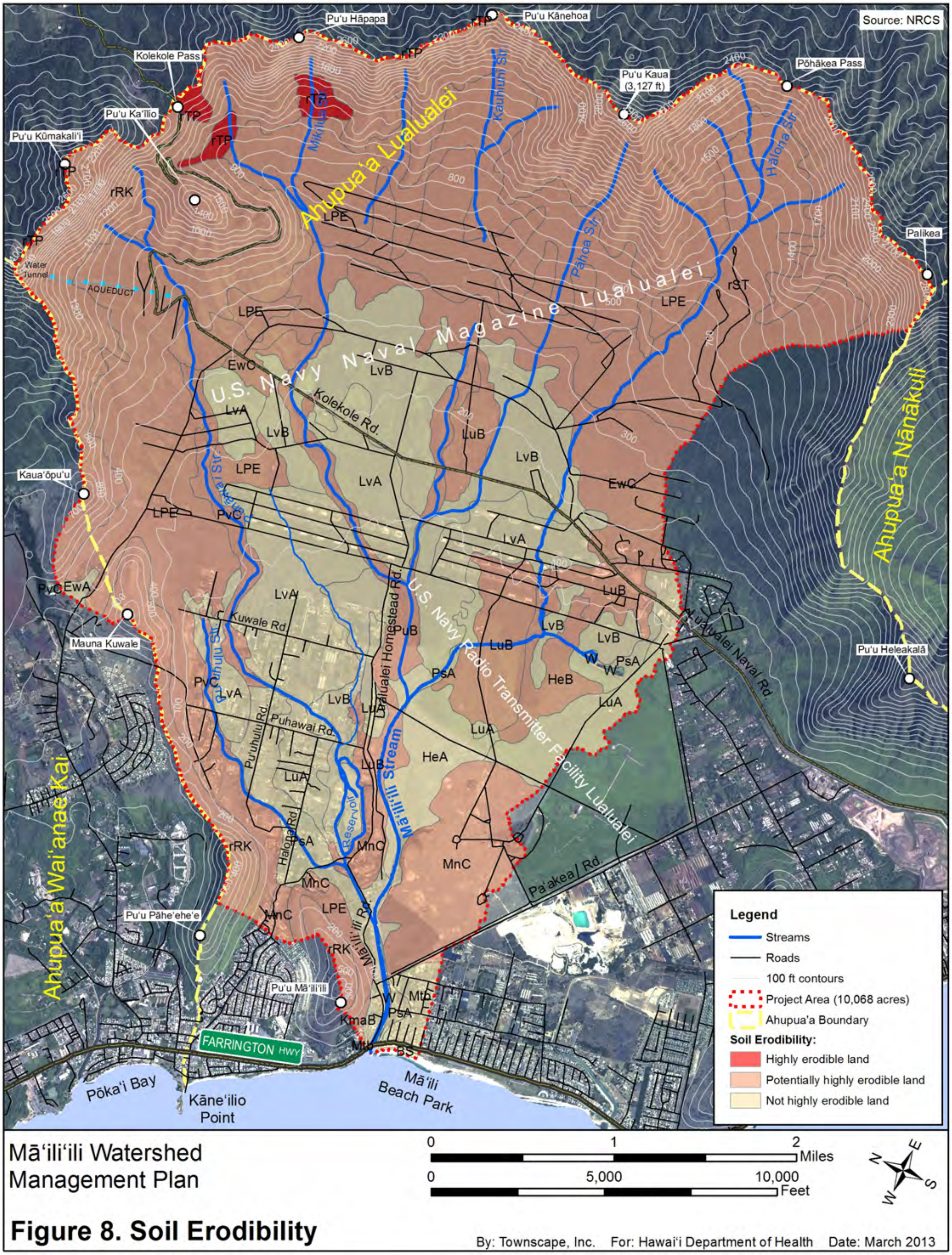


Figure 8. Soil Erodibility

The following detailed descriptions of the soils are in order from largest to smallest acreage present in the Māʻiliʻili Watershed.

Lualualei series:

This series contains fine, deep and well-drained clay soils that are found at low elevations and gentle slopes in areas with low rainfall. They are suitable for sugarcane and truck crop cultivation, pasture land and development. This series is found on several Hawaiian Islands. It makes up 43.5 % of the project area and is found throughout the watershed, mostly at the lower elevations.

LuA and LuB (Lualualei clay): This very sticky clay soil is found on alluvial fans and is underlain by coral, gravel or sand. When dried, it displays wide cracks. Runoff and permeability are slow and the erosion hazard is said to be "no more than slight" for LuA and "slight" for LuB.

LvA and LvB (Lualualei stony clay): This soil is associated with proximity to drainage ways and has similar characteristics as Lualualei clay. The difference is the abundance of stones in the soil, which makes it difficult to use machines for cultivation.

LPE (Lualualei extremely stony silty clay): This soil type, also similar to Lualualei clay, is found on the steeper slopes. It contains so many stones on the surface and throughout the profile that cultivation is impractical. It can be used for pasture, however. Runoff is medium to fast and the erosion potential is moderate to severe due to the slope.

Rock/stony land:

Soil types whose symbols start with an "r" are distinguished individually. This "series" contains all the different rocky, stony and sandy land types, including "rough broken land", "rubble land", etc. There are three types of "r" soils in the Māʻiliʻili Watershed, covering roughly 37 % of the project area.

rRK (Rock land): This land type can be found on all Hawaiian Islands and contains any land, where exposed rock covers 25-90 % of the surface. The rock outcrops are mainly basalt and andesite, which are separated by very shallow soils. This type of land is not suitable for cultivation, but can be used for pasture and wildlife habitat.

rST (Stony land): This land type, found on the sides of drainages and valleys on Oʻahu, consists of large boulders and stones, covering 15-90 % of the surface. The boulders are deposited by water and gravity and are separated by silty clay loam soils that usually allow for some plants to root. This land type is not suitable for agriculture, but can be used for wildlife habitat and recreational activities.

rTP (Tropohumults-Dystrandepts association): Areas mapped as "rTP" are found specifically in mountainous areas throughout the Waiʻanae Mountain Range. They contain three different soils, Tropohumults, Dystrandepts and some Histosols. Tropohumults are found on narrow ridges at high elevations and are well-drained acidic soils. Sometimes this reddish-brown silty soil is covered in a hard purplish crust where vegetation is absent. Dystrandepts are dark-colored medium acid soils found on steep slopes and narrow ridges at lower elevations. Most of this association is very steep and not accessible and is generally unsuitable for agriculture.

Pulehu series:

This soil series contains fine well-drained silt and clay soils found on alluvial fans, stream terraces and basins. They are suitable for growing sugarcane, truck crops, pasture and for building housing. There are three types of Pulehu soils in the Māʻiliʻili Watershed, covering about 6.2 % of the watershed.

PsA (Pulehu clay loam): This clay loam soil is found at gentle slopes along the lower reaches of Māʻiliʻili Stream and its tributaries. It is moderately permeable with a slow runoff rate. It is highly suitable for agricultural crops and the erosion hazard is said to be "no more than slight".

PuB (Pulehu stony clay loam): This soil is similar to PsA, but contains enough stones to make tilling the soil difficult. Apart from the stones, it is still a highly capable soil for intertilled crops. The runoff rate is slow and the erosion hazard slight.

PvC (Pulehu very stony clay loam): This soil is also similar to PsA, but contains enough stones to make the workability very difficult. It is typically used for pasture and wildlife habitat. The runoff rate is slow to medium and the erosion hazard is slight to moderate, depending on the slope.

ʻEwa series:

This series includes well-drained, moderately permeable clay and clay loam soils formed from alluvium after volcanic processes. These soils are mostly found on the NAVMAG installation and cover roughly 5 % of the project area. ʻEwa soils are generally considered excellent for growing a variety of agricultural crops, although the types present here are stony. Two ʻEwa soils are present in the watershed, the only difference between them being the slope.

EwA and EwC (ʻEwa stony silty clay): Most of the ʻEwa soil in the project area is EwC, which differs from EwA based on slope. While EwA is considered good for agriculture, but not easily tillable, EwC is suitable for pasture. The runoff rate of EwA is very slow and the erosion hazard low. EwC has a slow to medium runoff rate with a slight to moderate erosion hazard.

Mamala series:

Mamala soils are shallow well-drained soils found on coastal plains because they formed over coral limestone and calcareous sand. They can be found at low to moderate slopes and in the Māʻiliʻili Watershed, are mostly found on the Navy RTF installation, covering roughly 4.4 % of the total project area at low elevations.

MnC (Mamala stony silty clay loam): This moderately permeable clay loam soil is stony, but still considered good for agricultural crops, including sugarcane, truck crops, orchards and pasture grass. The runoff rate is very slow to moderate, depending on the slope, and the erosion hazard is slight to moderate.

Haleʻiwa series:

This series occurs along coastal plains and contains deep and well-drained soils. These fine soils only cover about 3 % of the project area, all on Navy lands. They are excellent agricultural soils and can be found at level to very high slopes. Two Haleʻiwa soils are present at the Navy RTF.

HeA and HeB (Haleʻiwa silty clay): HeA is a moderately permeable soil that is deep enough to allow plants to root to depths of over 5 feet. It is sometimes subject to non-damaging overflow. It is suitable for sugarcane, pasture and truck crops. The runoff rate is very slow and erosion hazard low. HeB has a slow runoff rate and slight erosion hazard. In addition to the typical crops, it is also suitable for pineapple cultivation.

Mokulēʻia series:

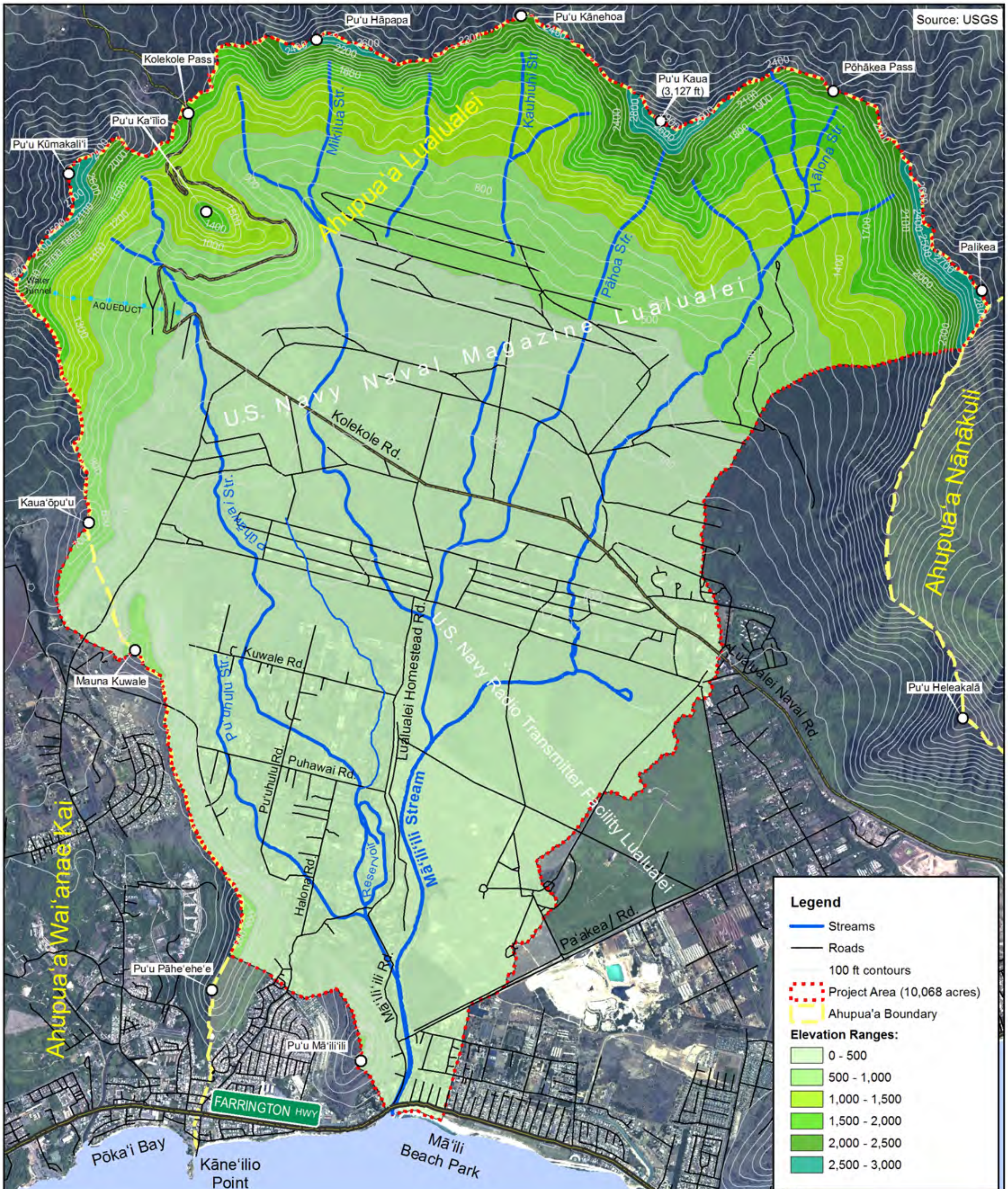
The project area contains a small pocket of Mtb (Mokulēʻia clay) in the residential area just makai of Paʻakea Road. This soil has a low permeability and is extremely sticky, making it difficult to work with, but it is suitable for sugarcane and pasture. The runoff rate is very slow and erosion hazard low and it is typically found at level to very gentle slopes.

Keaʻau series:

There is a very small pocket of KmaB (Keaʻau stony silty clay) in the project area on the slopes of Puʻu Māʻiliʻili. This deep, poorly drained soil is stony enough to hinder machine cultivation. The runoff rate is slow and the erosion hazard slight.

2.1.4 Topography

Lualualei is a large and gently sloping valley compared to other ahupuaʻa on Oʻahu. The very gently sloped valley floor with a 0-5 percent gradient reaches over three miles inland from the shore and the mouth of Māʻiliʻili Stream from sea level to only 100 foot elevation. Between the 100 foot and 400 foot contour, the slope increases slightly for about 1.5 miles before reaching the base of the mountains. From here, the slope gets gradually steeper. At the back of the valley, the very steep slopes of the Waiʻanae Mountain Range have nearly vertical cliffs (see Figures 9 and 10). The highest point in the watershed is Puʻu Kaua, the third highest peak on Oʻahu at 3,127 feet. The watershed is bounded by several other prominent peaks, including Mauna Kuwale (855 ft) to the north, Puʻu Kūmakaliʻi (2,880 ft) to the northeast, Puʻu Hāpapa (2,883 ft) and Puʻu Kānehoa (2,728 ft) to the east and Palikea (3,098) to the southeast (1) (8).



Mā'ili'ili Watershed Management Plan

Figure 9. Elevation (feet)

By: Townscape, Inc. For: Hawai'i Department of Health Date: March 2013

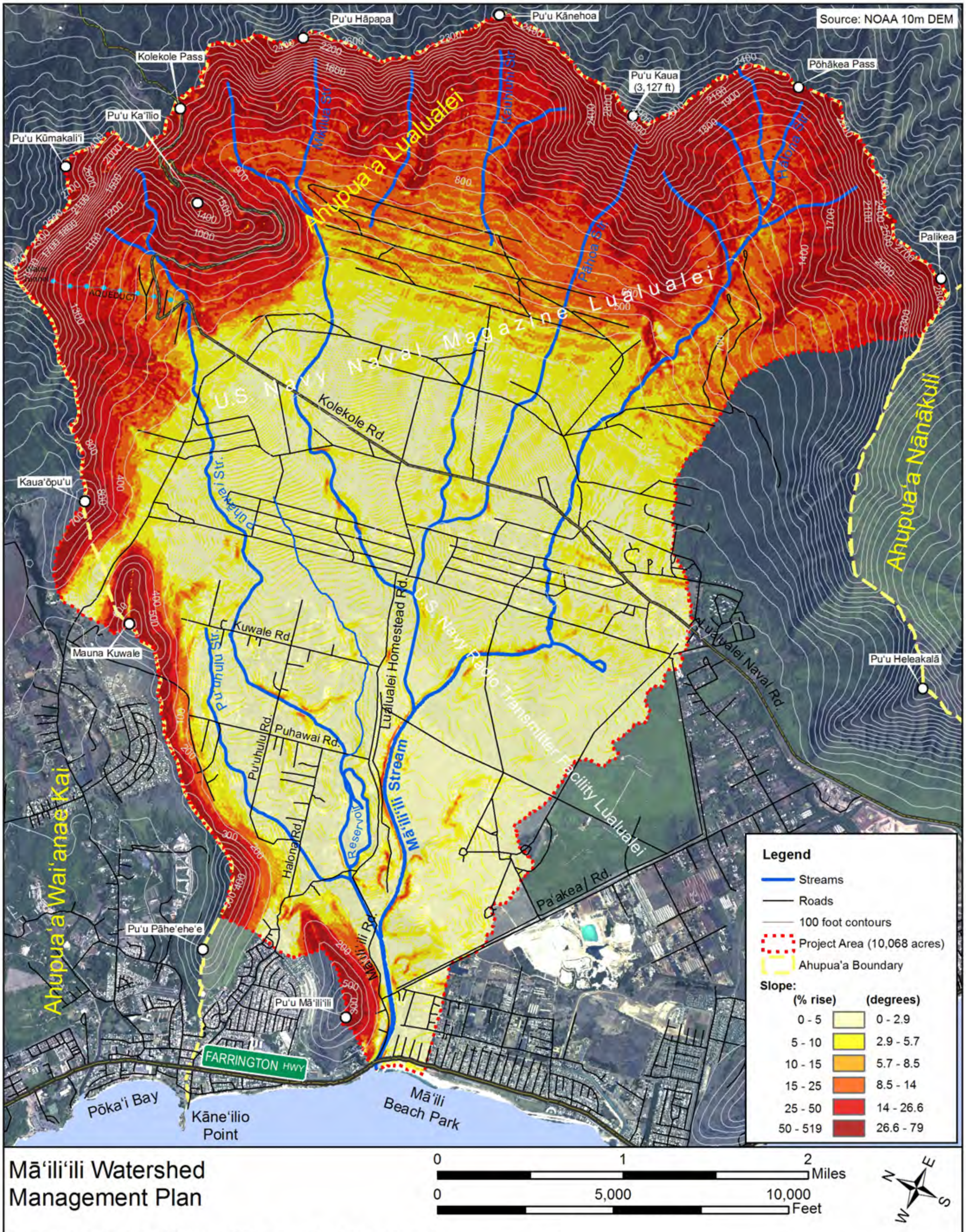


Figure 10. Slope (% and degrees)

2.1.5 Climate

The climate in the Hawaiian Islands is mainly influenced by the characteristic northeasterly tradewinds, which carry with them moisture picked up over the ocean. These winds and moisture hit the windward sides of each island first, creating clouds and sometimes heavy rainfall there, before moving towards the drier leeward sides [(18)]. Climatic conditions in the Māʻiliʻili Watershed are typical for leeward areas. The amount of rainfall in the Waiʻanae Mountain Range is much lower than in the Koʻolau Range, resulting in a hot, sunny, and dry climate on the coast and somewhat wetter conditions at higher elevations. The average annual rainfall in the project area ranges from 21 inches at the coast to 50 inches at the summit of Puʻu Kūmakaliʻi. In comparison, on the windward side of Oʻahu, it is not unusual for coastal areas to experience 50 inches of rain per year and mountainous areas up to 279 inches per year. On average, the wettest month in the watershed is January and the driest month is July [(23)].

Coastal areas have low temperatures of 59 °F in the winter and 67 °F in the summer and high temperatures of 79 °F in the winter and 87 °F in the summer. The coolest months are January and February; the hottest months are August and September. Data on climate change indicate that the future climate in this area will likely be hotter and drier [(11)].

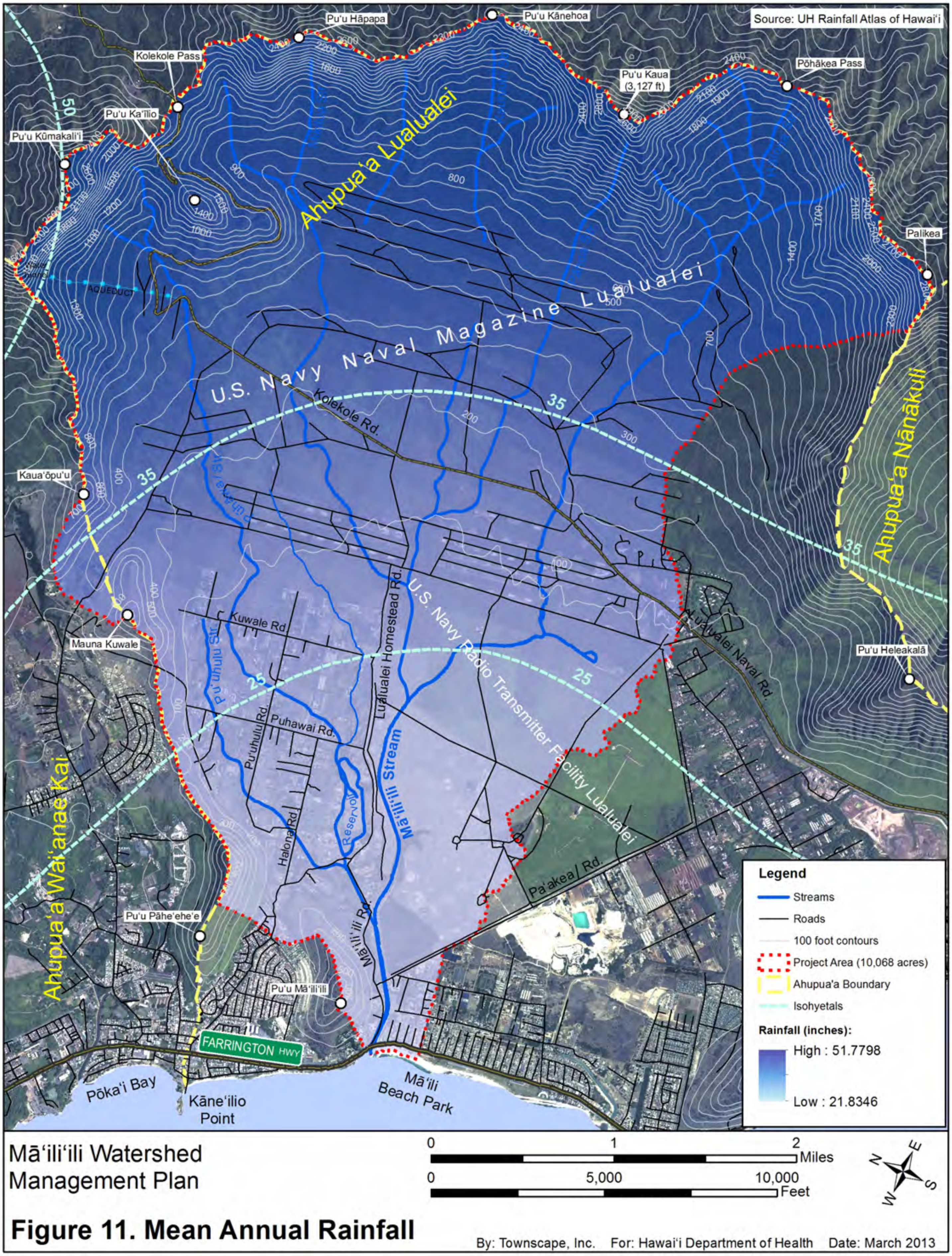


Figure 11. Mean Annual Rainfall

2.1.6 Surface and Groundwater Hydrology

Hydrology is the science and study of the movement, quality, and distribution of water over a geographic area, e.g. a watershed. The hydrologic cycle (or "water cycle") is the foundation for understanding both surface and groundwater hydrology. The hydrologic cycle is an ongoing process proceeding endlessly, regardless of the presence or absence of human beings. Rainfall and other precipitation falls onto the land, where it is taken up by trees and other vegetation. Some of it infiltrates the soil and re-charges groundwater, some of it evaporates back into the atmosphere, and the rest flows over land as runoff, enters streams and other water features and ultimately discharges into the ocean. The evaporation from the ocean and the land once again forms clouds and the cycle continues. Although the cycle is endless and not dependent on humans, human activity can significantly alter the hydrologic cycle. For example, changes in land use and vegetation and the creation of impervious surfaces can drastically change runoff patterns and infiltration rates [(24)].

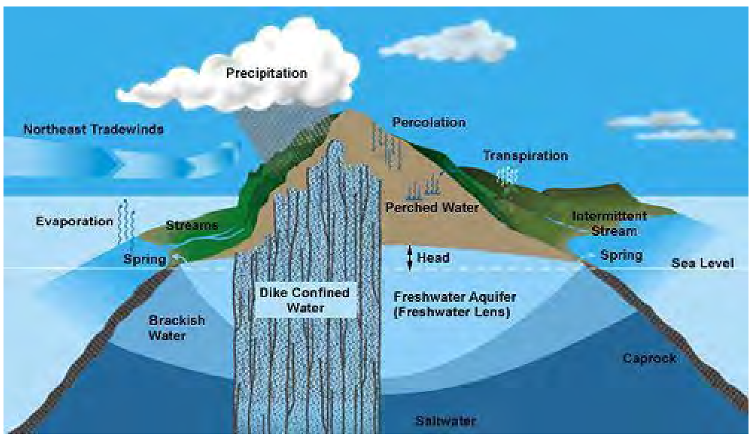


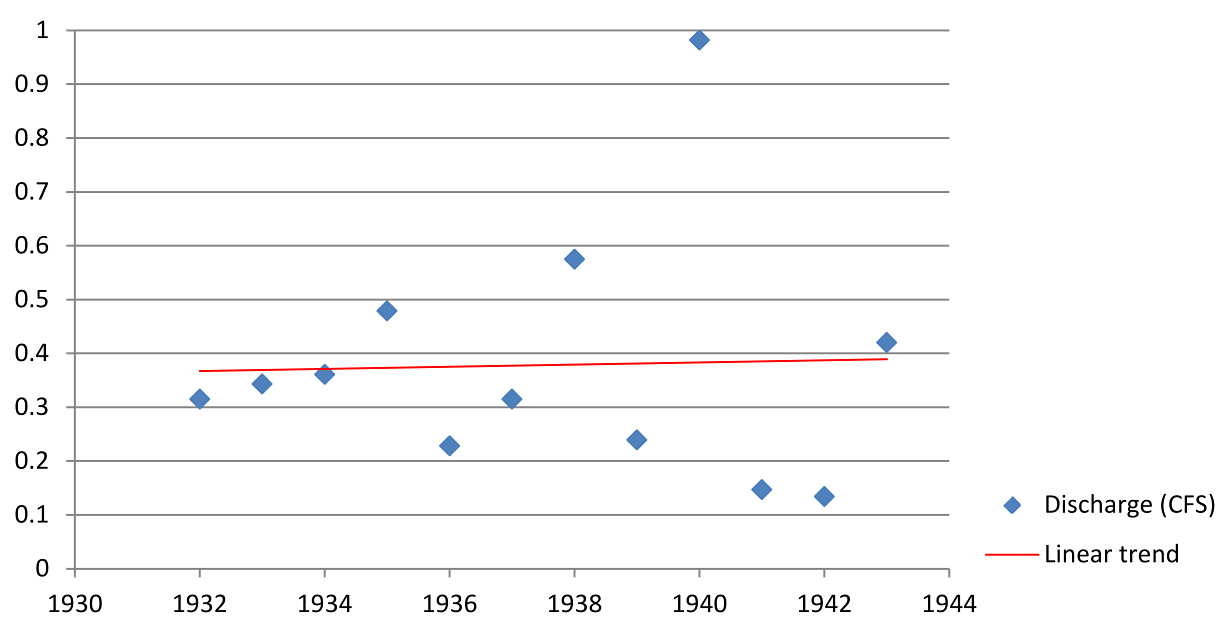
Figure 12. The Hydrologic Cycle. Source: BWS [(111)]

The Māʻiliʻili Stream drainage basin is about 10,068 acres in size. Māʻiliʻili Stream has a drainage network of multiple tributaries. The main stem has a flow length of about 6.97 miles. The entire drainage network has a total length of about 20.9 miles, most of which flows through U.S. Navy lands. The lower reaches of the stream have been channelized with concrete to mitigate flooding issues. Since Hawaiian watersheds are subject to sudden intense rainfall, combined with the nature of the topography (very steep slopes), flash flooding occurs frequently, causing very fast changes in stream flow, which can cause not only flooding, but sudden, natural and temporary reductions in coastal water quality. This is why the ocean frequently looks brown after a storm or has elevated bacteria levels. Channelizing streams for flood control was a very common practice in the 1960s and 1970s. However, this practice brings with it a myriad of environmental problems. The alteration of the streambeds and banks with concrete are destructive to habitats, causing declines in aquatic species. The high velocity at which rainwater enters the ocean through concrete channels can increase the levels of trash, nutrients and other pollutants [14].

The streams in the project area are classified as "intermittent", meaning they don't flow year-round, but only after it rains. This is typical for streams on leeward sides of islands. Streams on windward sides are typically perennial due to the high amount of rainfall [25]. There is anecdotal evidence that streams in the Wai'anae moku may have been perennial at some point. Human activity such as growing sugarcane and other crops has historically reduced streamflow in Hawai'i due to the creation of stream diversions for irrigation. Some evidence suggests that excessive groundwater withdrawals may impact streamflow as well. There have been some reports that the Navy may have diverted the stream somewhere on its land, but this was not verifiable.

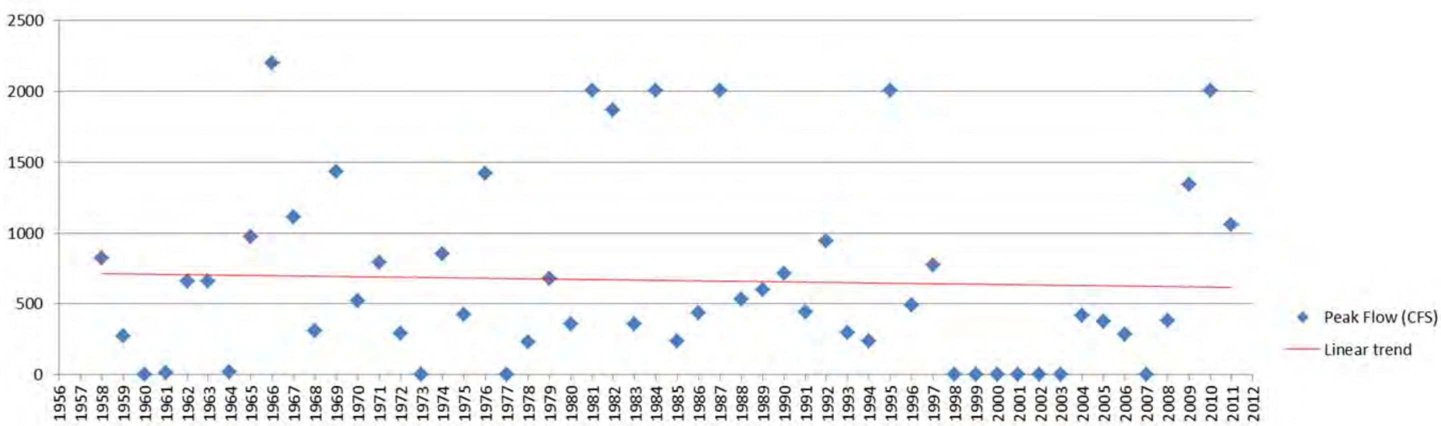
There are only two stream gages in this watershed in the upper reaches of two of the tributaries (USGS station 16212000 at Pūhāwai Stream and USGS station 16212200 at Mikilua Stream, see Figure 15). The stream gage data at Pūhāwai Stream collected daily discharge data (average daily flow) from 1930-1944 and annual statistics starting in 1932. The data suggests that during that time period, there was ongoing, very light flow at the location of the gage. When Townscape conducted field work on the Navy lands, light flow was observed slightly upstream of this old gage. See the graph below (Figure 13) for details on data collected at this station. In this graph, the daily discharge rates were further averaged by year because the total number of data points for daily discharge amounted to over 5,000 [26].

Figure 13. Average Daily Discharge by Year (in CFS) at USGS gage 16212000 (Pūhāwai Str.)



The stream gage at Mikilua Stream collected peak flow data from 1958-2011. Peak flow is the maximum flow rate a stream reaches after a rainfall event. This type of data is useful for flood planning, but does not help understand daily conditions and can therefore not be used to compare to daily discharge rates. The graph below (Figure 14) shows peak flow trends recorded at this station, averaged by year. Note that this is an average based on the measurements taken and does not take into consideration the amount of rainfall at each rain event. Looking at numbers for individual peak flow measurements can be more useful, but would require many individual graphs. Unfortunately, daily discharge data is not available from this particular gage [26].

Figure 14. Average Annual Peak Flow (in CFS) at USGS gage 16212200 (Mikilua Stream)



Due to the lack of additional stream gages, peak flows for the main stream and other tributaries after rainfall events are not entirely known. Peak flow estimates were modeled for the Lualualei Flood Study in 2001 using the HEC-1 model. Peak flow for the Māʻiliʻili Stream basin during a 5-year rainfall event was estimated at 2,934 cfs. The results for a 10-year, 50-year, and 100-year rainfall event were 5,021 cfs, 13,251 cfs, and 17,678 cfs respectively (2).

The groundwater aquifers in the Waiʻanae moku are recharged by rainfall and fog drip. The Lualualei Aquifer, an unconfined freshwater dike aquifer with a high level of vulnerability to contamination, has a sustainable yield of 4 million gallons per day (MGD) [1]. Waiʻanae does not have enough of its own groundwater resources to fill the demand, so about half of the district's potable water is imported from the adjacent Pearl Harbor Aquifer Sector. The majority of potable water used in Lualualei is for residential purposes and agriculture. About 90% of potable water in Waiʻanae is provided by the Board of Water Supply (BWS). There are many private groundwater wells in the area as well, but many of them are brackish. The potable water demand is projected to increase in Waiʻanae, by about 2 MGD by the year 2030 [11]. Groundwater resources are protected by the State's Underground Injection Control Program, which limits underground injection wells based on the status of the underlying aquifer as a drinking or non drinking water aquifer. Areas makai of the UIC line allow for a wider variety of wells, while areas mauka of the UIC line have stricter limitations to prevent groundwater contamination [1]. Similarly, the pass and no pass zones established by the Board of Water Supply prohibit installation of waste disposal facilities in areas mauka of the boundary line [27] (see Figure 15).

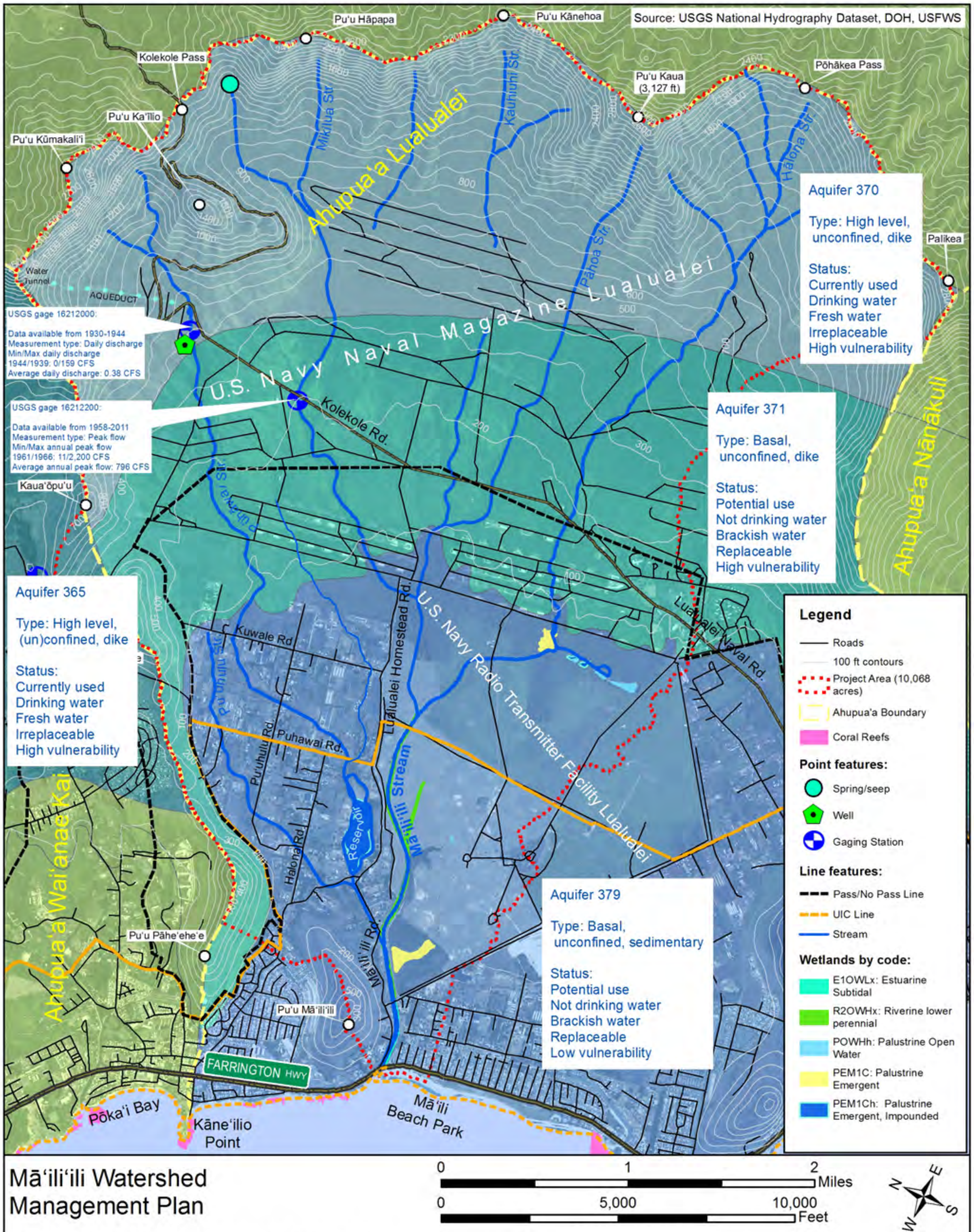
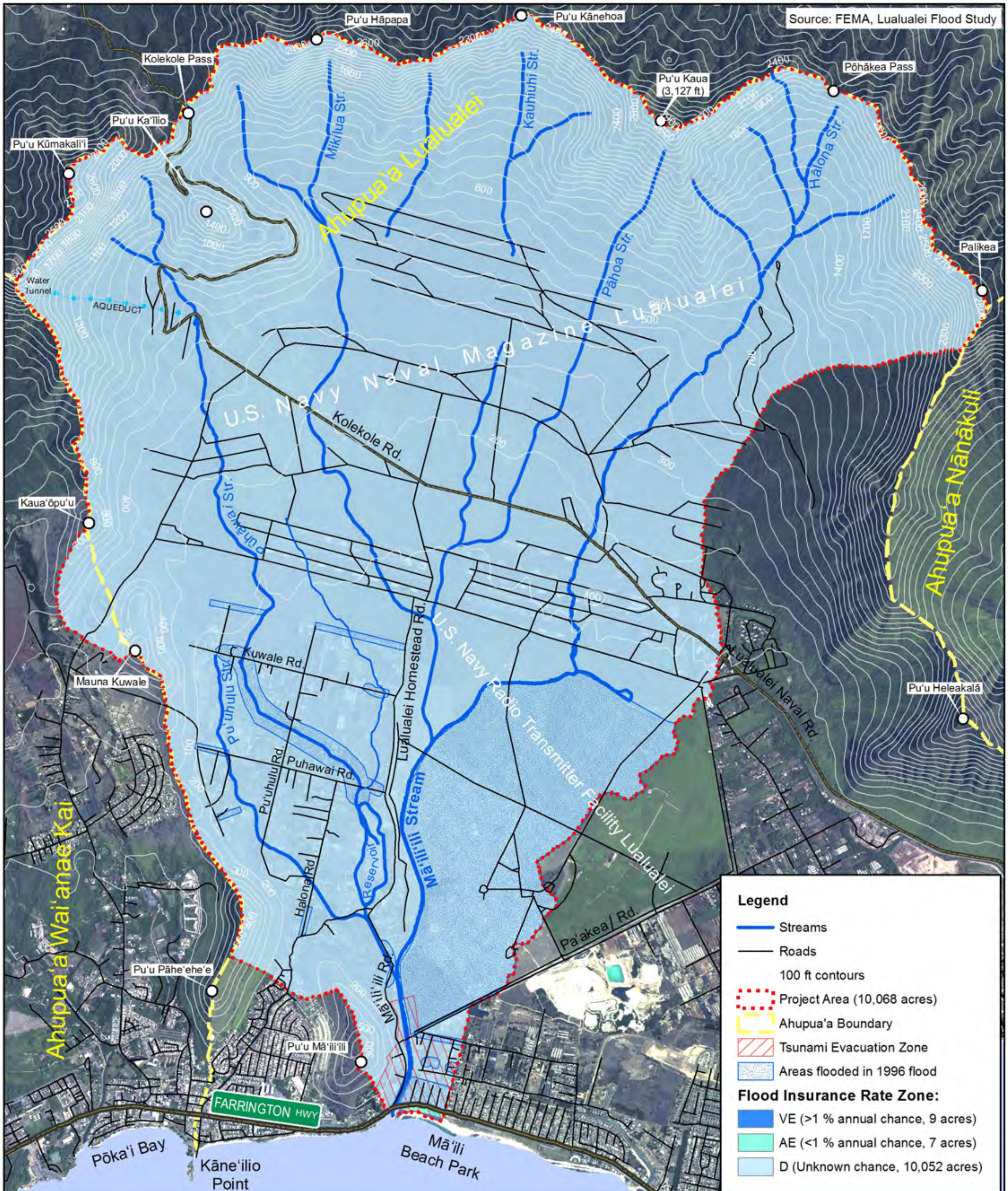


Figure 15. Hydrographic Features

2.1.7 Hazard Areas: Flooding and Fires

Areas subject to coastal flooding or tsunami inundation are identified on Flood Insurance Rate Maps provided by the Federal Emergency Management Agency (FEMA) for the National Flood Insurance Program. Insurance rates are based on flood probability. The project area contains three different flood hazard zones. Approximately nine acres at the mouth of Māʻiliʻili Stream along the beach are designated as "VE" with a 1% or greater annual chance of flood, a 26% chance of flooding over the course of a 30-year mortgage and a base flood elevation of 14 feet. Just mauka of the VE zone are about seven acres of zone "AE", with a 1% annual chance and 26% chance of flooding over the course of a 30-year mortgage. The remainder of the watershed is designated as zone "D", for which the probability has yet to be determined, but due to flood events of the past, it is known that many of the residential and agricultural areas have a relatively high risk. The tsunami inundation area extends about 3,500 feet inland from the shoreline and the mouth of the stream channel [1] (See Figure 16).

Due to the arid climate and vegetation types, the fire risk throughout most of the valley is extremely high, with much of the watershed considered "Fire Regime Group 1", with a 35 year fire return interval for low and mixed severity fires [28] (see Figure 17).



Mā'ili'ili Watershed Management Plan

Figure 16. Flood Zones

By: Townscape, Inc. For: Hawai'i Department of Health Date: March 2013

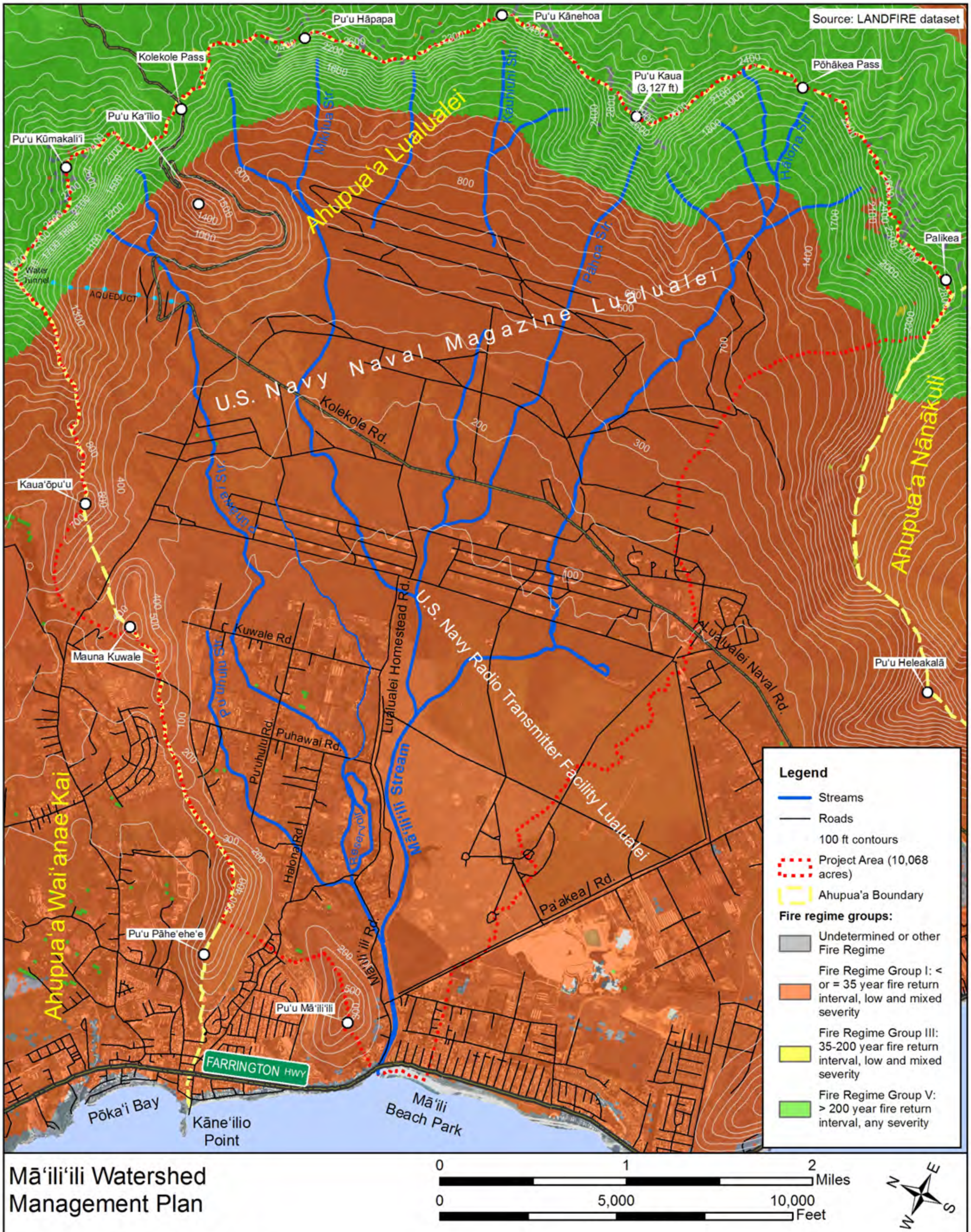


Figure 17. Fire Risk

2.1.8 Biological Resources

Most of the project watershed is covered with non-native forest, grass and shrubland (see Figure 22 on pg. 65). There are some spread out and some isolated areas of native vegetation in the mountains. Table 5 shows the acreages and percentages of land cover as identified by the USGS GAP analysis program.

Since most of the watershed is under military control, there are no public hunting areas. The upper reaches of the watershed, where some native vegetation is still present amongst invasive species such as strawberry guava, contain 1,388 acres of designated “critical habitat” for 25 native and endangered plant species. Somewhat overlapping with the critical plant habitat are 1,623 acres of critical habitat for the endangered endemic ‘elepaio bird. The density of threatened and endangered plants is low throughout the lower reaches of the watershed and increases in the mauka areas. The critical habitat areas have a “very high” density of threatened and endangered plants, according to DOFAW maps [(1)] (see Figure 18).

Consultations with community stakeholders revealed a dramatic decline in marine and stream aquatic species over the course of older residents’ lifetimes. The concrete channelization of streams can wreak havoc on aquatic freshwater ecosystems. Despite the concrete, some native freshwater organisms such as Samoan crabs, mullet (‘ama‘ama) and the Hawaiian flagtail (āholehole) were observed during a biological reconnaissance survey conducted by AECOS [(13)]. This survey also discovered nesting pairs of the endangered Hawaiian stilt (ae‘o).

There are several wetland areas in the watershed, including the lower reaches of the Mā‘ili‘ili Stream channel and a constructed wetland known as Niuli‘ii Pond at the Navy RTF installation. This wetland was used for treatment of sewage effluent from the Navy installations when there was military housing on site. Now that the bases are mostly uninhabited, there is not enough effluent available and the pond is fed with additional potable water. This wetland is a protected area and is home to a variety of water birds.

The US Navy is implementing an Integrated natural Resource Management Plan on both Naval installations. Activities implemented under this plan include predator control (rodent trapping) for the benefit of nesting birds; protected species monitoring for a variety of endangered birds, snails and arthropods; ongoing botanical surveys and conservation mapping; tagging of endangered plants; feral ungulate control and more [(29)]. The Navy lands and the adjacent Forest Reserve have ongoing problems with feral pigs and goats. Since the public is not able to access the land to hunt, the Navy engages in occasional hunting by helicopter as the steep cliffs are inaccessible on foot. One part of the management recommendations under consideration by the Navy is to allow for public hunting on certain days to benefit local hunters as well as the environment [(29)].

The Navy also has four designated "Special Management Areas" in their Lualualei lands. These were selected based on numbers of native plants, animals, and endangered taxa.

The four SMA's are as follows:

Puʻu Hāpapa: 30 acres, contains one fenced endangered plant enclosure to keep out ungulates. Contains 3 types of habitat: lower unit with 90% native vegetation; upper unit with 50-60% native; cliff faces with high percentage native. The exclosure is in the lower unit and provides habitat for 10 endangered species.

Hālona Valley: 280 acres of mostly Christmas berry. There are patches up to 1 acre containing 50-60% natives. It contains an enclosure to protect a small forest of native trees from ungulates.

Puʻu Kaua: 125 acres, mostly on vertical cliffs. Below the cliffs is mostly koa haole and kukui. Some pockets of native trees provide habitat for seven endangered plants.

Puʻu Kāʻilio: 247 acres, mostly alien vegetation with koa haole and prickly-pear cactus. Some areas have native dryland plants and shrubs. Habitat for 3 endangered species.

Table 5. Land Cover Types [1] (see map, Figure 22 on page 63)

Land Cover	Acreage	% of Watershed
Agriculture	351	3.5
Alien Forest	1,040	10.3
Alien Grassland	2,186	21.7
Alien Shrubland	2,883	28.6
Closed ʻŌhiʻa Forest	3	0.03
High Intensity Developed	41	0.4
Kiawe Forest and Shrubland	1,672	16.6
Low Intensity Developed	1,458	14.5
Mixed Native-Alien Forest	351	3.5
Mixed Native-Alien Shrubs and Grasses	21	0.2
Native Shrubland/ Sparse ʻŌhiʻa	2	0.02
Open ʻŌhiʻa Forest	23	0.2
Open Water	18	0.2
Uluhe Shrubland	1	0.01
Very Sparse Vegetation to Unvegetated	18	0.2

2.1.9 Cultural Resources

Lualualei Valley contains many remnants of pre-contact Hawaiian culture, including a coastal trail, terraced fields formerly used to grow kalo and ‘uala (taro and sweet potato) as well as multiple heiau and habitation sites. Many of these sites are located on military lands, thereby denying access to the public. Some people argue that this has actually saved cultural sites from the challenges of development because the military installations are largely undisturbed. Any potential transfer of the military lands in the future could put these cultural sites at risk. Part of this watershed plan included an analysis of historic sites in the valley by UH archaeology professor Dr. Ross Cordy. His detailed report (“Overview of historic properties in the Māʻiliʻili drainage of Lualualei”) can be found in Appendix B.

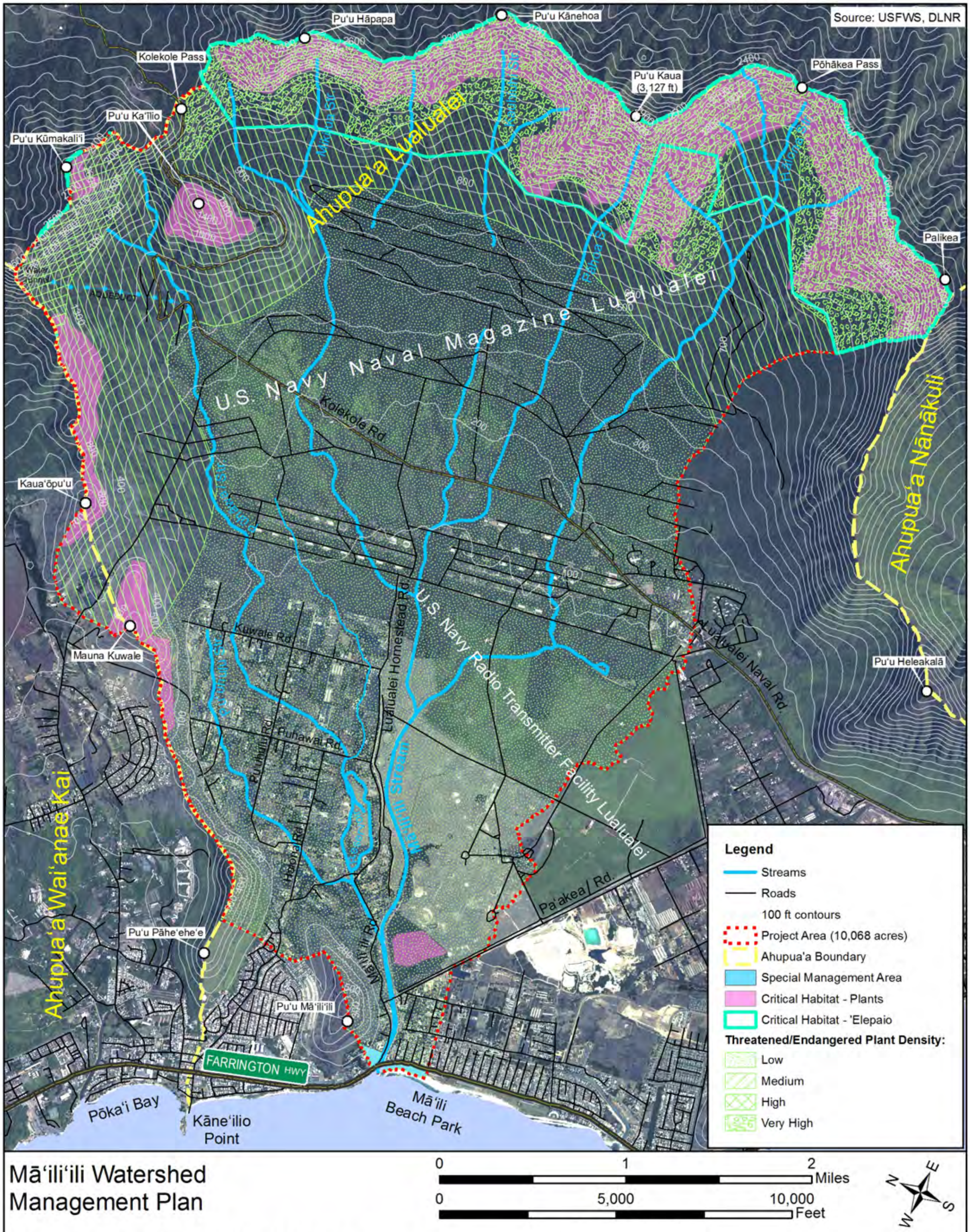


Figure 18. Protected Areas

2.2 Land Use Characteristics

2.2.1 History of the Area

Ideas on when early Polynesian settlement of the Hawaiian Islands occurred are changing now – with settlement between AD 800-900 advocated more recently and others still suggesting sometime between AD 300-600. Archaeological evidence suggests that the windward side of O'ahu was the first area of permanent settlement and farming on the island, due to its abundant water resources. Archaeological hypotheses propose that as windward areas became increasingly settled, people began settling and farming the shoreline and lower valleys of the leeward side, beginning about AD 1000. By AD 1300 most of the leeward side's lower valleys were occupied. The Wai'anae area of the island was settled during this time period, based on research in the lower valleys of Wai'anae and Mākaha. It is expected that coastal settlement of Lualualei also occurred in this period. By the 1300s-1400s, houses and fields began to spread into the upper valleys of Wai'anae, and archaeological work in Lualualei's upper valley documented the presence of habitations and dryland agriculture beginning in these years [30]. Oral histories indicate that three larger countries formed on O'ahu in the 1300s – 'Ewa-Wai'anae-Waialua, Kona (the Moanalua to Kuli'ou'ou area), and the Ko'olau side. These oral histories further document the unification of O'ahu into one kingdom in the 1400s. This marked the start of more stratified societies. In the early 1700s, the O'ahu Kingdom expanded, including Kaua'i (supposed through inheritance) and Molokai (through conquest) [18] [30]. At this point, the kingdom had perhaps 70,000 – 90,000 people. At the time of first European contact in 1778, the four kingdoms in the Hawaiian Islands were highly stratified, often called archaic states (much like the Mayan, Greek and early Near Eastern city states). The Wai'anae district was a more remote, rural district in these years, as the royal centers of the kingdom were primarily in Waikiki, Kailua and areas around Pearl Harbor. Within the district, Wai'anae valley was the demographic, economic, political and religious center of the district. Lualualei was one of the rural areas of this district, largely populated by commoners with farms up at the base of the mountains [30].

In 1783, O'ahu was invaded and conquered by the Maui Kingdom under Kahekili. Twelve years later (in 1795), the Kingdom of Hawai'i under Kamehameha defeated the Maui Kingdom at the Battle of Nu'uanu and gained control of O'ahu and the other Maui Kingdom lands. In 1810 the Kaua'i Kingdom ceded its lands to Kamehameha, and the islands were unified [30].

European contact introduced foreign diseases, particularly venereal diseases causing dramatic declines in birth rates and in replacement generation sizes. By 1855 the overall population of the islands was only one-quarter of what it had been at the time of the first European Contact. European contact also altered the settlement of the kingdom [11]. Honolulu became a very large urban port-town. By the 1840s-1850s, rural populations were also declining due to movement into

Honolulu. By the 1870s, the Waiʻanae population was down to about 500 people. Very few people resided in Lualualei by this time. Also, in the 1840s, a new industry was emerging, cattle ranching – on Oʻahu particularly on large leased lands in the Central Plateau and on the Waiʻanae side of the island [(11)]. Ranching in Lualualei began in 1851 and continued until 1902. By the 1870s, the Dowsett-Galbraith occupied large portions of Lualualei Valley. The sugarcane industry boomed in the 1870s, and by 1892, 300 acres of sugarcane had been planted in Lualualei by the Waiʻanae Sugar Company, based in Waiʻanae Valley [(29)].

By the 1930s, the valley moved into another era. The central and upper parts of the valley were taken over by the U.S. Navy (see section 2.2.6.1) which retains control over most of the valley to this day. Along the shore, homesteads were given out (not Hawaiian homesteads) by the Territory, and residents began to repopulate shoreline areas. Today, this residential expansion continues, and the population of Lualualei has dramatically increased in recent years [(31)].

2.2.2 Present Day Community Demographics

The Waiʻanae Senate District (District 21) of Honolulu County is one of the less populated districts with a population of 48,519, amounting to about 5% of Oʻahu's total population of 953,207 (2010 U.S. Census). The Māʻiliʻili Watershed is located within or partially within the following Census Tracts: 96.08 (most of the Navy lands), 97.04 (most of the agricultural/residential neighborhoods around Puhawai Road), and 96.03 and 97.03 around the stream mouth/shoreline area. Since most of the watershed is owned by the U.S. Navy, but without housing much military personnel, the population density in the watershed is extremely low compared to other parts of Oʻahu. The total population for the watershed is approximately 2,011 with a population density of 128 people per square mile. The population density for the Island of Oʻahu is 1,699 people per square mile. However, to put it into perspective, the population density in the Puhawai neighborhood is about 1,362 people per square mile, which is much closer to the island average. If the Navy lands are eventually returned to the State of Hawaiʻi, these numbers are likely to change dramatically. The project area is partially contained in the Census Designated Places of Māʻili and Waiʻanae. Within Census Tract 97.04, which contains the majority of the watershed's population, 53% of the population is "Native Hawaiian or other Pacific Islander". The 2010 mean annual family income for this area was $75,309 and the average family size was 4.84. The mean per capita income was $16,592, which is quite low compared to $27,880 for the entire State [(31)].

2.2.3 State Land Use Districts

Lands in Hawaiʻi fall within one of four State Land Use Districts, as defined by the State Land Use Law (HRS §205). The Māʻiliʻili Watershed contains three of these districts, Agricultural (73%),Conservation (26%) and Urban (1%) (see Figure 19). Most of the project area from Paʻakea Road to the upper reaches of the watershed is in the Agricultural District, which is under the jurisdiction of the State Land Use Commission and the City & County. The Conservation District covers the mauka portions of the watershed. This district is under the jurisdiction of DLNR's Office of Conservation and Coastal Lands and is further divided into sub-zones. 72% of Conservation Land in the project area is in the "Limited" sub-zone, 14% is in the "General" sub-zone, 12% is in the "Protective" sub-zone, and 2% is in the "Resource" sub-zone. In the map legend, the sub-zones are listed from least to most restricted. The Urban District, which is further managed through the County's zoning designations, amounts to only 1% of the total project area [(1)].

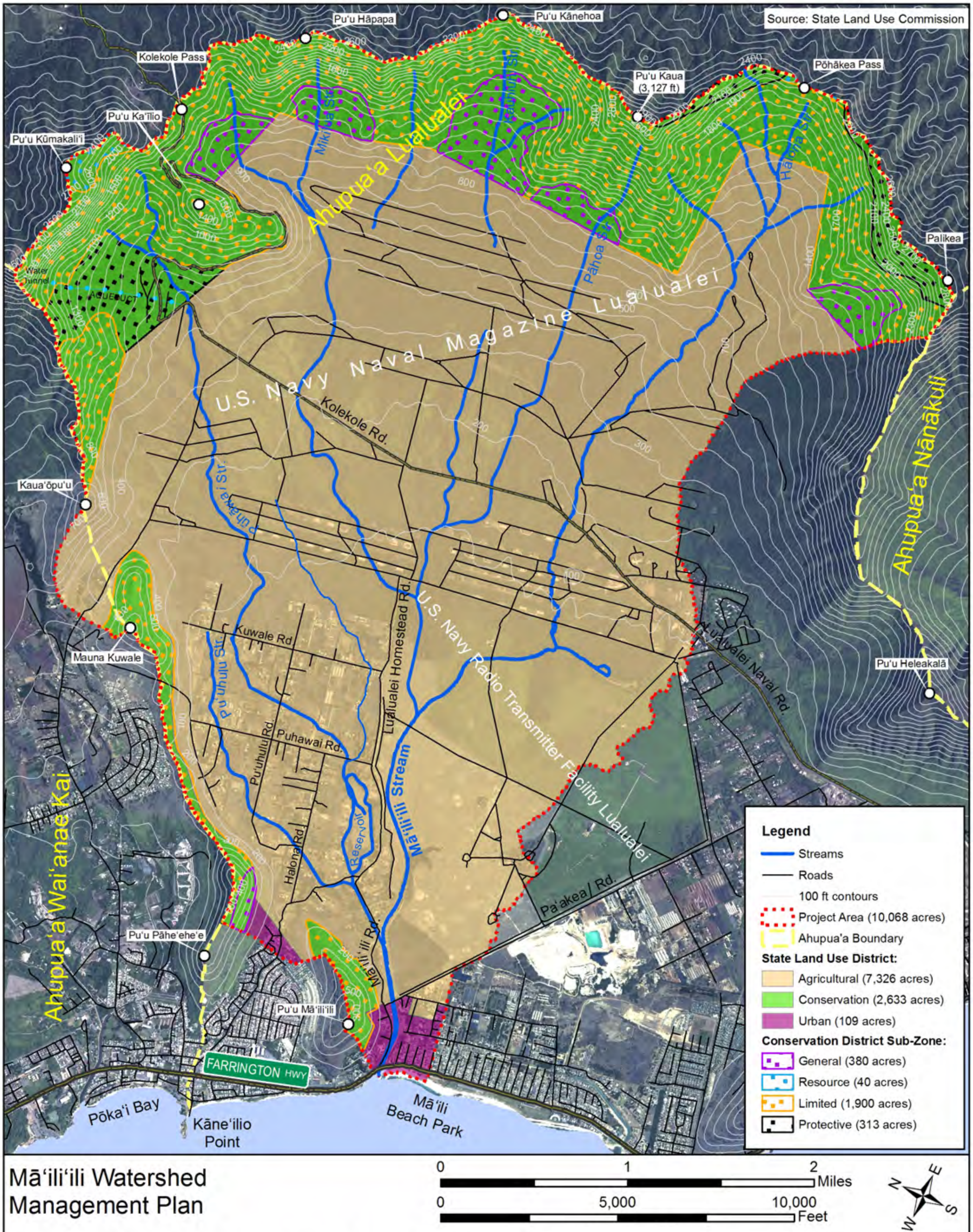


Figure 19. State Land Use Districts

By: Townscape, Inc. For: Hawai'i Department of Health Date: March 2013

2.2.4 County Zoning

For lands not in the State Land Use Conservation District, the Counties have zoning jurisdiction. Lands within the Conservation District, are by default zoned as Preservation (P1 Restricted). The majority of the project area is zoned "F-1 Military and Federal" and "P-1 Restricted". The remaining land is primarily zoned for agriculture ("Ag-1 Restricted" and "Ag-2 General") [1].

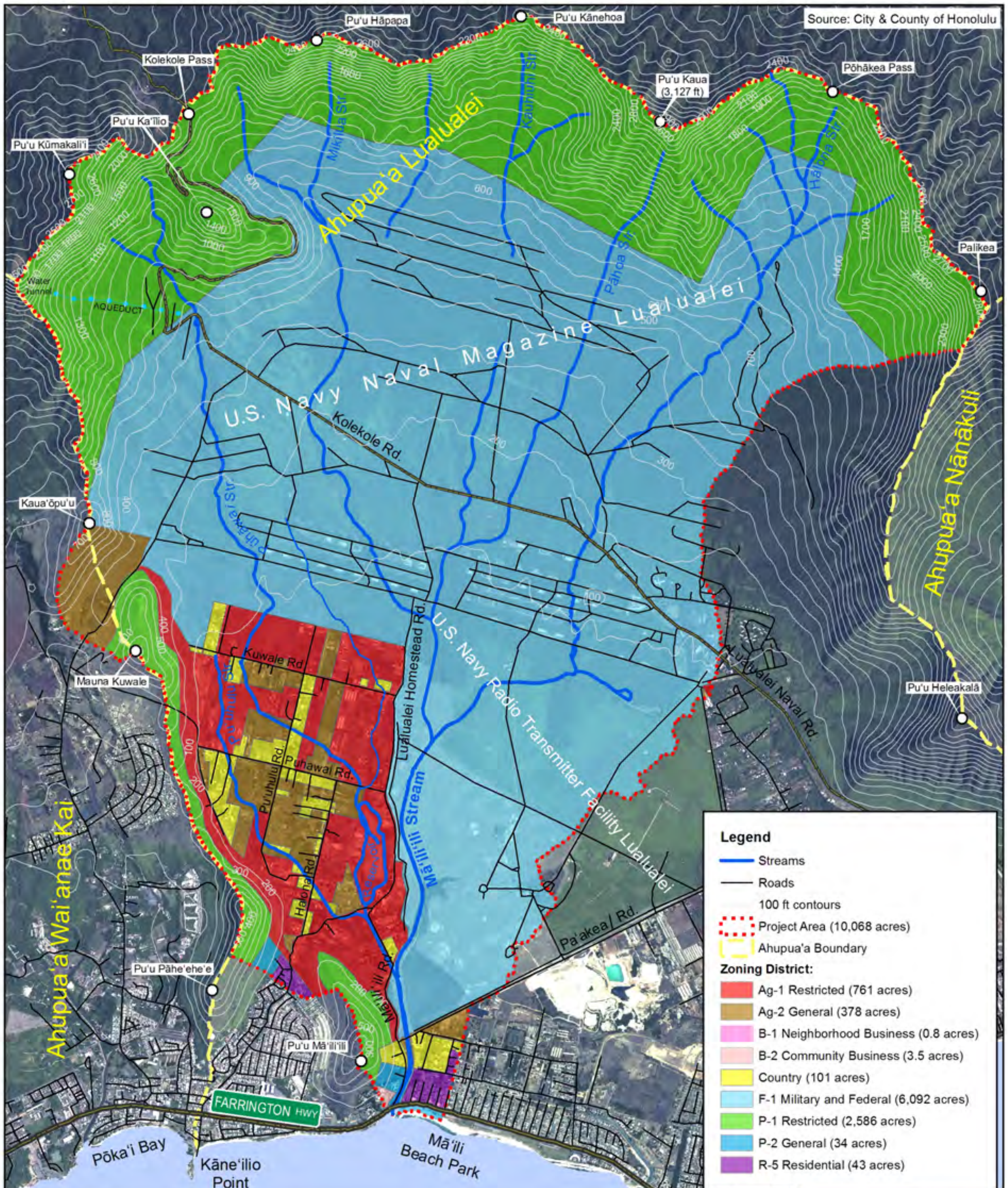


Figure 20. County Zoning

2.2.5 Land Ownership

There are a total of 571 TMK parcels in the project area. The federal government is the largest landowner, with about 79% of the watershed (2 large TMKs) under the control of the U.S. Navy. The second largest landowner controlling roughly 6% of the watershed, is the State of Hawaiʻi, which owns roughly 700 acres along the ridgeline above NAVMAG, covering parts of Lualualei and Nānākuli. This land was set aside as the "Lualualei Forest Reserve" by Executive Order 4414, signed by Governor Neil Abercrombie in July of 2012. The State lands, mostly managed by DOFAW, are followed closely in acreage by the Department of Hawaiian Homelands at 5%. The City & County of Honolulu owns one 14-acre parcel on Kuwale Road (under lease by Kahumana Farm) and additional acreage along Farrington Highway. The remainder of the project area (the majority of the TMK parcels) is private property (see Figure 21 and Table 6) (1).

Table 6. Land Ownership (1)

Landowner	Acreage	% of Watershed
Federal Government (Navy)	7,996	79
State Government	580	6
Dep. of Hawaiian Homelands	475	5
City & County of Honolulu	32	0.3
Private	985	9.7

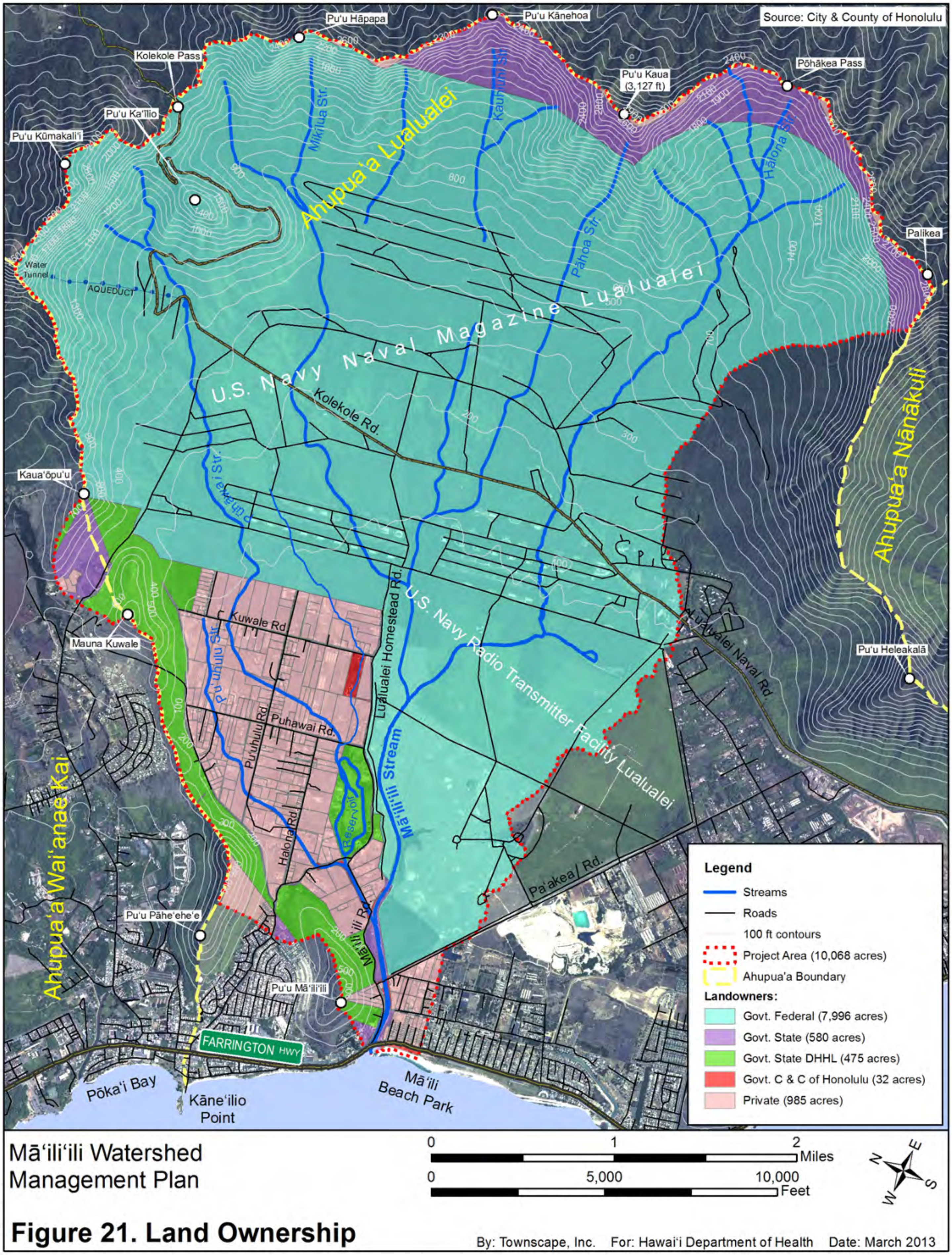


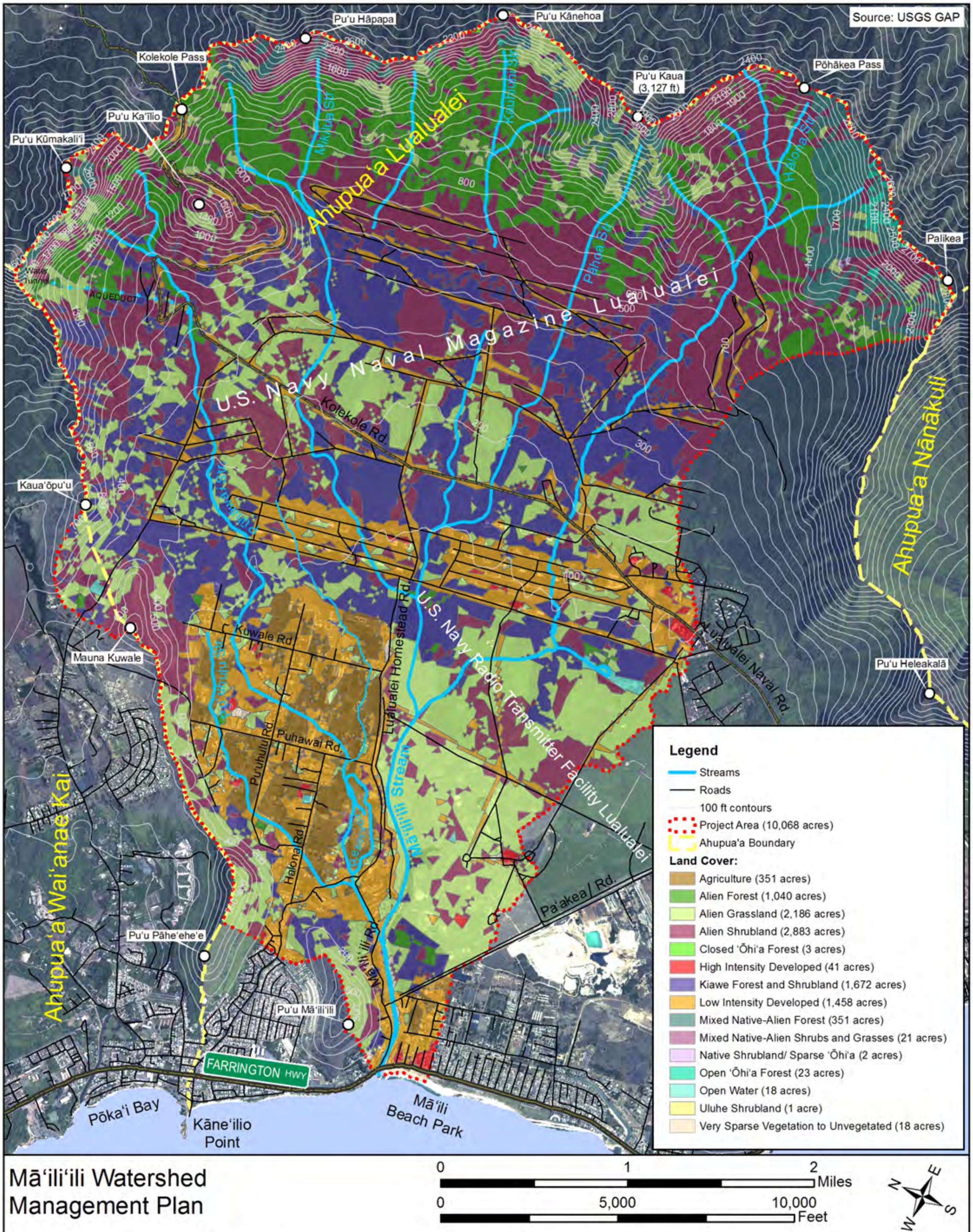
Figure 21. Land Ownership

2.2.6 Land Uses

The land uses in the watershed can be broadly separated into military use, small-scale agricultural use and light industrial/urban use. Figure 22 illustrates some of the land uses and vegetation types.

2.2.6.1 Military

With space at Pearl Harbor becoming scarce in the early 20th century, the U.S. government started expanding its military operations on Oʻahu to other parts of the island. The Navy first acquired land in Lualualei in 1930 and 1931 for the construction of a new transmitter facility as well as for munitions storage. Initially, 7,940 acres were acquired, mostly by purchase from the McCandless Estate (a former cattle ranch) and by federal executive orders from the State (then Territory) of Hawaiʻi, Department of Hawaiian Homelands. The transmitter, which is used to communicate with submerged submarines in the Pacific Ocean, was activated in 1936 and remains the primary Department of Defense long-range radio transmitter station in Hawaiʻi. Its two 1,500 foot antennas, which were built in 1972, are the highest structures in the State. The receiver and control station are located in Wahiawa. The Radio Transmitter Facility (“RTF Lualuelei”) covers approximately 1,700 acres of land in Lualualei, most of which is in the Māʻiliʻili Watershed (29) (32). The adjacent munitions storage known as Naval Magazine (“NAVMAG Lualualei”) occupies approximately 7,498 acres, most of which is in the Māʻiliʻili Watershed (29). The mission of NAVMAG is “to receive, renovate, maintain, store, and issue ammunition, explosives, expendable ordnance items and weapons, and technical ordnance material for the Navy, Air Force, Army and other activities and units as designated by the Chief of Naval Operations” (33). The magazine, one of three ordnance storage facilities on Oʻahu, contains 266 underground and above-ground ammunition storage areas (29). The magazine used to employ 1,500 people in the 1950s and had facilities and housing much like other bases, most of which have been shut down. The magazine handles about 31,000 tons of munitions annually (34). In the 1980s, the State of Hawaiʻi filed suit against the Federal Government for the seizure of the Lualualei lands, which was overturned because the statute of limitations had expired. In 1995, U.S. Senator Daniel Akaka introduced the Hawaiian Homelands Recovery Act, which was signed by President Clinton on November 2nd. This act assigned a monetary value to the lands confiscated in Lualualei. To resolve the matter, DHHL received 894 acres of surplus federal land valued at the same amount in 1998 (34).



Mā'ili'ili Watershed Management Plan

Figure 22. Land Cover

By: Townscape, Inc. For: Hawai'i Department of Health Date: March 2013

2.2.6.2 Residential and Small-scale Agriculture

The majority of private land in the project area is to the northeast of the Māʻiliʻili Stream channel in the neighborhoods around Puhawai, Puʻuhulu, Halona and Kuwale Road. These are mostly residential homes and small-scale agricultural operations in the form of vegetable and herb farms, chicken farms, some piggery operations and a plumeria flower farm. Roughly 40 % of the neighborhood is just residential, with the remainder under cultivation. Our visually based GIS assessment (see Figure 23) shows that up to 72% of all cultivated parcels are under basil cultivation, with many parcels in monoculture. Most of the parcels in the neighborhood are in the range of 2-15 acres and are family-owned. The area includes two prominent community-based organic farming operations, MAʻO Organic Farms and Kahumana Organic Farm and Café, and the Naked Cow Dairy, a local small-scale dairy and cheese operation.Field observations of these lands confirmed that there is still a problem with large trash items being stored on people's land in close proximity to drainages. There were also some activities that were not in accordance with the agricultural land use and zoning designations of the area, such as light industrial activities. There are some residential lots makai of Paʻakea Road closer to Farrington Highway that are not used for agriculture (1).

<u>GIS Methodology used for Figure 23:</u>

This map shows the results of a visually-based GIS assessment using parcel layers and satellite/aerial imagery (1). The goal was to get an overview of how many parcels in the agricultural neighborhood are in fact being actively cultivated, what percentage of parcels is cultivated, how many parcels are under basil cultivation and which and how many parcels are either bisected by or within 100 feet of a stream. The results will help prioritize parcels and areas for agricultural BMP implementation.

For this analysis, we used the C&C TMK data layer, clipped to the neighborhood. We overlaid this onto a 2009 NRCS aerial photo and zoomed into each of the 295 parcels to visually assess whether they were under cultivation. We then measured the square footage/acreage under cultivation and filled in a spreadsheet with information on each parcel, including whether the crop was confirmed or assumed to be basil, if the owner is known and if there is a stream nearby. We cross-referenced each with the newest Google Earth imagery, which was used to make the final designation because it contains the newest satellite imagery.

Note: Basil was well recognizable on many parcels; however, as this was a visual analysis, there may have been some farms that were erroneously marked as basil because they grow similar looking crops.

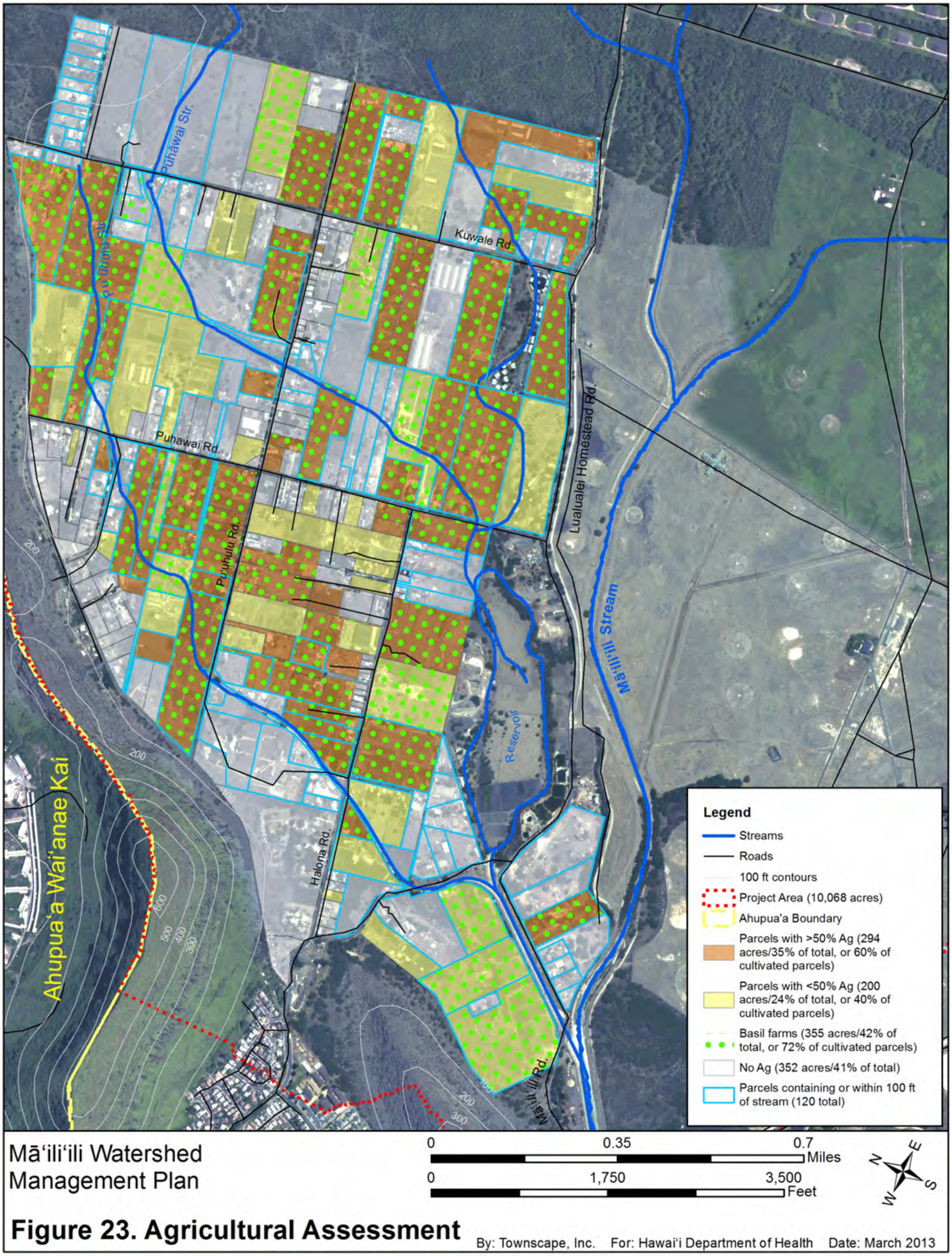


Figure 23. Agricultural Assessment

2.2.6.3 Impervious Surfaces and Sewer Infrastructure

Impervious surfaces are natural or man-made surfaces that don't allow water to penetrate and infiltrate into the soil. Instead, water runs off of impervious surfaces, carrying with it whatever pollutants have accumulated on the surface. In the case of roads and parking lots, these are mostly petroleum contaminants and dirt. Anything covered in asphalt, stone, roofing materials and other impenetrable materials is considered impervious. This includes dirt roads where the soil has been so compacted that water can no longer infiltrate it. When rain falls onto a natural environment with forests and other vegetation, the rain will infiltrate into the soil and eventually recharge the groundwater aquifer. Water that runs off from impervious surfaces does not contribute to this process and instead has the potential to pollute surface water by entering rivers, streams, and the ocean [(24)].

In the Māʻiliʻili Watershed, approximately 564 acres, or 5.6 % of the watershed is covered with impervious surfaces, which is relatively low compared to many other watersheds on Oʻahu. The impervious surfaces include Farrington Highway, all the smaller roads connecting from the highway to private lands, as well as roads on the military installations. There is a small section of commercial uses near the stream mouth along the highway with parking lots and concrete structures, including the Waiʻanae Coast Comprehensive Health Center [(1)]. During the Lualualei Flood Study, it was determined that many of the roads were not optimally designed for water drainage, creating sump conditions where runoff creates pools and can potentially cause flooding. One of the major design flaws is the fact that Farrington Highway is higher than the roads connecting to it from the mauka side. In the case of a storm, the water is not able to drain and creates pools along the mauka side of Farrington Highway.

There are three different storm drain systems in the area. As a State highway, Farrington Highway is part of the larger Oʻahu MS4. MS4 stands for "Municipal Separate Storm Sewer System". This means that stormwater runoff is diverted from roads and other surfaces into a sewer system that is separate from the sanitary sewer system which carries raw sewage. This type of separate design prevents excess runoff from overwhelming the sanitary sewer system and thereby prevents raw sewage overflows. In some countries, there are combined sewer systems. Stormwater in an MS4 area is diverted into storm drain systems that carry the water into State waters, including streams, rivers and the ocean, to prevent flooding. Therefore it is important to prevent any illegal dumping in storm drains, as they are a direct connection to waterbodies. Due to the large amounts of runoff after Hawaiʻi rain events, coastal waters can be temporarily polluted after rain events. Municipalities with a population higher than 100,000 are required to obtain an NPDES permit to release stormwater into State waters [(35)]. The roads throughout the private land in the project area are City roads and therefore regulated under the City storm sewer system, which has a separate NPDES permit for its MS4 [(36)]. The Navy roads fall under yet another separate MS4. Each MS4 is required to have a Storm Water Management Program Plan to ensure implementation of BMPs, which include activities such as street sweeping and stream clean-ups to keep debris out of storm drains [36]. The private neighborhoods in the watershed have insufficient drainage systems, which contributes to flooding and possibly water quality problems. Many of the culverts are of insufficient size to handle storm peak flows and drainages are overgrown with vegetation that keeps water from flowing [2]. The City stormwater infrastructure is depicted in Figure 24.

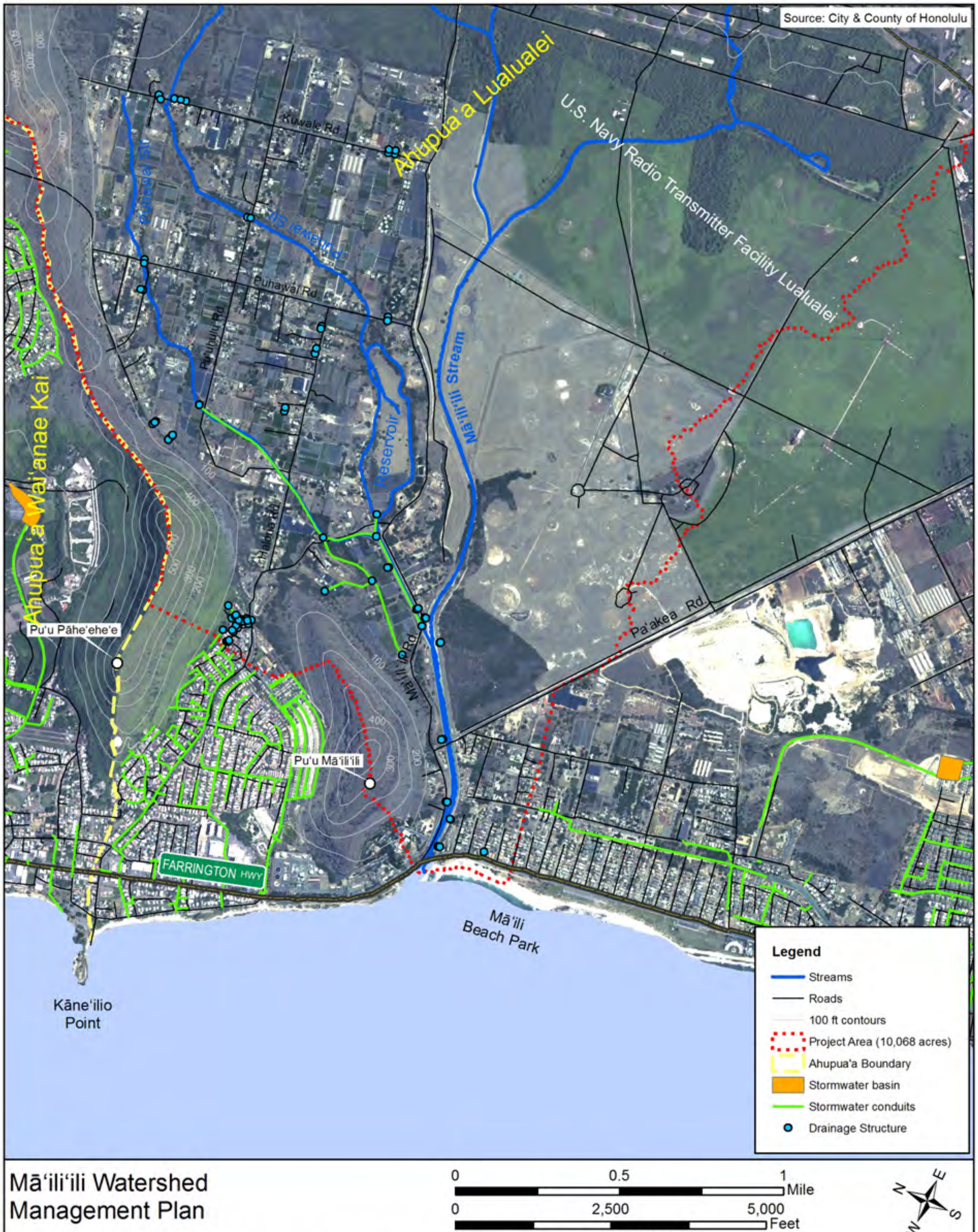


Figure 24. C&C Storm Drain System

By: Townscape, Inc. For: Hawai'i Department of Health Date: April 2013

Sewage treatment in the project area is mostly provided by individual wastewater systems (IWS) such as septic tanks and cesspools. The only parts of the watershed tied into the County sewer system are on the south side of the stream mouth around Farrington Highway (see Figure 24). The Wai‘anae Wastewater Treatment Plant is just north of the project area, but does not service neighborhoods around Puhawai Road. This primary and secondary treatment plant releases its effluent via an ocean outfall pipe 6,184 feet offshore at a depth of 107 feet [(37)].

Cesspools have been considered problematic in terms of water quality for a long time and the EPA and State DOH have taken measures to phase out the use of cesspools. Large capacity cesspools have been banned and the construction of any new cesspool is no longer permitted in areas designated by HAR §11-62 as “Critical Wastewater Disposal Areas”, which includes the entire Island of O‘ahu. DOH recommends that all existing cesspools be replaced by modern septic tanks. Cesspools are essentially holes in the ground that collect sewage without actual treatment. Over time, the solids settle to the bottom and the wastewater effluent seeps into the surrounding soil. Cesspools fail easily due to the buildup of sludge at the bottom, which causes clogging of the system. Leaking cesspools contribute raw sewage to the surrounding soil and have the potential to contaminate groundwater [(38)]. The same problem can occur with leaking septic tanks. Therefore all IWS are regulated by the DOH Safe Drinking Water Branch.

Hawai‘i is the U.S. State with the most cesspools in place: Over 170,000 cesspools are still being used due to a lack of sewer service in many areas. Septic tanks provide some level of wastewater treatment through filtration and microbial digestion of the sewage. When properly maintained, they are considered by DOH as a safe alternative for areas out of range of public sewer systems. However, the same potential exists for groundwater contamination and the spread of infectious diseases if the septic system isn’t properly maintained, which is often the case as renters and homeowners aren’t aware of the requirements [(39)]. It is not known how many homes in the project area have cesspools versus septic tanks. However, many rural areas including others along the Wai‘anae Coast are still using cesspools.

Figure 25. C&C Sewer System

2.2.6.4 Recreation

Typical recreational activities in the Waiʻanae moku include ocean-based activities such as collecting limu, swimming, fishing, diving, surfing, and boating as well as land-based activities such as hunting, gathering and hiking [40]. Since the mauka areas of the watershed are owned by the military and are thus inaccessible to the public, there is not much land-based recreation to engage in in the project area. Ocean-based activities have been practiced in this watershed for generations and long-term residents have many stories to share about their ocean activities and what kind of fish and limu used to be available when they were children [40] [41]. The coastal areas surrounding the Māʻiliʻili Watershed include several beach parks (Māʻili Beach Park, Lualualei Beach Park, Pōkaʻi Bay Beach Park). Due to the hot and sunny climate on the Waiʻanae coast, the beaches on this side of the island are excellent recreation areas on most days of the year. There are many prime fishing and SCUBA-diving/freediving sites along the Waiʻanae coast and several surf breaks. Anecdotes from long-time residents revealed that the beaches used to be pristine and the only "trash" that once found its way to the beach after a storm event was of natural origin, such as kukui nuts, which were collected and used for lei-making. Now, rainfall events carry anthropogenic trash to the beach, along with brown water (likely from sediments) [40].

2.2.6.5 Future Uses [12]

In accordance with the Oʻahu General Plan, Waiʻanae is not one of the main development centers on Oʻahu. Instead, it is meant to maintain its rural character and receive support to maintain and improve existing populations and infrastructure [12]. The vision of the Waiʻanae Sustainable Communities Plan is to maintain and enhance the region's ability to sustain its unique character, current population, growing families, rural lifestyle, and economic livelihood, all of which contribute to the region's vitality and future potential. The plan focuses heavily on sustainability principles and sustainable development in the fields of agriculture, renewable energy, green technology, ecosystem and cultural site restoration, and economic development. It allows only minimal increases in housing, resort, and light industrial development. Any developments not meeting the sustainability criteria would not be approved. The future activities relevant to the project area outlined in the WSCP are as follows:

Restrict coastal urban, suburban, and resort development makai of Farrington Highway: No development except small-scale re-development of existing commercial properties.

Preserve and restore stream corridors: Establish "Stream Conservation Corridors" to prompt State and City agencies to initiate programs to enhance stream flow and protect the natural ecology of Waiʻanae's streams, floodplains, and associated ecosystems. This needs to include a "no dumping rule", siltation basins or other runoff mitigation measures, and stream corridor vegetation restoration. A community-based "adopt-a-stream" initiative is suggested.

Preserve and protect cultural sites and cultural landscapes: Full archaeological inventory surveys and community-based management of identified cultural sites.

Improve transportation systems within the District: Farrington Highway is currently the only access to the Waiʻanae coast. Building an additional access road is a very expensive, but desired option, along with public transportation (bus, rail, boats) and walking/bike paths.

Designate, plan, and develop Town Centers and Community Gathering Places: Designate Waiʻanae town center and smaller "village centers", including one in Lualualei. This should include a concentration of small retail businesses, restaurants, professional offices, medical clinics, and social services centers. Community Gathering Places would be several acre park-like areas.

Develop and support community-based businesses: Increase local employment opportunities and reduce restrictions on working from home. This would also reduce traffic problems. Increase cultural, educational, and healthcare facilities and related job opportunities.

Partnering of government agencies with community-based organizations in order to better manage Waiʻanae's natural and cultural resources: By partnering with community organizations, the government and the environment can benefit from their vast amount of local knowledge and experience. This will aid in developing stronger and more meaningful resource management programs.

2.3 Watershed Conditions

Much of the unlined portions of Māʻiliʻili Stream are privately owned. The lined portions of the stream are owned and maintained by the City. However, the waterways are considered State waters and are thus regulated by DOH in the interest of preserving water quality. The stream is classified as "Class 2". The objective of Class 2 waters is to protect their use for recreational purposes, the support and propagation of aquatic life, agricultural and industrial water supplies, shipping, and navigation (HAR §11-54-2).

Māʻiliʻili Beach was listed on the 303(d) list as meeting criteria for enterococci, but needing further monitoring in order to determine if designated uses are met [42]. There were no lab or field samples for the beach until now and it was one of the "70 dirtiest beaches in America" as determined by the Natural Resources Defense Council [11].

A limited amount of water quality testing done for this study indicated very heavy nutrient concentrations and generally degraded water quality and habitat conditions in streams and coastal waters, as summarized in section 2.3.1.2.

2.3.1 Water Quality Standards

Water Quality Standards in Hawaiʻi are set by law in HAR Chapter §11-54 and are administered by DOH. There are separate water quality standards for streams, estuaries, embayments, open coastal waters and oceanic waters. For the Māʻiliʻili Watershed, criteria for all except embayments are potentially applicable. Water quality standards exist for typical physical, chemical and biological indicators, as well as toxic chemicals. The Hawaiʻi State water quality standards tables and additional detailed information can be found in Appendix A.

As part of CWA section 303(d) ("Impaired Waters and Total Maximum Daily Loads") requirements, the States are required to report to Congress on the state of their waters. This results in the production of the 303(d) list, which needs to be submitted to EPA every two years on even-numbered years. This list is a database of each State's impaired and threatened waters and includes information on attainment or non-attainment of the State's water quality standards. Based on this list, States prioritize which waterbodies are in need of TMDL development. Total Maximum Daily Loads (TMDLs) are the maximum amount of pollutants a waterbody can handle and still be able to meet water quality standards. Unfortunately, due to lack of funding, the States don't actually have the resources to continually test and monitor water quality and the CFR requires only the evaluation of "all existing and readily available information" in developing the 303(d) list. Therefore, many waterbodies in Hawaiʻi do not have enough data to show all possible impairments or include them in the TMDL process, as is the case for Māʻiliʻili Stream. However, States are allowed to use data collected by outside organizations, so community-based water quality testing through grants and community organizations could potentially aid in providing the necessary data [43].

2.3.1.1 Understanding Water Quality: Physical, Chemical and Biological Indicators

Water quality can be separated by physical, chemical and biological parameters. Water quality impairments can come from both natural and anthropogenic inputs. Results of water quality testing are analyzed holistically because some physical, chemical, and biological pollutants have a synergistic relationship. For example, influx of agricultural runoff may introduce fertilizers into a waterbody. The increased nutrient content may result in an algal bloom which leads to a rapid increase in plant biomass, followed by a rapid plant die-off. The aerobic decomposition of the dead plant matter results in an increase in the biological oxygen demand (BOD) in the water and increased levels of suspended solids. The excessive oxygen consumption by the decomposing bacteria results in a decrease in dissolved oxygen (DO) in the water column, making it difficult for other aquatic organisms to survive. This process is known as "eutrophication".

There are various water quality indicators that are tested for water quality analyses, some of which are specifically regulated by water quality standards. Levels of these parameters may fluctuate naturally with time and space, or unnaturally due to anthropogenic pollutants. Some of the most common indicators used are listed below and further described in Appendix A [44].

Physical Water Quality Parameters:

Temperature

Total Suspended Solids (TSS)

Turbidity

Electrical Conductivity

Chlorophyll a

(Stream flow)*

* Stream flow is not necessarily an indicator of water quality, but is a typical measurement taken during water quality sampling to assess overall stream condition

Chemical Water Quality Parameters:

pH

Dissolved Oxygen (DO)

Biological Oxygen Demand (BOD)

Salinity

Nitrogen

Phosphorus

Biological Water Quality Parameters

Enterococci

Clostridium perfringens

2.3.1.2 Water Quality Situation in the Project Area [45]

The water quality in Māʻiliʻili Stream has not been subject to any ongoing monitoring or testing by DOH or other organizations. In order to get an understanding of the water quality situation in the watershed, Townscape in partnership with AECOS Inc. coordinated a water sampling and monitoring effort to obtain at least a minimum level of baseline data. The results of this sampling effort are summarized here.

Four sampling stations were initially identified and from February to March 2014, three samples were taken at each of these four stations in order to provide geometric mean results that can be compared with state water quality standards. After further fieldwork and hearing more community input, two additional sampling stations were added to get a better understanding of water quality on the Navy side and water quality of streams affected by basil farm runoff. Due to budget constraints, only one sample was taken at these two additional stations (#3 and #6). The sampling locations and pollutants that exceeded water quality standards at each station are shown in Figure 26.

All sampling stations showed high nutrient levels, some with nutrient levels so high they were 500 times higher than the state water quality standard, especially in the agricultural neighborhood. All stations had detectable levels of arsenic, lead and zinc; however, these were at natural levels considered normal due to volcanic soils containing these metals. With one exception, pesticides and herbicides were only detected coming from Navy lands, with low levels (below state water quality standards) of Lindane, Heptachlor, Aldrin and Endosulfan Sulfate. The agricultural areas did not show detectable pesticide/herbicide levels with the exception of a minute level of the herbicide Dicamba at Station #5 and a potentially problematic level of Dieldrin at Station #6. Dicamba was detected at a level so low, it was 40,000 times lower than the EPA allowable lifetime amount (LHA) for drinking water, 4mg/L [46]. Dieldrin, which was banned in the 1980s, is still detectable in many soils in Hawaiʻi due to its long-term persistence [47]. The level of Dieldrin detected at Station #6 exceeded the state's "chronic" water quality standard. This means that chronic or long-term levels could have negative effects on stream habitat [45].

Stations #5 and #6 had excessively high levels of nutrients, including Nitrogen and Phosphorus, indicating heavy fertilizer use in these agricultural areas. Water quality results are shown in Table 7. Values exceeding standards are shown in red. Please see Appendix A for additional information on water quality sampling and standards. See Appendix B for the full AECOS report and analysis of water sampling results conducted for this study.

Long-term water quality sampling and monitoring is needed to get a more accurate understanding of the water quality situation over time, with seasonal and other fluctuations. However, these initial data can be used as a baseline for further analyses and for the state to list the waterbody as impaired.

Table 7. Water Quality Results *

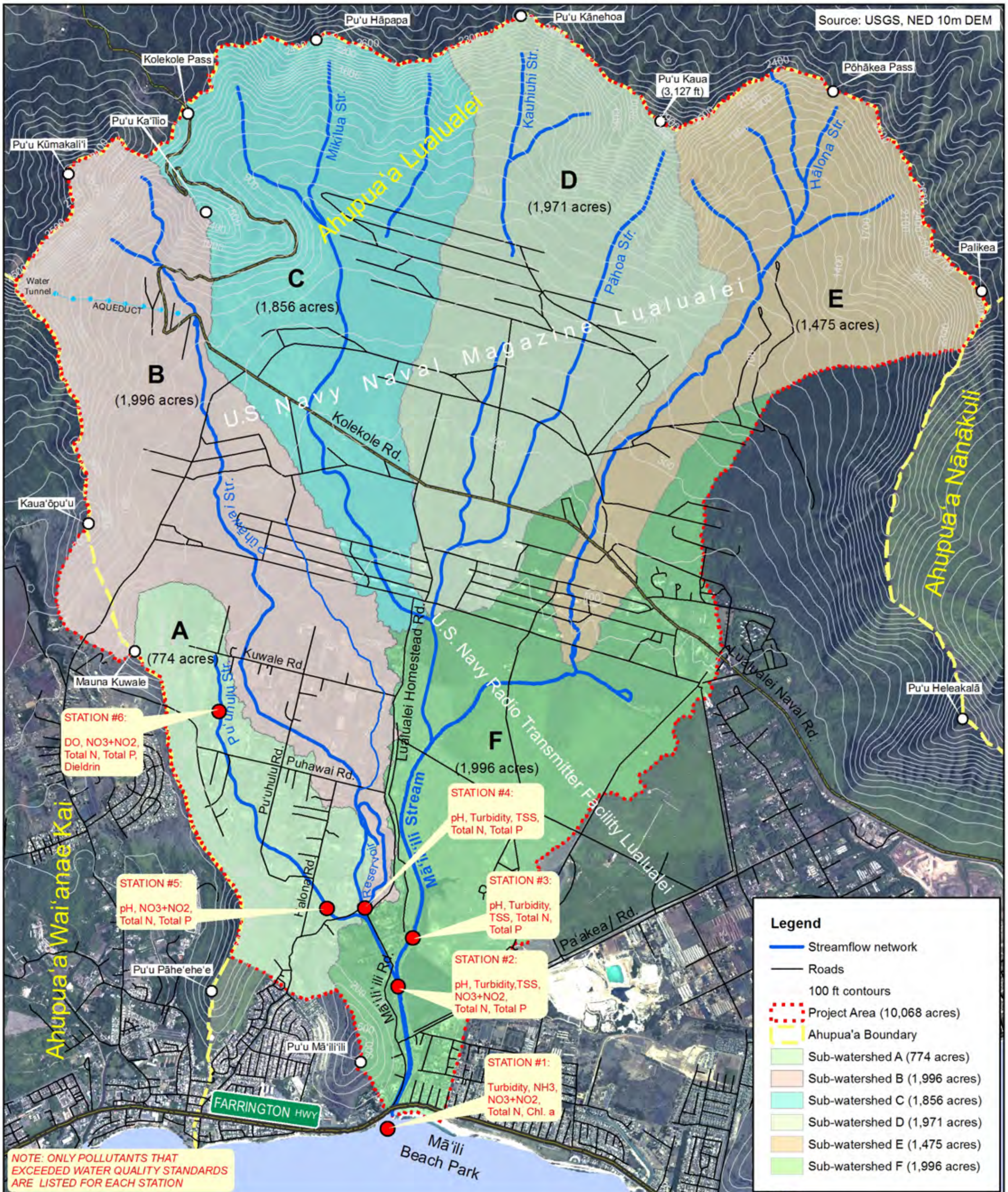
Station Number ⇨ / Measurement ⇩	#1	#2	#3	#4	#5	#6
Temperature (ºC)	25.6	28.3	32.8	32.5	30.7	22.5
Salinity (PSU)	35	2	16	2	5	4
pH	8.06	**8.97** **(5.5-8.0)**	**8.87** **(5.5-8.0)**	**9.05** **(5.5-8.0)**	**8.43** **(5.5-8.0)**	7.69
DO (% sat.)	113	240	168	209	150	**20** **(>80)**
Turbidity (NTU)	**2.20** **(0.50)**	**7.54** **(5.0)**	**56.8** **(5.0)**	**6.48** **(5.0)**	2.64	0.72
TSS (mg/L)	8	**38** **(20.0)**	**168** **(20.0)**	**44** **(20.0)**	4	2
Ammonia (µg N/L)	**8** **(3.50)**	21	-	69	110	-
Nitrate + Nitrite (µg N/L)	**355** **(5.00)**	**6620** **(70.0)**	52	33	**36600** **(70.0)**	**37300** **(70.0)**
Total N (µg N/L)	**1860** **(150.0)**	**8210** **(250.0)**	**5410** **(250.0)**	**4757** **(250.0)**	**40850** **(250.0)**	**44100** **(250.0)**
Total P (µg P/L)	7	**409** **(50.0)**	**206** **(50.0)**	**1275** **(50.0)**	**2100** **(50.0)**	**8880** **(50.0)**
Chlorophyll α (µg/L)	**0.48** **(0.30)**	-	36.7	-	-	-
Arsenic (µg/L)	2.16	1.1	2.38	3.5	6.4	4.34
Lead (µg/L)	0.528	0.245	0.326	1.36	4.82	0.12
Zinc (µg/L)	0.8	8.1	5.39	9.05	17.2	13.7
Herbicides (µg/L)	-	-	-	-	Dicamba 0.096	-
Organophosphorus pesticides (µg/L)	-	-	-	-	-	-
Organochlorine pesticides (µg/L)	-	-	Lindane 0.0042 Heptachlor 0.0021 Aldrin 0.003 Endosulfan Sulfate 0.0063	-	-	**Dieldrin** **0.0069** **(0.0019)**

***Notes:**
Please note that the numbering of stations is different from the numbering in the original AECOS report (Appendix F). For ease of use, the numbering in Table 7 was changed to reflect a makai to mauka sequence.

Values listed in **bold red font** exceed water quality parameters, which are shown in parentheses. The parameters shown are "geomean" standards. Only stations 1, 2, 4 and 5 resulted in geomean values. Stations 3 and 6 were only sampled once, thus the results are one-time results not directly comparable to geomean standards. **Please note that different standards apply to station #1 because it is an ocean site. All other stations are stream sites.**

The dashes (-) indicate that the analyte in question was not detected in the sample.

See Appendix A and Appendix F for further details.



Māʻiliʻili Watershed Management Plan

Figure 26. Water Quality Sampling Stations

By: Townscape, Inc. For: Hawaiʻi Department of Health Date: May 2014

2.3.2 Potential Threats to Water Quality

The pollutants DOH is required to report to EPA are sediments, Nitrogen, and Phosphorus. These are the primary pollutants of concern in Hawaiian watersheds. However, other pollutants including toxic substances are also of concern. Potential threats to water quality in terms of sediments and nutrients are agricultural runoff, which carries sediments and fertilizers into streams, causing increased levels of Nitrogen, Phosphorus, sediments and turbidity. The same pollutants can also be contributed by human and animal fecal matter, including underground injection wells, cesspools and septic tanks and feral ungulates in the upper reaches of the watershed. In addition, these sources can contribute disease-causing bacteria. Sediments are also related to erosion due to vegetation loss and feral ungulate rooting activities (24). Toxic substances include many different compounds, including pesticides, petroleum products, solvents, PCBs and many more. Pesticides are contributed via agricultural runoff or non-agricultural areas, where vegetation is controlled with herbicides. Other toxic substances include metals, solvents, PCBs, VOCs, PAHs, TPHs and other petroleum contaminants, which can be contributed from impervious surface runoff. These substances have also been found on the military lands and are being addressed by the Restoration Advisory Board (RAB) for the base.

2.3.4 Past and Present Clean-up Efforts

One of the facilities at NAVMAG was part of the greater Pearl Harbor Complex Superfund site (aka CERCLA site). Superfund sites are contaminated sites regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) administered by the EPA (48). There are several transformer sites at the Lualualei Navy lands. Soil samples taken outside the transformer sites in 1998 revealed contamination with polychlorinated biphenyls (PCBs), a chemical used as a coolant for transformers. As part of the clean-up effort of the Pearl Harbor Superfund site, soils from this transformer site and others were excavated and transported to Barber’s Point for treatment in a thermal desorption unit. After removal of contaminants, the soils were returned. Multiple clean-up and restoration efforts have been completed under management of the Restoration Advisory Board (RAB), made up of community members and experts. The latest clean-up effort discussed at the most recent RAB meeting on May 29, 2013, is a “Time Critical Removal Action” (TCRA) at an old landfill located on the southern boundary of the project area inside NRTF. This landfill, which was used from the 1940s to 1980s for disposal of construction debris, was required by EPA to undergo further testing for contaminants. Levels of PAH, PCBs, dioxin and pesticides in the soil were above acceptable levels. The TCRA is in process to remediate any potential impacts to human health and the environment (49) (50).

In 2011/2012, State Representative Jo Jordan organized a massive community stream clean-up in the watershed, bringing together volunteers from various groups, including State Civil Defense, Youth Challenge, various faith-based groups and government agencies to remove vegetation, overgrowth and trash. They recovered roughly 200 old tires, corrugated iron, concrete rubble, man-made stream blockages and dead animals, among other things [51].

2.4 Pollutant Source Assessment

In alignment with the Hawaiʻi Watershed Guidance, a pollutant source assessment should identify major causes and sources of water quality impairment. In order to achieve this, the Guidance states that "natural baseline pollutant load levels should be known" [6]. Since the Māʻiliʻili Watershed has not undergone much previous study or analysis, a more detailed pollutant analysis including ongoing water quality testing is needed in the future. The currently available data as described in section 2.3.1.2 suggest that agriculture may be the main contributor of nutrients in sub-watersheds A and B. According to the NOAA Ordnance Reef Study, groundwater in Waiʻanae also has an extremely high level of dissolved nitrates due to leaching from agricultural fields. This has led to terrible algal blooms in other parts of the State, but the Waiʻanae coast has not experienced intense algal blooms [14]. The biological reconnaissance survey conducted by AECOS (described in section 1.5.5) did discover an influx of nutrient-rich groundwater in the channeled portions of Māʻiliʻili Stream, which further indicates a fertilizer problem.

Sub-watersheds C-F are all Navy lands. The specific sources of suspended solids (likely sediments), nutrients and four organochlorine pesticides coming from the Navy lands are unknown because there was only one sample taken at one sampling station indicating the total concentration of pollutants after draining all the Navy lands. Nutrients and sediments may be from natural sources such as erosion and feral ungulates while pesticides could be persistent in the soil from decades ago. Further sampling, study and investigation may help uncover specific sources.

Townscape's field work identified some areas of concern as possible pollutant sources shown in Figure 27. Details of the field work observations are as follows (see photos in Appendix C):

"Windshield reconnaissance survey" of non-military lands (March 14, 2013): driving the various roads in the lower parts of the watershed, taking pictures, and identifying and GPS-recording sites of potential importance.

Results:

- The streams are mostly dry

- Some properties are storing old cars and large trash items
- There are some illegal dumping areas, but we did not observe any major ones. It appears that the trash situation has gotten better since the last stream clean-up.
- Most of the private lands are under basil cultivation. Pesticide spraying and burning of trash was observed.

“Windshield reconnaissance survey” of Navy installations (April 18, 2013): The first tour of both Navy installations with members of Navy Natural Resource Management staff and archaeologist. Tour gave an overview of management measures being implemented on Navy lands and provided a basis for the photo permit application for the follow-up tour.

Results:

- Lands at NAVMAG are only used for munitions storage. No personnel live on site anymore
- Vegetation is maintained mostly via manual cutting/mowing and some herbicides. Areas around gravel-covered magazines are mowed in a 50-foot radius. Close to the gravel, herbicides are used.
- Ordnance stored on site includes mostly smaller munitions used by the Army and Marine Corps. Naval munitions are typically larger weapons such as torpedoes and missiles. Those are stored at West Loch.
- There are two sources of potable water for the Navy installations: a pipeline delivering water from the water tunnel near Kolekole Pass and a deep well filling two 750,000 gallon storage tanks. Since the installations are no longer inhabited, most water is used for fire control and maintenance.
- Vegetation at NAVMAG appeared to be mostly koa haole and non-native grasses, and abundant prickly-pear cactus and some kukui at higher elevations. Some streambeds are very overgrown.
- Wastewater from the installations goes into a 50,000 gallon septic tank. Effluent from this tank goes into Niuliʻi Pond, a constructed wetland that is home to water birds. Since there is not much sewage anymore, the wetland has to be supplemented with potable water.
- There are major ungulate problems in the upper reaches of the watershed. Aerial goat hunting takes place periodically and pigs are rampant throughout, causing widespread damage and erosion.
- There are many cultural/archaeological sites at NAVMAG
- The water drainage systems at NAVMAG consist of bridges and culverts that appear to be in good condition. Some could be improved via plant removal.
- There was a little bit of stream flow in the upper reaches of Pūhāwai Stream along Kolekole Road

- The RTF installation is covered in well-manicured grass
- The water drainage system consists of a well-engineered network of swales that channel sheet flow and stormwater from this flat land towards Mā'ili'ili Stream. Some swales are concrete lined.
- The gravel/dirt road along the lower fence leads through an endangered plant area that contains ihi'ihi lauakea, a Hawaiian clover-like fern.
-

Streambed walk and inspection of non-military lands with State Civil Defense staff (May 20, 2013): Field inspection of streambed conditions in the private land neighborhood around Puhawai Road. Steven Sigler of State Civil Defense was heavily involved in past stream clean-up efforts and has knowledge of the people in the area and the conditions on the ground. He guided us up the streambeds of Pūhāwai and Pu'uhulu Streams (see Figure 27).

Results:

- Streambeds are generally overgrown with non-native grasses and trees, but in most areas, this vegetation appears to "flatten" during storm events and should not be causing clogs or flooding.
- Some areas could benefit from vegetation removal and dredging
- There are several areas of concern for heavy streambank erosion. This includes the area near the Lindberg property, where the landowner has stabilized the streambanks with concrete. The DeOcampo property just makai of the Pu'uhulu bridge is on the edge of the streambank. Mr. Sigler explained that during heavy rainfall events, water exiting the bridge slams into this curved streambank, eroding it away. Ms. DeOcampo's property line has receded 15 feet due to this.
- There is an area where water pools and provides a breeding ground for mosquitoes. Dredging this area and removing some vegetation could help the water flow instead of pooling, thereby reducing vector/health concerns due to heavy mosquito breeding.
- Some property owners have built berms to protect their properties from flooding. The berms have failed in the past.
- The City & County dug a trench just makai of the DeOcampo property to show how much lower the natural streambed is. They have since abandoned the project to use the machines elsewhere, but property owners are hoping the City will return to dredge this area some more because the water is not flowing much and feeding the mosquito pond downstream.
- The US Army Corps of Engineers (USACE) is currently working on a follow-up flood study to focus on medium-term implementable (and more affordable) projects to alleviate flooding.
- We observed several areas of streambank erosion and some light water flow in the Pu'uhulu tributary. The water smelled unpleasant and had some algae growth.
- Regular periodic stream clean-ups/maintenance are recommended.

Follow-up photo survey of Navy installations with photo permit (May 22, 2013): Follow-up windshield tour to take pictures of drainages inspected during first tour. Due to Navy security regulations, photography was not allowed at the first site visit and a photo permit had to be obtained for the follow-up tour.

Results:

NAVMAG:

- Panorama shots from the rocket testing facility provide a good overview of the whole valley.
- Stormwater runoff flows through an engineered system of drainage structures, including bridges, culverts and some concrete channels.
- Stream channels were generally very overgrown with koa haole and non-native grasses.
- Some herbicide use was observed near streambanks.
- The water pipe delivering potable water from the water tunnel appears to be in normal condition. A second abandoned pipe was too overgrown to be identified. However, unidentified leakage from an area next to the newer pipe suggested that the abandoned pipe may be leaking.
- Light stream flow was observed in the upper reaches of Pūhāwai Stream.
- There were a few areas with low-level streambank erosion
- Some drainage structures included debris grates to keep larger debris out of bridges/culverts.

RTF:

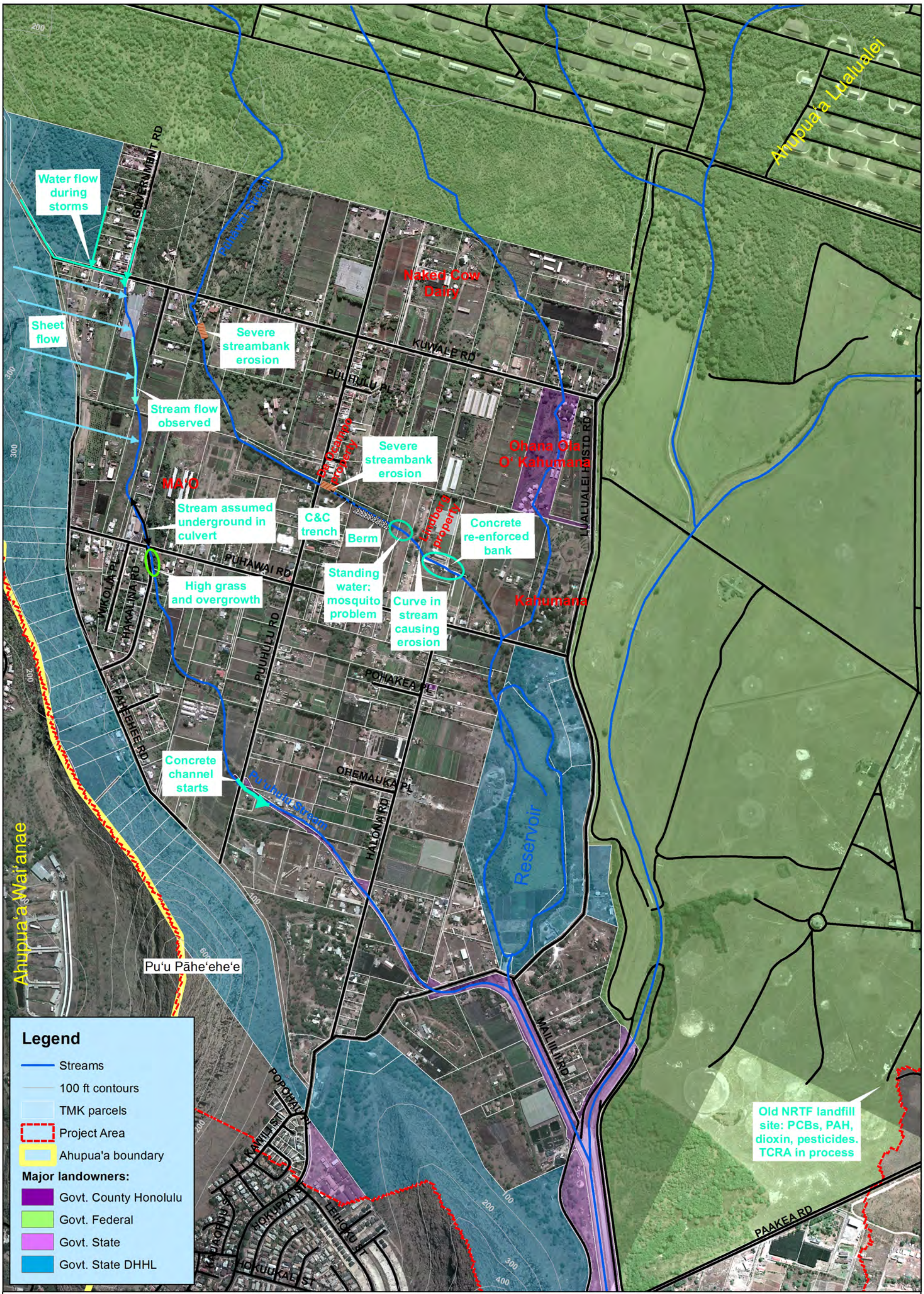
- No birds were observed at Niuliʻi Pond
- The grass swales, culverts and bridges throughout the site appeared to be well-engineered and maintained. This is unlikely to be a source of debris.
- There may be some herbicide contributions to the water from here.

Streambed walks and inspection of non-military lands with local community members (Spring 2014): Muliple field inspections of streambed conditions in the private land neighborhood around Puhawai Road with local community members.

Results:

- Many farms have large trash items, including old fertilizer containers piled up alongside streams.

- We discovered one area where the streambed has been backfilled. This was reported to DOH for enforcement.
- It appears that there are several illegal backfill operations occurring in the agricultural neighborhood. Farmers and community members need to be made aware of the issues surrounding these activities.
- It appeared that even when it was dry and there was no natural stream flow, excess irrigation water from basil farms was creating some flow and ponding with very nutrient-rich water.
- Community members have noticed a decline in tadpoles in Puʻuhulu Stream ever since basil irrigation water has been contributing to stream flow.



Mā'ili'ili Watershed Management Plan

Figure 27. Preliminary Pollutant Source Assessment

0 0.375 0.75 Miles

0 800 1,600 2,400 3,200 4,000 Feet

By: Townscape, Inc. For: Hawai'i Department of Health Date: May 2013

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2.4.1 Stakeholder Interview Notes

Fourteen interviews were conducted with community, political and agency stakeholders. Bulleted summary notes on items addressed by interviewees are listed below and broadly categorized into six groups. A detailed compilation of individual interview notes can be found in Appendix D [(40)] [(41)] [(52)] [(53)] [(54)] [(55)] [(56)] [(57)] [(51)] [(58)] [(59)] [(60)] [(61)] [(62)].

Dumping:

- The community in general was largely unaware of the Māʻiliʻili Stream enforcement case against the City & County that resulted in this WMP. Most people had no idea that this dumping had occurred.
- Multiple people brought up the issue of unpermitted industrial activity on agricultural lands in the Puhawai neighborhood, including junkyards and cement recycling. The community wishes for a general increase in enforcement by the City against unpermitted activities and illegal dumping.
- Some people dump large and small items in streambeds and cover them up. Many properties store large trash items such as refrigerators and buses.
- Tire dumping is a specific dumping concern.
- There is concern about people with abandoned farm wells on their property and whether there may be illegal dumping of waste into abandoned wells, which could contaminate groundwater.
- One person mentioned the need for piggery operations to move to more modern waste disposal systems such as dry litter systems.
- Multiple people repeatedly mentioned various illegal activities by landowner David Souza, who caused a lot of flooding issues by deliberately damming Pūhāwai Stream. Lands formerly owned by Mr. Souza have batteries and equipment buried throughout and he is currently facing legal action.

Navy Lands:

- The community is concerned about what types of (possibly toxic) pollutants may be coming from the Navy lands because many rumors exist about what types of ordnance is stored at NAVMAG, etc. There is also concern about pesticide use.

- There is concern about potential wasting of water from pipes connected to the water tunnel at NAVMAG that are leaking and anecdotal reports of large leaking water pipes seen on Navy lands.

Water Quality:

- Some people reported sickness and skin rashes from entering the ocean after storms.

- There are several hotspot areas for streambank erosion that were discovered during the stream clean-up.

Historic Information:

- Every person interviewed who grew up in the area, reported a decline in stream and marine fish, invertebrate, and limu species since their childhoods.

- Stormwater runoff 40+ years ago included only natural material such as kukui nuts. Now, stormwater is browner and contains a lot more anthropogenic trash.

- People reported that the climate has gotten hotter and drier over the past few decades.

- There were some reports from older people that the streams used to flow year-round during their childhood.

- There were multiple unverifiable reports of various stream diversions throughout the watershed, by the Navy and sugarcane industry.

Political Issues:

- There is a general feeling in the community that the Waiʻanae coast gets neglected by the government compared to more affluent communities and therefore a lot of problems such as illegal dumping are able to continue.

- There is a general expectation that some stakeholders may not collaborate in future project implementation because they have special interests they are trying to secure.

- The basil farms are of concern not just for the environment, but apparently a human rights advocacy group (Pacific Alliance to stop Slavery) is also investigating for bad working conditions, human trafficking and lack of protective gear when spraying pesticides.

- State politicians are interested in assisting with future needs in the watershed, particularly Senator Maile Shimabukuro and Representative Jo Jordan.

Future Projects from this WMP:

- There is huge concern about the pesticides being sprayed at the numerous basil farms. Suggestions were made to implement educational projects about pesticide use and Chinese-speaking interviewees offered to help with the communication aspect as many of the basil farmers only speak Chinese.

- A huge clean-up effort was initiated and coordinated by State Representative Jo Jordan in 2011/2012 and there is great interest in ongoing projects like this, including community water quality monitoring.

- Educational programs were suggested to teach people about illegal dumping.

- Interest in clean-up of abandoned properties through 319 and/or Brownfields funding

- DOFAW recently acquired roughly 700 acres of land mauka of NAVMAG, which was designated by Executive Order 4414 as the "Lualualei Forest Reserve". To date, no specific management measures have been implemented yet, but there is future potential for collaboration between DOFAW and the Navy for ungulate control, etc.

- There was repeated questioning of how meaningful this kind of WMP is really going to be and emphasis that projects to be implemented need to actually make a difference.

2.4.2 Point Source and Non Point Source Pollution

Pollutants transported in runoff (stormwater, agricultural, urban) can be categorized as either point source or non point source pollution. Point source pollution is discharged from a distinct and known point such as a sewage outfall pipe. The CWA allows for the limited and regulated discharge of certain pollutants from point sources directly into surface waters, e.g. a pipe. Point sources are regulated under the CWA via National Pollutant Discharge Elimination System (NPDES) permits (15). In Hawaiʻi, DOH CWA administers NPDES permits. In the Māʻiliʻili Watershed, NPDES permits have been issued for various dairy operations, gas stations, construction projects, Navy sewage pipes, the Māʻiliʻili Stream debris removal following the stream dumping case, etc. Long-term permits are in effect for the Navy MS4, the City & County MS4, as well as the State DOT (Oʻahu) MS4 (36) (35).

Non point source (NPS) pollution comes from a variety of sources that may or may not be known and can not be traced back to a specific point, such as a pipe. Therefore it is so difficult to control water quality problems because the source of NPS is usually unknown and hard to control. NPS pollution can come from agricultural fields, streets, parking lots, the upper reaches of watersheds and various diffuse sources. Part of the watershed management planning process is to identify the land uses contributing to NPS pollution within a watershed, quantify load reductions, and propose remedial actions (7).

2.4.3 Analysis of Strengths, Weaknesses, Opportunities & Threats (SWOT)

Table 8. SWOT Analysis

Strengths (S)	Weaknesses (W)
• Project ideas will be able to align with the WWMP and WSCP • Some funding is already available • WMP will make projects eligible for 319 funding • Some low-cost projects are easy to implement	• Lack of water quality data • Access to Navy lands difficult • Access to Navy data difficult • Navy procedures take time • Streams are not perennial • Lack of larger scale funds for capital improvements projects • Lack of watershed organization to push for project implementation
Opportunities (O)	**Threats (T)**
• Plenty of community interest • Combined water quality/flood control projects • Expand the involvement of students and volunteers • Active pursuit of fundraising • Create Watershed Hui	• Loss of federal and other funding sources due to bad economy • Loss of federal and other funding sources due to government cutbacks • Loss of even more government capacity to enforce/implement • Climate change

3. Watershed Management Strategies

Sections 1 and 2 described the land use characteristics and identified water quality problems in the Māʻiliʻili Watershed. Management strategies will need to address the lack of water quality monitoring data and the pollutants of concern as identified below. Some strategies and practices are meant to provide “multiple benefits” as outlined in the project proposal, for example related flooding and ecosystem restoration benefits. These may not have an immediately measurable water quality effect, but are expected to bring long-term beneficial impacts to the ecosystem and the community.

3.1 Management Measures and Management Practices

As described in the Hawaiʻi Watershed Guidance, a management measure is a group of management practices that address a particular general water quality issue. For example, the guidance lists six different management measures that apply to agriculture in Hawaiʻi. These include “Erosion and sediment control”, “Nutrients” and “Pesticides”, all of which are of importance in the Māʻiliʻili Watershed. There are multiple management practices available for achieving each management measure. For example, erosion control can be addressed via cover crops and crop rotation, planting of field borders and other agricultural erosion BMPs [(6)]. Locations of BMPs for mauka areas are shown in Figure 29 (pg.119); locations for makai BMPs are shown in Figure 30 (pg. 121). This watershed plan lists the management practices by land use/cover type. The six land cover types used for this plan are:

Agriculture: The private neighborhood around Puhawai Road

Forested Lands: The mauka areas of forested Navy and DOFAW lands

Uplands: The mauka areas of shrubland on the Navy installation (NAVMAG)

Grasslands: The maintained grassy areas on the lower Navy installation (RTF)

Riparian Zone: The stream channels and banks throughout the watershed

Residential: This includes the urban areas and also addresses non-agriculture related issues in the private neighborhood.

3.2 Pollutants of Concern

Until more longer term water quality data are obtained, we can use best professional judgment based on initial sampling, field assessments and literature review, as well as water quality models to identify pollutants of concern. The four pollutants of concern are listed in the following sections.

3.2.1 Nutrients

Qualitative observations and some quantitative data suggest that there is an influx of nutrients from the agricultural neighborhood, which is a typical problem in any watershed containing agricultural land uses due to fertilizer inputs (13). Nutrients have also been identified as a top priority water quality problem in Hawaiʻi (and the US) and other watersheds in the Waiʻanae moku with similar conditions have nutrient-related impairments (42). In addition, the known presence of feral pigs in the uplands and the lack of centralized sewage treatment are indicators of potential nutrient problems. According to our STEPL modeling results (see Tables 15 and 16 in section 3.3.1), the highest average (per acre) nutrient contributions come from agricultural lands. However, the total acreage under cultivation is small relative to the size of the watershed, so additional nutrients might be coming from the uplands. Our limited water quality data indicate very high nutrient loads coming from the agricultural areas.

3.2.2 Pesticides/Herbicides

Pesticides were repeatedly identified during stakeholder consultations as a great concern throughout the private agricultural neighborhood, particularly for areas under basil cultivation. The mis-use of pesticides and use of illegal pesticides on basil farms on Oʻahu has been investigated by DOH and DOA over the past few years (63) and local residents and organic farmers are extremely concerned about this issue. Community members are also concerned about pesticides/herbicides possibly coming down from Navy lands and affecting water quality. Our limited water quality data did not indicate agriculture-related pesticide/herbicide problems. Waters coming from Navy lands had detectable but low levels of four organochlorine pesticides. Pesticides are not part of the STEPL model, but future longer term water quality testing may confirm pesticide problems.

3.2.3 Sediments

Field inspection revealed that eroding streambanks are of particular concern in the Puhawai neighborhood. Sediments are likely to be a problem in any agricultural watershed. According to our

STEPL modeling results (see Tables 15 and 16 in section 3.3.1), the highest average (per acre) sediment contributions come from agricultural lands. However, the total acreage under cultivation is small relative to the size of the watershed, so additional significant sediment loads might be coming from the uplands. Water quality data suggest that TSS, which includes sediments, were elevated in the agricultural areas and very high on Navy lands.

3.2.4 Trash

Stakeholder consultation revealed a long-standing issue with trash dumping, which is a common problem in the Waiʻanae moku. Field inspections revealed some trash problems on roadsides and in streams, as well as storage of bulky and potentially hazardous items such as vehicles and refrigerators on people's properties, often in close proximity to streams.

3.2 Goals, Strategies & Management Practices

As described in section 1.3, the Hawaiʻi Watershed Guidance outlines a six-step planning process for watershed plans. Step 3 of this process is to "Set Goals and Identify Solutions". This begins with an articulation of management goals, objectives to achieve those goals, and measurable indicators or targets for achievement of the objectives. Indicators and targets are typically a quantitative measure and depending on the goal, can be environmental (e.g. water quality measurements), programmatic (e.g. database tracking BMP installation) and social (e.g. sign-in sheets at community meetings) [(6)]. Section 3.2.1 lists the goals, objectives and indicators identified for the Māʻiliʻili Watershed.

3.2.1 Goals, Management Objectives & Indicators

Goal 1: Meet State water quality standards in the Māʻiliʻili Stream, estuary and nearshore waters.

Objective 1: Establish baseline water quality data for the watershed.

Indicator(s): Water quality measurements

Objective 2: If baseline data indicate impairment, reduce pollutant loads. If there are no impairments, maintain water quality.

Indicator(s): Decrease in measured pollutant levels/maintenance of status quo

Goal 2: Identify and prioritize management practices to control non point source pollution.

Objective 1: Select physically and economically feasible management practices.

Indicator(s): Maps showing BMP locations; basic cost estimates

Goal 3: Increase public awareness and understanding of water quality issues in the Māʻiliʻili Watershed.

Objective 1: Work with community and partner organizations to coordinate outreach activities to farmers, residents, and other landowners.

Indicator(s): Number of people at community meetings

Objective 2: Work with community and partner organizations to promote public participation.

Indicator(s): Number of people signed up for stream clean-ups or other volunteer activities.

Goal 4: Spark public interest in BMP implementation.

Objective 1: Work with community and partner organizations to raise awareness of available funding and other assistance opportunities.

Indicator(s): Number of people at community meetings, number of landowners requesting or inquiring about financial and technical assistance.

3.2.2 Management Practice Recommendations by Source

The management practices described in this watershed plan are based on guidelines from the Hawaiʻi Watershed Guidance [(6)]. Many of the management practices recommended by the Guidance come from the NRCS "Field Office Technical Guide" (FOTG), a database of conservation practices and references, customized for each state [(64)]. These "conservation practices" (i.e. BMPs) are particularly extensive for agriculture, but were amended wherever needed with additional management practices not covered by NRCS. When using the STEPL model, which can calculate load reductions for some of the NRCS practices, it makes sense to use this NRCS system in order to get the most accurate load reduction results. However, for certain land use types it was necessary to suggest non NRCS practices, which are listed with no associated FOTG #. Cost estimates were made using NRCS FOTG spreadsheets wherever possible and/or through consultation with service providers and RS Means cost data [65]. Any cost estimates NOT based on NRCS data are denoted with an asterisk (*). These were used when NRCS data was unrealistic and we had access to more detailed locally relevant information.

3.2.2.1 Agriculture

The Hawaiʻi Watershed Guidance lists six management measures related to agriculture, four of which apply to the Māʻiliʻili Watershed (Erosion and Sediment Control, Nutrients, Pesticides, and Irrigation Water). The STEPL results and especially water quality data show high contributions of nutrients and possibly sediments coming from agricultural areas, which is to be expected. The agricultural neighborhood is a priority area for BMP implementation.

Table 9. Management Practices for Agriculture (see Figure 30)

Management Practice	FOTG#	Flooding*	Implementation	Cost Estimate
Conservation Crop Rotation	328	✓	Farmers	$97/acre
Cover Crop	340	✓	Farmers	$516/acre
Critical Area Planting	342	✓	Farmers	$857/acre
Field Border	386	✓	Farmers	$1,017/acre
Filter Strip	393	✓	Farmers	$30/foot (for vetiver)*
Integrated Pest Management	595		Farmers	$77.66/acre
Mulching	484		Farmers	$12-24/cy (non-plastic)
Nutrient Management	590		Farmers	$97.31/acre
Vegetative Barrier	601	✓	Farmers	$30/foot (for vetiver)*

*Checked if practice has a beneficial side effect on flooding

BMP definitions and details [64]:

CONSERVATION CROP ROTATION (# 328) refers to the growing of crops in a planned sequence on the same field, which can help improve soil quality, reduce erosion and decrease the need for pesticides and fertilizer by avoiding the typical pitfalls of a monoculture.

COVER CROPS (# 340) refers to grasses, legumes and other plants used as part of a crop rotation (see #328) to provide seasonal cover and soil conditioning benefits. A cover crop is considered a crop in the conservation crop rotation (#328).

CRITICAL AREA PLANTING (# 342) refers to the establishment of permanent vegetation in areas with heavy erosion problems, including eroded streambanks. It is particularly useful for areas requiring stabilization before or after flood events. This management practice also applies to the "Riparian Zone" when used in or alongside a stream. Additional uses are road construction areas, urban conservation sites or generally degraded areas.

FIELD BORDER (# 386) refers to strips of permanent vegetation bordering agricultural fields. This management practice can help reduce runoff and wind erosion from fields and thereby improve water quality. The Pacific Islands Vegetative Guide provides a long list of suitable species. This practice is recommended for all agricultural fields with erosion and runoff concerns and particularly for the basil fields to minimize fertilizer and pesticide runoff. Vetiver grass is recommended to help remediate pesticide problems as it has many phytoremediation applications.

FILTER STRIP (# 393) refers to a strip of herbaceous vegetation planted in an area where it captures runoff from overland flow. This can help reduce suspended solids and other contaminants in the watershed. This practice is recommended for the hillside/ridge between Mauna Kuwale and Puʻu Pāheʻeheʻe. The Pacific Islands Vegetative Guide offers a comprehensive list of suitable species.

INTEGRATED PEST MANAGEMENT (# 595) is a site specific combination of pest prevention, avoidance, monitoring and suppression strategies. This management practice should be adopted by farms that are managing pests and is of particular concern for the basil farms. IPM programs use the best most current information on pest life cycles and control methods to control pests in the most economical way with least possible hazard to people and the environment. IPM is described by EPA as a "continuum", i.e. farms could be using some IPM solutions but can move farther along the continuum by employing all possible IPM techniques. IPM would likely consist of an educational program for farmers. Assistance on best practices is available through agricultural extension offices.

MULCHING (# 484) is the application of plant residues or other materials to a land surface to conserve soil moisture and temperature, suppress weed growth, improve soil quality and facilitate establishment of vegetation. Mulching is often used at organic farms to help suppress plant diseases and weeds. This practice is generally recommended for any farm and for non-organic farms could potentially help reduce the amount of pesticides required.

NUTRIENT MANAGEMENT (# 590) is the proper management of amount, source, application and timing of fertilizer inputs. Misapplication or overuse of fertilizers is a common problem and similar to Integrated Pest Management, every farm applying nutrients to their crops should be provided with the proper information and training on correct nutrient management. This requires the development of a nutrient budget. Assistance is available from agricultural extension offices.

VEGETATIVE BARRIER (# 601) refers to permanent strips of stiff vegetation established along slope contours or across concentrated flow areas such as ephemeral gullies, which are typical for agricultural areas with tillage and irrigation. There are no large gullies that are observable via aerial imagery in this watershed, but any smaller concentrated flow erosion areas identified in the future can be addressed with this management practice. The NRCS FOTG specifically recommends vetiver grass due to its Vegetation Stiffness Index (VSI).

Hawaii Sunshine Vetiver can be used as a field border, filter strip or vegetative barrier, providing multiple benefits [66]

3.2.2.2 Forested Areas

The Hawaiʻi Watershed Guidance lists ten management measures for "forestry", many of which are not applicable to the Māʻiliʻili Watershed as there is no timber extraction and the forested lands are limited to Navy and State Forest Reserve lands. The STEPL results for forested lands show very low contributions of sediments and other pollutants. However, this does not take into account the existence of invasive species that can alter the hydrology (e.g. strawberry guava) and feral ungulates, which are known to be present throughout the Navy and forest reserve lands. The Navy is already actively managing four protected areas at NAVMAG and implementing several of the

NRCS conservation practices there. Table 10 shows the additional recommended management measures for forested lands.

Table 10. Management Practices for Forested Areas (see Figure 29)

Management Practice	FOTG#	Flooding	Implementation	Cost
Fence	382		Navy/DOFAW	$20/ft
Forest Stand Improvement	666	✓	Navy/DOFAW	$10,000/acre*
Riparian Forest Buffer	391	✓	Navy/DOFAW	$7.40/plant
Ungulate Control (material incl. traps/snares)	N/A		Navy/DOFAW	$50/acre*

BMP definitions and details (64) (67):

FENCE (# 382) refers to construction of a fence barrier to control the movement of people or animals. In Hawai‘i, fences serve to control feral ungulates, including pigs and goats, which have an extremely detrimental effect on forest ecosystems and water quality. The Navy already has some fenced enclosures. Opportunities may exist to connect fences to existing DOFAW or Army fences or create additional enclosures.

FOREST STAND IMPROVEMENT (# 666) refers to the manipulation of species composition, in this case specifically the selective removal of invasive species such as strawberry guava or christmasberry from a priority area like an enclosure or an area with a high density of invasives. This can have direct and indirect beneficial impacts on water quality. The Navy has four specially managed habitat areas with fenced enclosures in the upland and forest areas where this management practice can be implemented to improve the species composition.

RIPARIAN FOREST BUFFERS (# 391) are areas of selected trees and shrubs planted upgradient of a streambed to reduce excess sediments, organic material, nutrients and pesticides. This practice would be best implemented after removing invasive species from an area to restore native habitat or in areas where vegetation may be sparse. Exact locations for implementation of this management practice would have to be assessed together with Navy and DOFAW.

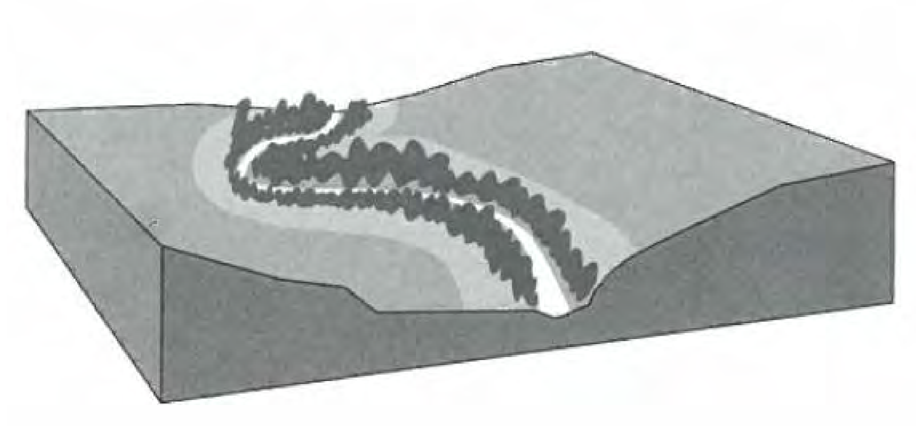


Diagram: Riparian Forest Buffer (67)

UNGULATE CONTROL refers to the removal of feral ungulates including pigs and goats by trapping, snaring or hunting. This can be done throughout a landscape, but is of particular importance after creating a fenced enclosure. The Navy should focus on ungulate control in and around the four special management areas. These areas are up mauka, where pig rooting and other activities can be a major NPS pollution source. There may also be potential for partnering with DOFAW to coordinate ungulate control between the Navy lands and the forest reserve as well as partnership with WMWP and the Army to connect existing and new fences. Due to access limitations, public hunting is currently not allowed. However, the Navy's Integrated Natural Resource Management Plan lists permitted/controlled public hunting with dogs and knives as a future possibility, along with aerial goat and pig hunting in partnership with DOFAW. Fees for public hunting programs could then be re-directed to fund future natural resource management activities at the NAVMAG installation.

3.2.2.3 Uplands

The Hawaiʻi Watershed Guidance doesn't provide specific management measures or guidance for "uplands" as this is a term used in this document to define the mostly kiawe and haole koa dominated areas covering most of NAVMAG. Many of the forestry and riparian BMPs can be applied on these lands as well. The Navy is already actively managing four protected areas at NAVMAG and is implementing several of the NRCS conservation practices there. Table 11 shows the additional recommended management measures for the forested/shrubby uplands.

Table 11. Management Practices for Uplands (see Figures 29 and 30)

Management Practice	FOTG#	Flooding	Implementation	Cost
Forest Stand Improvement	666	✓	Navy/DOFAW	$10,000/acre*
Fuel Break	383		Navy	$398/acre
Restoration and Management of Rare or Declining Habitats	643		Navy/DOFAW	$437/acre
Riparian Herbaceous Cover	390	✓	Navy	$10/sf or $30/ft for vetiver*
Sediment Basin	350	✓	Navy/USACE	$44/cy
Ungulate Control	N/A		Navy/DOFAW	$50/acre*

BMP definitions and details (64):

FOREST STAND IMPROVEMENT (# 666) refers to the manipulation of species composition, in this case specifically the selective removal of invasive species such as haole koa and christmasberry from a priority area like an enclosure or an area with a high density of invasives. This can have direct and indirect beneficial impacts on water quality. The Navy has four specially managed habitat areas with fenced enclosures in the upland and forest areas where this management practice can be implemented to improve the species composition. There is also a small pocket of native ‘iliahi (sandalwood) with potential for a small fenced enclosure.

A FUEL BREAK (# 383) is a strip or area of land, where vegetation has been cleared or reduced to control and reduce the spread of wildfires. The bare soil left behind by wildfires can increase sediment delivery in a watershed. Fuel breaks can help protect some of the fenced enclosures as well as reduce the risk of fire spreading towards Wai‘anae Valley. A situation like this occurred in 2012, when a fire originating from Lualualei NAVMAG spread into Wai‘anae Valley and caused widespread destruction. That fire was stopped by the taro lo‘i of Ka‘ala Farm, which acted as a firebreak. Since the Navy is not using much water anymore, some local stakeholders have suggested constructing taro lo‘i as a green firebreak between Lualualei and Wai‘anae Valley.

Taro loʻi at Kaʻala Farm served as a fire/fuel break during a 2012 wildfire

RESTORATION AND MANAGEMENT OF RARE OR DECLINING HABITATS (# 643) applies to areas that have or are currently supporting endangered native plants and animals. The purpose is to restore native aquatic or terrestrial habitat and improve biodiversity. This can include small or large fenced enclosures such as the ones already implemented by the Navy. An additional area the Navy could focus on is a small pocket of sandalwood trees off of Dent Street.

The existing wildlife refuge at NRTF supports endangered native water birds

RIPARIAN HERBACEOUS COVER (# 390) refers to the planting of grasses, sedges and other plants in riparian zones. There are many benefits of this management practice, including improved water quality, reduced flooding, stabilization of streambanks for erosion control, etc. The exact locations of eroding streambanks at NAVMAG are unknown, but some minor areas were observed during our field visit.

A SEDIMENT BASIN (# 350) can help reduce sediment transport in stormwater runoff by capturing and detaining runoff until sediments have settled in the basin, before releasing the remaining water through an engineered outlet. According to STEPL results, sediment load is highest from subwatershed B. The most suitable location for a sediment basin would be just mauka of the private neighborhood on Kuwale Road, although it can be assumed that much of the sediment load is actually coming from the agricultural areas makai of that location (see Figure 30). At this location, a basin would drain roughly 1,700 acres. At a cost of $44 per cubic yard, a sediment basin large enough to contain 10% of the 100-year storm would cost $14 Million. Although a sediment basin would theoretically reduce sediment runoff, as these costs are very high, it is an unlikely BMP for implementation. The NRCS FOTG describes it as a last practice in a series of erosion control and sediment capturing practices.

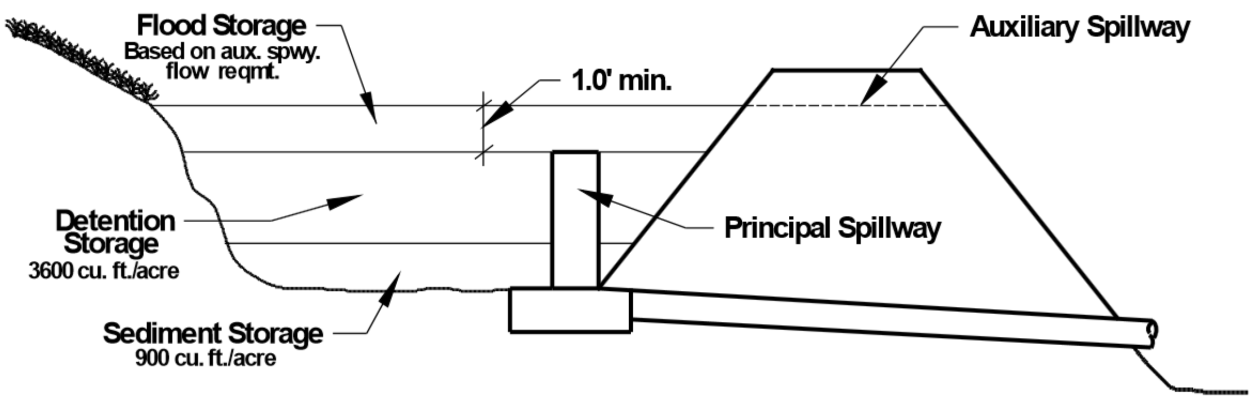


Diagram: Sediment Basin (64)

UNGULATE CONTROL refers to the removal of feral ungulates including pigs and goats by trapping, snaring or hunting. This can be done throughout a landscape, but is of particular importance after creating a fenced enclosure. The Navy should focus on ungulate control in and around the four special management areas. These areas are up mauka, where pig rooting and other activities can be a major NPS pollution source. There may also be potential for partnering with DOFAW to coordinate ungulate control between the Navy lands and the forest reserve as well as partnership with WMWP and the Army to connect existing and new fences. Due to access limitations, public hunting is currently not allowed. However, the Navy's Integrated Natural Resource Management Plan lists permitted/controlled public hunting with dogs and knives as a future possibility, along with aerial goat and pig hunting in partnership with DOFAW. Fees for public hunting programs could then be re-directed to fund future natural resource management activities at the NAVMAG installation [29].

3.2.2.4 Grasslands

The grasslands covering the Naval RTF are already being actively managed with NRCS practices such as grassed waterways and wildlife habitat protection/predator control at the constructed wetland (Niuliʻi Pond). Part of RTF close to the Māʻiliʻili Stream channel contains a small area with native and endangered plants, which have already been tagged and are being monitored.

Table 12. Management Practices for Grasslands

Management Practice	FOTG#	Flooding	Implementation	Cost
Grassed Waterway	412	✓	Navy	$1.20/sq ft
Integrated Pest Management	595		Navy	$77.66/acre

BMP definitions and details [64]:

GRASSED WATERWAY (# 412) refers to shaped or graded stream channels with suitable vegetation (including grass) with the purpose of transporting runoff without causing erosion or flooding. This management practice is already in place at NRTF. Future maintenance or modifications may be necessary if additional pollutant loads are expected.

Existing grassed waterways at NRTF

INTEGRATED PEST MANAGEMENT (# 595) is a site specific combination of pest prevention, avoidance, monitoring and suppression strategies. IPM programs use the best most current information on pest life cycles and control methods to control pests in the most economical way with least possible hazard to people and the environment. The Navy is keeping a manicured mowed grassland area at this installation and Integrated Pest Management is recommended as a holistic approach towards weed control.

3.2.2.5 Riparian Zone

The riparian zone includes the stream channels, banks and adjacent buffer areas. This was chosen as a separate category due to existing specific streambank erosion problems.

Table 13. Management Practices for Riparian Zone (see Figure 30)

Management Practice	FOTG#	Flooding	Implementation	Cost
Gabions (6‘x3‘x3‘)	N/A		City	$500 each*
Geotextiles (woven mesh)	N/A		City	$3.50/sy*
Riparian Herbaceous Cover	390	✓	Commnity	$10/sf or $30/ft for vetiver*
Streambank and Shoreline Protection	580		Various	Depending on specific activities.
Stream clean-ups	N/A	✓	Community	N/A
Water Quality Monitoring	N/A		CWB, Community	$1,000 per sample (assuming volunteer labor and borrowed in-stream equipment)*

BMP definitions and details [64] [67] [68]:

GABIONS are rock- filled “cages” or wire baskets used in many engineering applications, including the stabilization of streambanks or slopes. A small gabion retaining wall is recommended makai of the upper Puʻuhulu Rd. bridge to reinforce the severely eroding streambank. This retaining wall and the surrounding bank should also be planted with erosion controlling vegetation.

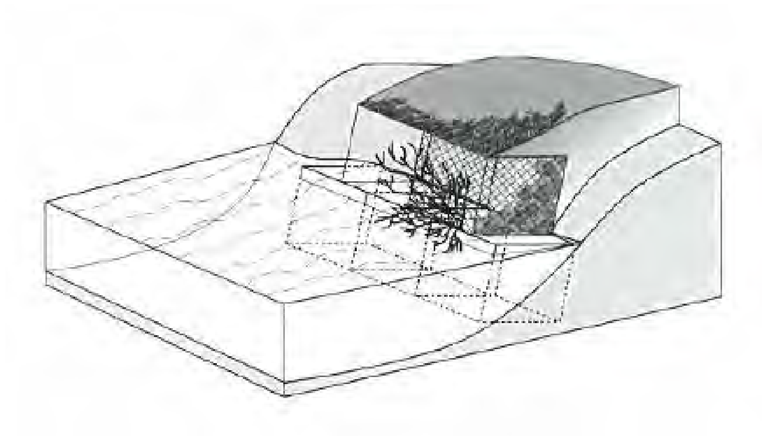


Diagram: Vegetated Gabions [67]

GEOTEXTILES are materials used to cover, support and protect eroded areas such as streambanks and can include a variety of different types, including coconut coir logs and woven mesh fabric. Coconut coir logs facilitate the establishment of vegetation which can help meet a longterm streambank stabilization goal.

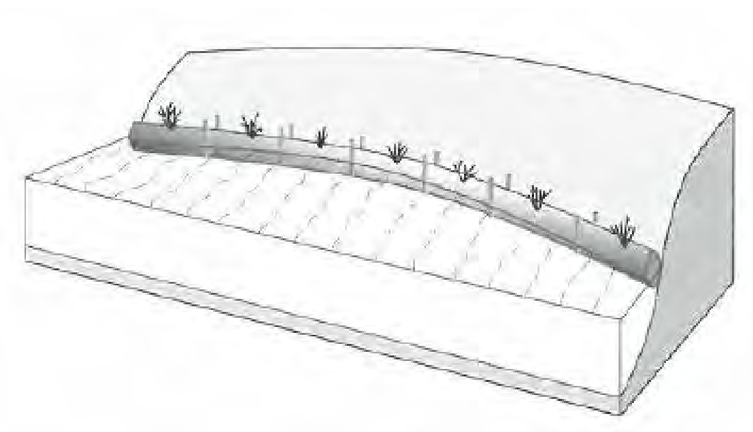


Diagram: Coconut fiber roll (coir log) [67]

RIPARIAN HERBACEOUS COVER (# 390) refers to the planting of grasses, sedges or other suitable plants to reduce erosion, trap sediments and improve water quality, among other benefits. Field reconnaissance revealed several areas of streambank erosion along Puʻuhulu and Puhawai Stream. Planting of grasses or other plants to stabilize streambanks and protect them from erosion is recommended along sections of these tributaries. Hawaiʻi Sunshine Vetiver, a non-invasive grass species specifically used for streambank stabilization and erosion control, could provide tremendous benefits for erosion and associated water quality problems, as well as flooding. It has been used successfully throughout the world to mitigate erosion and water quality problems. Vetiver is also known to remove toxic contaminants from water and soil and is therefore often used for bioremediation purposes. A vetiver installation pilot project along Puhawai Stream could be a great first step in showing the capabilities of this BMP. Vetiver is planted in rows at a cost of $30 per linear foot. Depending on the specific site conditions, including slope and soils, the spacing of vetiver rows is 3 feet on average. The vetiver nursery could also teach a community group how to install vetiver themselves and then provide the plants. This would bring the cost down considerably.

Vetiver has many applications, including slope and streambank stabilization and erosion control [66]

STREAMBANK AND SHORELINE PROTECTION (# 580) is a general NRCS conservation practice that covers any "treatment(s) used to stabilize and protect banks of streams or constructed channels…" Proposed treatments need to be specified on a case by case basis.

STREAM CLEAN-UPS such as the ones organized in the past by Representative Jo Jordan should be repeated at least bi-annually to keep trash and debris out of the streambeds. Community stream clean-ups can increase channel capacity immensely, reducing flood hazards [68].

Clean-up effort with State Civil Defense removed several truckloads of trash and debris

WATER QUALITY MONITORING is recommended as an ongoing practice to establish baseline data and monitor the water quality over time. There may be opportunities to do this as a community project involving students to increase community participation and reduce overall monitoring costs.

3.2.2.6 Residential

Residential areas are those considered “urban” on the land cover maps, as well as the private neighborhood around Puhawai, which is both a residential and agricultural area. The management practices listed here don’t refer to agricultural activities in the neighborhood, but to general urban management measures related to onsite disposal systems and other identified problems.

Table 14. Management Practices for Residential/Urban Areas (see Figure 30)

Management Practice	FOTG#	Flooding	Implementation	Cost
Baffle Box	N/A		City	$40,000*
Cesspool replacement	N/A		Homeowners	$5,000-$12,000/1,000 gallons (septic tank); $20,000-$30,000/1,000 gallons (ATU)*
Culvert replacement	N/A	✓	City	$20,000-$50,000 for new culvert*
Illegal Dumping Control/Enforcement	N/A	✓	Community	N/A
Preventing Septic System Failure	N/A		CWB, Community	N/A
Zoning Enforcement	N/A		City/State	N/A

BMP definitions and details:

BAFFLE BOXES are pre-engineered concrete/membrane structures installed in line or at the end of stormwater drain pipes to filter out sediments, suspended particles and other associated pollutants before releasing the runoff into a water body. A baffle box at the end of the City drainage pipe would reduce pollutant loads entering the Māʻiliʻili Stream channel.

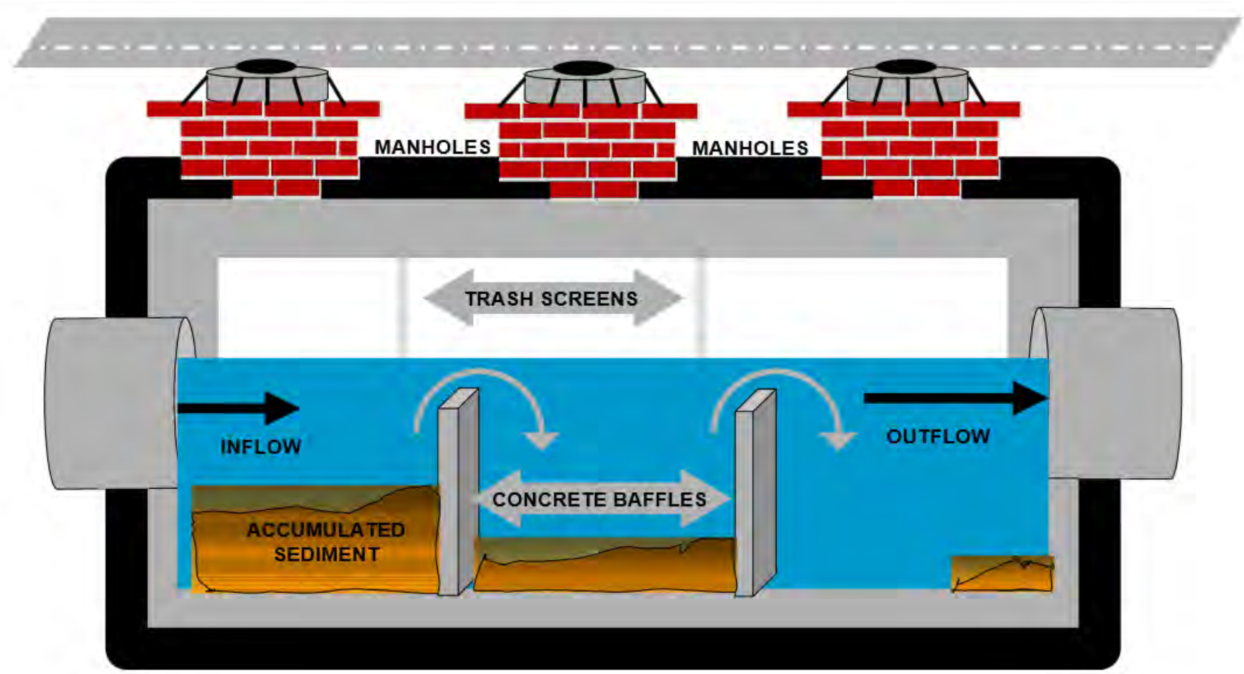


Diagram: Baffle Box (69)

CESSPOOL REPLACEMENT refers to the replacement of any known existing cesspool with a modern septic tank or Aerobic Treatment Unit (ATU). New cesspools are no longer permitted due to their known environmental impacts, but many old properties still using cesspools should replace them with septic tanks or better, Aerobic Treatment Units (ATU). This should be done on every property still using a cesspool, with priority focus on problematic/leaking cesspools. ATUs produce a higher quality effluent than septic tanks due to the secondary level of treatment provided by aerobic bacteria and are therefore much more costly (70).

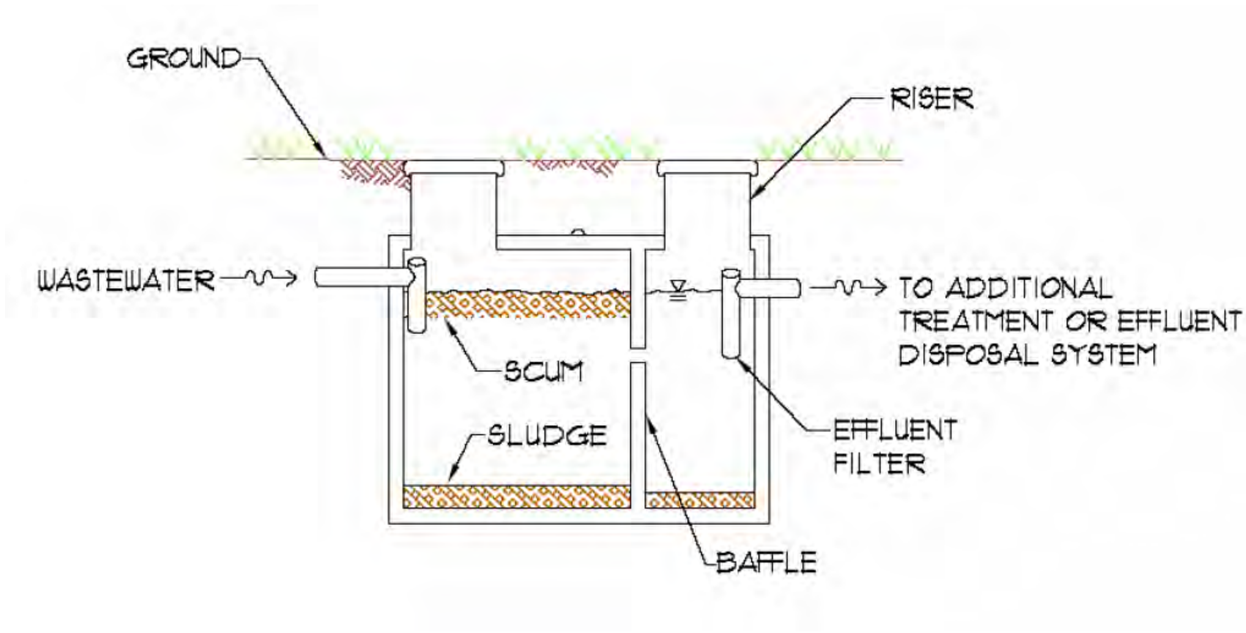


Diagram: Septic Tank (70)

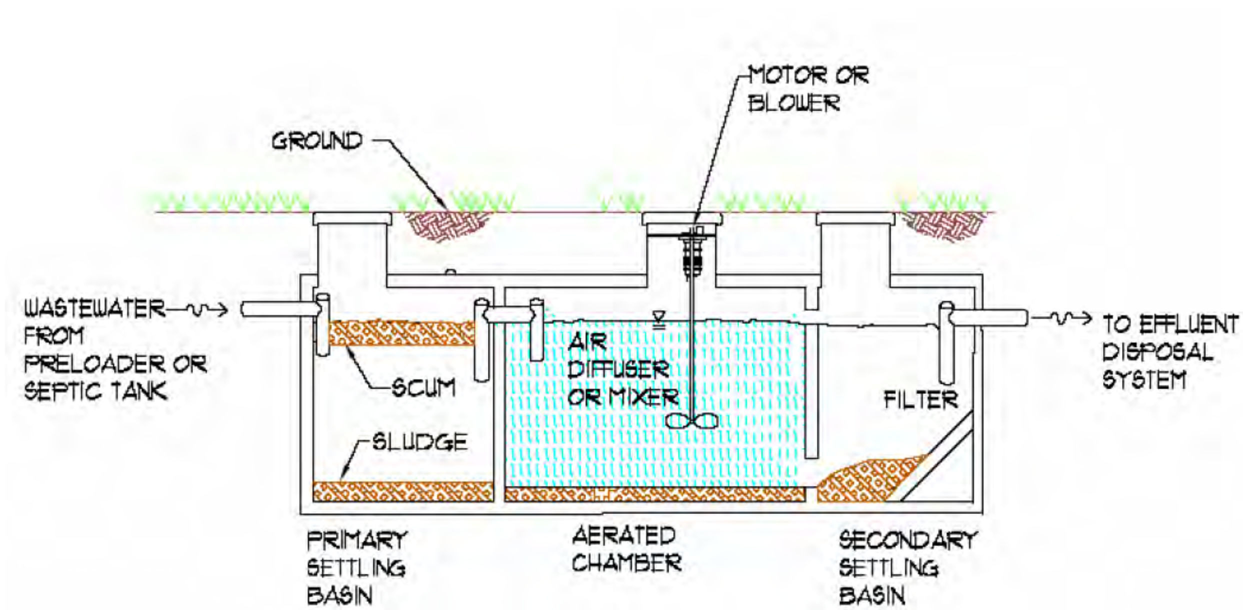


Diagram: Aerobic Treatment Unit (70)

CULVERT REPLACEMENT refers to the replacement of existing damaged or undersized culverts to ensure adequate conveyance of stormwater flows. Many of the culverts in the Māʻiliʻili Watershed were already identified in the Lualualei Flood Study as needing replacement [2]. Adequately designed culverts can reduce erosion and roadway flooding. Replacing an existing culvert with another culvert is one method, but culverts in general are not considered ideal because they cause erosion and upstream flooding problems if they become clogged. Better, yet more costly options would be to replace culverts with bridges; or for rural areas like this, to do away with culverts altogether and instead design the roads as fords that cross streams at their natural grade while allowing the stream to cross the road during heavy flows [68].

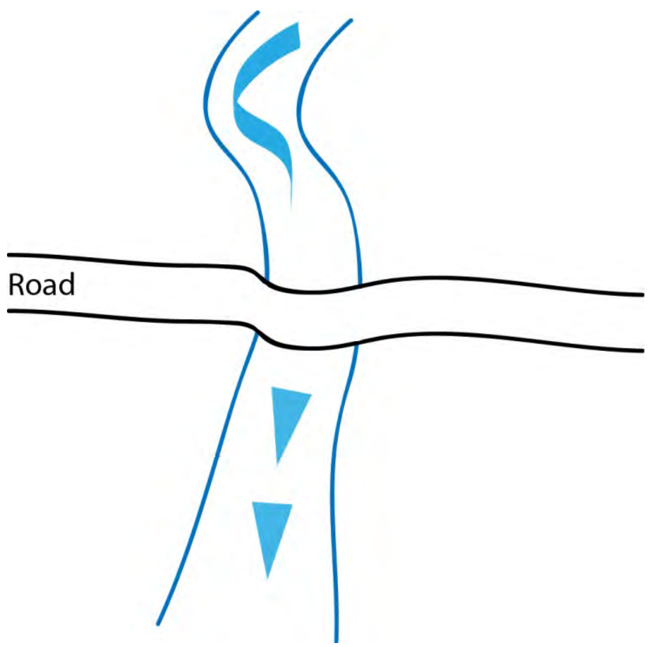


Diagram: Ford Crossings can be used in lieu of culverts

ILLEGAL DUMPING CONTROL/ENFORCEMENT refers to activities designed to prevent illegal dumping such as watching and reporting of violations by volunteers, as well as enforcement of anti-dumping laws by the applicable government entities. Trash in streams reduces the channel's flow capacity, so preventing stream dumping can also serve a secondary flood prevention goal [68].

PREVENTING SEPTIC SYSTEM FAILURE refers to educational/outreach activities to increase awareness among homeowners and other relevant people critical to ensuring proper functioning and maintenance of septic systems. This can include community outreach flyers informing people of the proper maintenance schedule for septic tanks. Hawaiʻi has one of the highest septic system failure rates in the nation at roughly 25% according to CWB.

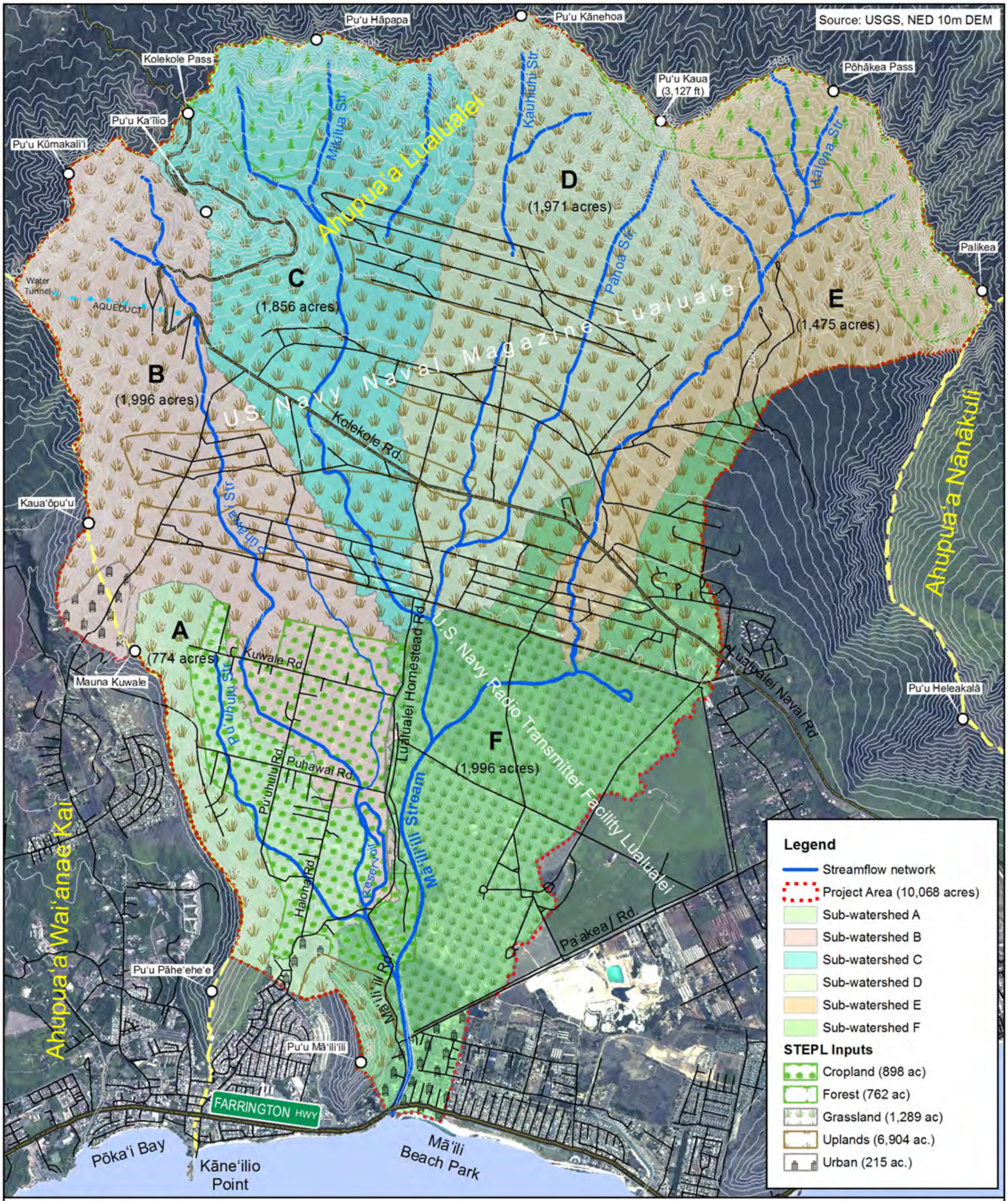
ZONING ENFORCEMENT refers to governmental enforcement of the state land use law and city zoning codes. This type of action was requested by several community stakeholders who are concerned about unpermitted uses of agricultural lands.

3.2.2.7 Future development low-impact development strategies

The Māʻiliʻili Watershed is mostly rural and not intended for commercial development. However, "Low Impact Development Strategies" (LID) is an approach recommended by EPA for all new developments, redevelopments and as retrofits to existing developments [(71)]. The City & County of Honolulu has adopted LID strategies into their amended Storm Drainage Standards as of 2013 [(72)]. The idea behind LID for new developments is to manage stormwater as close as possible to its source. Therefore, preventative measures can be taken instead of treatment after pollution has already occurred. Management practices for new developments include rain gardens, green roofs, permeable pavements and many more depending on the type of development and site specific conditions. Design and Guidance Manuals are available from EPA. The future of the Navy lands is unclear, but there is a possibility the Navy might sell all or portions of their holdings in Lualualei over the next 2-3 decades. According to EPA, LID when applied on a broad scale, can maintain or restore a watershed's hydrologic and ecological functions [(71)]. In the event that Navy lands are proposed for development in the future, or development of new sites takes place in this watershed, LID strategies should be used.

3.3 Pollutant Loads and Load Reductions

The model used to quantify pollutant load and load reductions for this watershed plan was STEPL ("Spreadsheet Tool for the Estimation of Pollutant Loads"), developed by TetraTech and approved by EPA as a pollutant load model [(73)]. This model can estimate loads for Nitrogen, Phosphorus, Sediments and BOD (Biological Oxygen Demand) as well as load reductions expected from implementing certain NRCS conservation practices. The model was not able to quantify load reductions for all BMPs discussed in this report. Since there are no TMDLs for this watershed, it is not possible to determine if the load estimates provided by the model are considered excessive, but the proposed water quality monitoring activities will determine whether water quality parameters are exceeded. Figure 28 shows the land use and sub-watershed inputs we used in the model.



Mā'ili'ili Watershed Management Plan

0 1 2 Miles

0 5,000 10,000 Feet

N E S W

Figure 28. STEPL Inputs

By: Townscape, Inc. For: Hawai'i Department of Health Date: August 2013

3.3.1 STEPL- baseline results

Tables 15 and 16 show the baseline results of the model, with no BMPs installed. Table 15 shows the load contributions by sub-watershed (as seen in Figure 28. "STEPL Inputs Map"), clearly indicating that the relative load (per acre) is highest from the agricultural areas. Table 16 shows the load contributions by source.

Table 15. STEPL baseline results by sub-watershed

Sub-watershed	Total annual N load (lbs)	N load per acre (lbs)	Total annual P load (lbs)	P load per acre (lbs)	Total annual sediment load (tons)	Sediment load per acre (tons)
A	23,874.7	30.88	8,270.2	10.69	5,006.3	6.47
B	45,173.6	22.48	15,086.8	7.5	10,269.8	5.11
C	29,499.0	15.92	9,955.3	5.37	7,072.8	3.81
D	35,873.3	18.25	12,082.6	6.15	8,650.2	4.4
E	17,794.4	12.11	6,245.7	4.25	4,623.3	3.14
F	41,003.7	20.5	9,740.4	4.87	5,524.7	2.76
Total/ *Average*	193,219.03	*19.19*	61,381.07	*6.09*	41,147.22	*4.09*

Table 16. STEPL baseline results by source

Source	Total annual N load (lbs)	N load per acre (lbs)	Total annual P load (lbs)	P load per acre (lbs)	Total annual sediment load (tons)	Sediment load per acre (tons)
Agriculture	31,073.5	34.71	10,536.34	11.77	7,746.95	8.65
Forest	662.34	0.87	293.83	0.38	101.47	0.13
Uplands	125,792.29	18.22	42,793.55	6.20	30,965.66	4.48
Grasslands	23,725.05	18.4	4,049.69	3.14	2,288.63	1.77
Urban	1,934.86	8.99	302.3	1.40	44.51	0.21
Septic	8,514.08	N/A	3,334.68	N/A	0	N/A
Groundwater	1,516.92	N/A	70.67	N/A	0	N/A
Total/ *Average*	193,219.0	*19.19*	61,381.07	*6.09*	41,147.22	*4.09*

3.3.2 BMP Effects and Load Reductions

The STEPL model only includes a few of the NRCS practices described here for its load reduction calculations. The model uses pollutant removal efficiency numbers for each management practice to render load reduction numbers. The pollutant removal efficiency has not been quantified for many of the management practices identified in this plan, so exact load reductions for the entire watershed are not quantifiable. Additional modeling was not part of the scope for this plan.

Table 17 serves as an example, showing the individual load reductions for some of the agricultural management practices the STEPL model was able to quantify. Practices recommended for the remaining (non-agricultural) sub-watersheds were not quantifiable within the scope of this plan, but are expected to result in significant load reductions.

Table 17. STEPL load reduction examples for Agriculture

BMP	% Area BMP Applied	Total annual N load (lbs)	% N Reduction	Total annual P load (lbs)	% P Reduction	Total annual sediment load (tons)	% Sediment Reduction
Buffer Strips	5 %	75	0.3	12	0.2	5.9	1.3
	20 %	300	1.3	47	0.8	24	5.3
Filter Strips	5 %	1,299	2.2	463	2.2	352	2.6
	20 %	5,196	9.0	1,850	8.8	1,406	10.3
Grass Swales	5 %	25	0.1	10	0.2	6.4	1.4
	20 %	100	0.4	40	0.7	26	5.8
Rain Gardens	5 %	157	0.7	31.5	0.6	0.0	0.0
	20 %	629	2.7	126	2.2	0.0	0.0
Sediment Basin	N/A (200 acre-feet)	9,022	20	3,024	20	2,201	21.4
Streambank Stabilization	5 %	1,485	2.6	529	2.5	406	3.0
	20 %	5,940	10	2,115	10	1,624	12

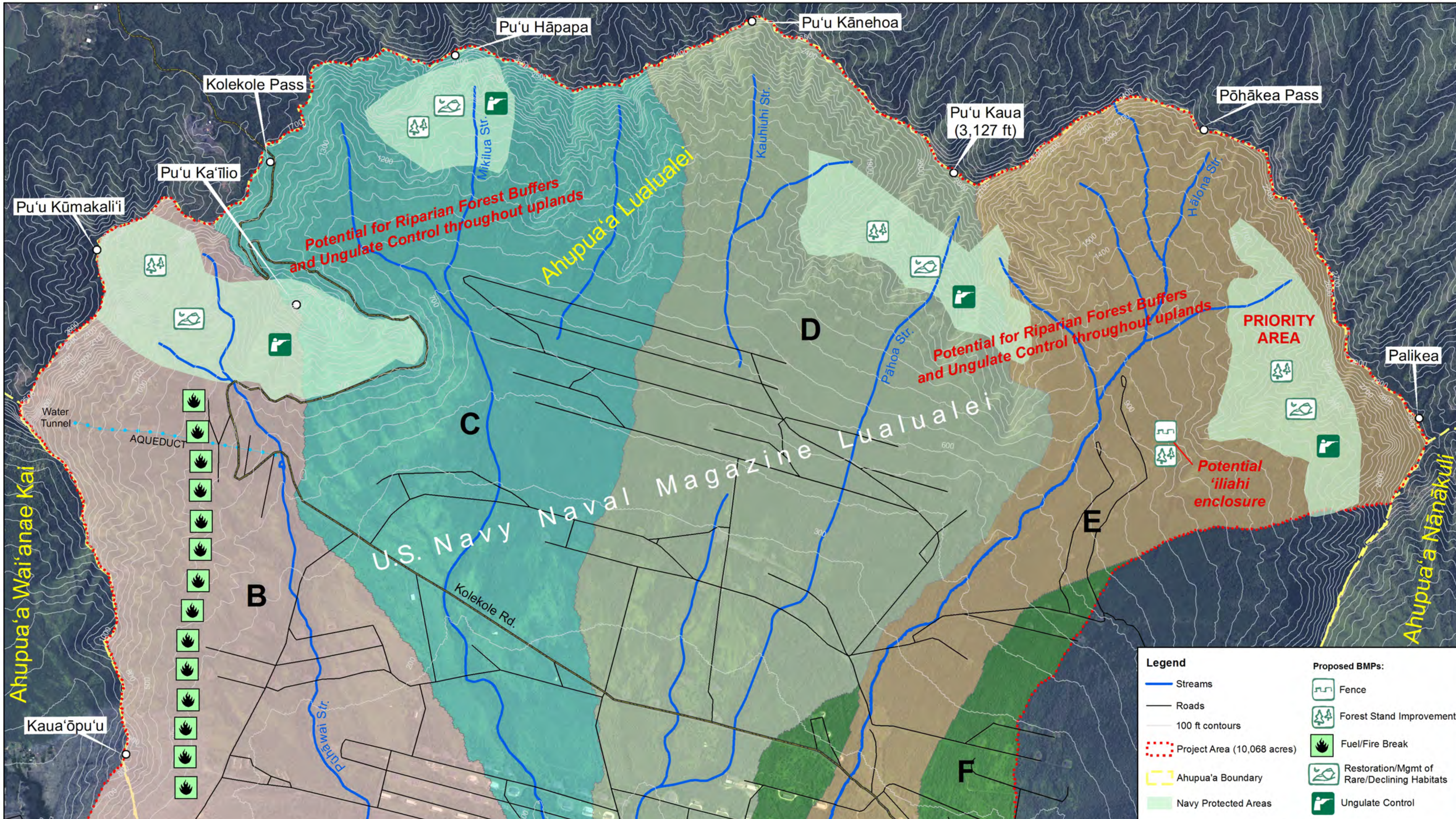
Table 18 illustrates qualitative assessments based on literature review. For practices listed in the NRCS FOTG, the "Conservation Practice Physical Effects" (CPPE) Matrix was used to qualitatively assess the effectiveness of each management practice on soil erosion and surface water quality. This matrix lists each conservation practice and assigns a level of effect on each individual resource concern [(74)]. For example, a sediment basin is listed as having a "moderate to significant" beneficial impact on sediment loads in surface water. Practices not listed in the FOTG were analyzed based on literature wherever possible.

Table 18. Management Practice Effects

Management Practice	FOTG #	Effectiveness
Agriculture:		
Conservation Crop Rotation	328	Slight to Moderate
Cover Crop	340	Slight to Moderate
Critical Area Planting	342	Moderate to Significant
Field Border	386	Slight to Significant
Filter Strip	393	Slight to Moderate
Integrated Pest Management	595	Slight to Significant
Mulching	484	Moderate to Significant
Nutrient Management	590	Significant
Vegetative Barrier	601	Slight to Moderate
Forest:		
Fence	382	Slight to Moderate
Forest Stand Improvement	666	Negligible. Long-term watershed benefits expected.
Riparian Forest Buffer	391	Significant
Ungulate Control	N/A	Slight to Significant depending on scale
Uplands:		
Forest Stand Improvement	666	Negligible. Long-term watershed benefits expected.
Fuel Break	383	Slight to Significant
Restoration/Management of Rare/Declining Habitats	643	Negligible. Long-term watershed benefits expected.
Riparian Herbaceous Cover	390	Slight to Significant
Sediment Basin	350	Moderate to Significant
Ungulate Control	N/A	Slight to Significant depending on scale
Grasslands:		
Grassed Waterway	412	Slight to Moderate
Integrated Pest Management	595	Slight to Significant
Riparian Zone:		
Gabions	N/A	Moderate to Significant
Geotextiles	N/A	Moderate to Significant
Riparian Herbaceous Cover	390	Slight to Significant
Streambank/Shoreline Protection	580	Slight to Significant
Water Quality Monitoring	N/A	N/A. Long-term benefits from data collection.
Stream Clean-ups	N/A	Significant impact on trash and debris.
Residential:		
Baffle Box	N/A	Slight to Significant, varies by conditions. (17,19)
Cesspool Replacement	N/A	Moderate to significant, varies by design etc. (12)
Culvert Replacement	N/A	Unknown. Long-term erosion and road failure benefits expected. (11,20)
Illegal Dumping Control & Enforcement	N/A	Depends on scale of control & enforcement effort. Potentially substantial.
Preventing Septic System Failure	N/A	Unknown. With the high rate of septic system failure in the state, benefits may be significant.
Zoning Enforcement	N/A	Unknown.

3.3.3 Priority Areas

Priority areas for installation and implementation of management practices are agricultural and riparian areas, as well as some of the Navy lands. Figures 29 and 30 show some of the suggested BMP locations.



Mā'ili'ili Watershed Management Plan

Figure 29. BMP Locations- Mauka

By: Townscape, Inc. For: Hawai'i Department of Health Date: January 2014

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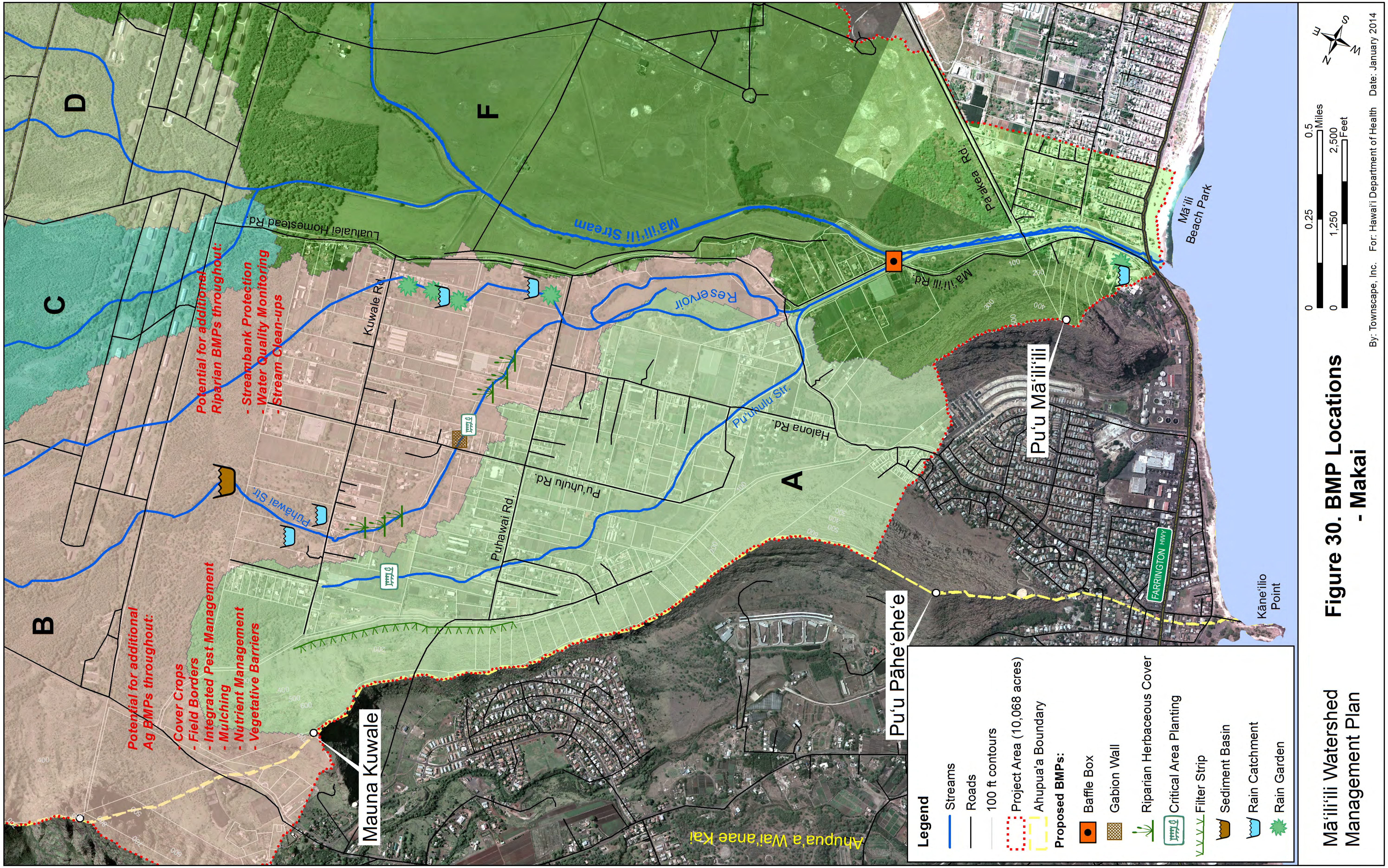
Figure 30. BMP Locations - Makai
Mā'ili'ili Watershed Management Plan
By: Townscape, Inc.
For: Hawai'i Department of Health
Date: January 2014
0 0.25 0.5 Miles
0 1,250 2,500 Feet
Legend
Streams
Roads
100 ft contours
Project Area (10,068 acres)
Ahupua'a Boundary
Proposed BMPs:
Baffle Box
Gabion Wall
Riparian Herbaceous Cover
Critical Area Planting
Filter Strip
Sediment Basin
Rain Catchment
Rain Garden
A
B
C
D
F
Mā'ili'ili Stream
Reservoir
Pu'uhulu Str.
Puhāwai Str.
Lualualei Homestead Rd.
Kuwale Rd.
Puhawai Rd.
Pu'uhulu Rd.
Halona Rd.
Mā'ili'ili Rd.
Pa'akea Rd.
Mā'ili Beach Park
Kāne'ilio Point
FARRINGTON HWY
Pu'u Mā'ili'ili
Pu'u Pāhe'ehe'e
Mauna Kuwale
Ahupua'a Wai'anae Kai
Potential for additional Riparian BMPs throughout:
- Streambank Protection
- Water Quality Monitoring
- Stream Clean-ups
Potential for additional Ag BMPs throughout:
- Cover Crops
- Field Borders
- Integrated Pest Management
- Mulching
- Nutrient Management
- Vegetative Barriers

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4. Implementation Plan

The primary focus of the implementation plan is to identify specific realistically doable projects, preferably with an identified “champion” who has expressed interest in taking the lead for implementation. These are the “priority projects”.

We consulted with several individuals, farmers and organizations who have expressed interest in submitting proposals for these implementation projects. Projects can include restoration activities such as re-planting of eroded streambanks, structural measures like sediment basins, or pollution reduction measures such as agricultural BMPs to reduce fertilizer runoff. In addition to 319 funding available through federal grants, projects in the Māʻiliʻili Watershed will be eligible for funding from the City & County settlement agreement. The available amount is approximately $750,000.

We prioritized projects based on the following criteria: (1.) Cost, (2.) Technical/permitting requirements, (3.) Identified “champion” for implementation, (4.) Expected benefits. Projects with a low cost and complexity that can be implemented with the settlement funds were identified as the highest priority (Group A). These are listed under Group A with a timeline of 3-5 years. More complex and/or costly projects for longer term implementation are included in Group B with a timeline of 5-10 years. Additional projects of higher cost and complexity or with low implementation likelihood are listed in Group C with an implementation timeline of 10-20 years.

The highest priority projects can be implemented using the settlement funds with additional funding sources listed in Table 18. These priority projects can be put out to bid by DOH via Requests for Proposal (RFP). It is not feasible for each farmer or landowner to have to respond to an RFP individually for each BMP they may want to install or implement as each proposal and resulting contract will have to go through the State procurement process. Instead, implementation of related projects will happen as part of specific “programs”, e.g. agricultural BMPs will be implemented by farmers with the assistance of a BMP program that will result from one of the RFPs presented in this plan. After completion of this watershed plan, DOH will start drafting RFPs for these projects and the winning bidder will implement projects that are part of the program outlined in the RFP.

4.1 Priority Projects: Group A (3-5 years)

4.1.1 RFP #1: Community Watershed Projects - *$150,000*

There is a need for a variety of community-based projects to be implemented in and around the Māʻiliʻili Watershed and for a community watershed group to establish a presence there. In order to implement many of the suggested management strategies and projects identified in the previous section (Watershed Management Strategies Plan), it will be necessary to have a person devoted to organizing and implementing community projects. This could be in the form of a "Watershed Community Coordinator" or similar title.

Projects to implement include, but are not limited to:

- Rain garden workshops and installation
- Rain catchment system workshops and installation
- Ongoing community water quality monitoring
- Ongoing community coral reef and ocean monitoring, in collaboration with Reef Check
- Illegal dumping control program
- Ongoing community stream clean-ups
- Educational programs for school children to learn about watershed health and best practices

We spoke with two community organizations that may be interested in responding to this type of RFP and who could devote a part-time staff member to coordinating and organizing community-based watershed projects along the Waiʻanae coast. Focus of this coordinator would be on the Māʻiliʻili Watershed, however, per the terms of the settlement agreement, the settlement money (which we propose as the source of funding for this position) can be used to improve water quality on the entire Waiʻanae coast. Moku-wide projects to be implemented by this coordinator in collaboration with the community and other interested parties will be activities such as educational programs for schools, which are likely to be outside the specific project area, but will bring benefits back to the watershed and surrounding areas. Watershed-specific activities would be things like workshops demonstrating low-impact development strategies such as rain gardens. These could be installed in the Māʻiliʻili Watershed. There may be potential for native plant restoration in the reservoir in the future. However, there is currently a farmer leasing the land to grow crops.

After speaking with CWB and two community organizations about the level of funding that would be required for a position like this, it was decided that this could be a part-time staff position for a minimum of 3 years in order for benefits achieved through implementation of these projects to become evident and measurable. After 3 years, if the community organization in question has established a well-functioning watershed program, they could apply for additional funding to keep the position going.

A similar situation occurred in the Koʻolaupoko moku, where a community watershed organization (Hui o Koʻolaupoko) that was supposed to be temporary in nature, continued operating on the windward side by receiving ongoing grant funding, which enabled them to hire staff to implement projects and coordinate with the community. They now have several community projects and have had thousands of volunteers attend their volunteer work days to install stream restoration projects on the windward side.

There is currently no organization similar to this in the Waiʻanae moku, but having an organization like this can help with long-term project implementation and benefits realized by the community. A similar organization on Kauaʻi that has successfully implemented many watershed projects is the Hanalei Watershed Hui [75]. Therefore, as suggested in the SWOT analysis in section 2.4.3 of this watershed plan, it would be beneficial to create a watershed hui on the Waiʻanae coast to facilitate long-term watershed protection and restoration for the entire moku.

Hui o Koʻolaupoko (HOK) could be used as a model and has offered assistance and training for creation of a watershed coordinator position and to help build capacity for whichever organization receives the contract resulting from this RFP. The organization would be able to contract directly with HOK for these capacity-building services.

After the initial 3-year period, the organization could keep the position alive with additional grants, including 319 funding and the EPA Targeted Watershed Grant Program, among others (see Table 19).The long-term vision is to have a functioning watershed organization with staff to work directly with stakeholders in the community and government agencies to improve watershed and community health for the entire moku.

Estimated funding for 3-year part-time position @ $20-$25/hr, plus benefits, plus materials and equipment **= $150,000**

Implementation Schedule:

Issue RFP soon after completion of watershed plan, start Watershed Coordinator position in 2015.

4.1.2 RFP #2: Agricultural Education and BMP Implementation Program - *$200,000*

Our land use analysis, stakeholder outreach and modeling revealed that agricultural activities are one of the main contributors of pollutant loads in the Māʻiliʻili Watershed. In addition, due to the majority of lands being under US Navy control, which has their own federal funding sources, it is most appropriate to spend the available settlement money on projects that will benefit and educate the community and local farmers as part of this Agricultural Education and BMP Program. Our consultations with NRCS revealed that there has been no implementation of agricultural BMPs with NRCS assistance in the Māʻiliʻili Watershed. Since NRCS is the major funding source for farmers to implement these activities, this suggests that likely very few BMPs are being used by farmers in this watershed, making it even more important to bring these issues and the availability of funding to the attention of Māʻiliʻili farmers.

Projects to implement include, but are not limited to (64):

- Nutrient Management Workshops and Education Series
- Integrated Pest Management Workshops and Education Series
- Basil Farmer Outreach and Education (in multiple languages and with multiple separate groups of farmers)

Installation of BMPs including, but not limited to:

- Cover crops/crop rotation
- Critical Area Plantings
- Field Borders
- Filter Strips
- Vegetative Barriers
- Grassed Waterways
- Rain Gardens
- Drip Irrigation
- Waste Management/dry litter systems for piggeries

In order for these activities to be implemented, it will require the commitment and dedication of an organization that has experience in providing services to agricultural communities in Hawaiʻi. There are a handful of organizations on Oʻahu that have demonstrated this ability and interest.

In addition to requiring agricultural and BMP expertise, a specific challenge for this watershed is the fact that many of the basil farmers do not speak English. Therefore, it will be necessary for the organization responding to this RFP to partner with an organization or individual(s) that is able to provide translation and facilitation services, primarily in Chinese, but possibly other Southeast Asian languages as well. One group with this kind of experience that has demonstrated a high level of interest is Pacific Gateway [(76)].

According to our GIS analysis (see Figure 23), roughly 72% of all cultivated parcels in the Puhawai neighborhood are growing basil, some exclusively. Most of these basil farmers are non- English speaking. Field reconnaissance also revealed that several wet streambeds are likely only wet due to runoff from basil farm irrigation water. This water is likely high in nutrients and pesticides, so priority focus should be on stream buffers and field borders around basil fields. Over one third of all parcels in this neighborhood are either bisected by a stream or within 100 feet of a stream and these parcels should receive priority BMP assistance to contain polluted runoff [(1)].

Funding for this priority RFP will come from the settlement agreement and these funds will be available for installation of BMPs on farms with a certain required cost-share by the farmers. Farmers can also apply for additional funding from various NRCS and other programs to cover their costs or supplement their needs (see Table 19 for additional funding sources).

During the course of this project, we consulted with several organizations that have experience in providing these types of services, including CTAHR and Oʻahu RC&D [(77)] [(78)]. Oʻahu RC&D currently has a similar program in Waimānalo, which could serve as a model for the program resulting from RFP #2. Activities will include community outreach, educational workshops, demonstrations and BMP installation. The Watershed Coordinator (RFP #1) should work in collaboration with this program to help facilitate outreach activities.

As discussed with agricultural producers and service providers during our outreach process, it will be critical for farmers to have an incentive to participate in this program. Often, farmers are too busy or unwilling to participate in initiatives that don't have a direct financial benefit to their operation. However, this issue will need to be addressed in multiple ways, with both positive and regulatory incentives. As advised by CWB, the Department of Health will put more focus on enforcement against NPS polluters in the future, providing a regulatory incentive. Positive incentives could include prizes, food and finding BMP solutions with multiple benefits, including for the farmers - e.g. if a farmer is battling with a certain pest, a field border using insectary crops such as sunn hemp or cilantro will help keep the pests away while reducing the farmer's pesticide expenses, resulting in a win-win situation.

Estimated funding for Agricultural Education and BMP Program, including staffing, materials, supplies and BMP installation funds **= $200,000**

Implementation Schedule:

Issue RFP soon after completion of watershed plan, start Phase 1 in 2015. Phase 1 will focus on parcels bisected by or within 100 feet of a stream and on farms that show a high level of commitment. Once the stream buffer areas have been covered or the program is unable to make continuing progress in these areas, start Phase 2 to expand activities into the rest of the agricultural neighborhood, including farms that are farther from a stream and/or that have demonstrated a low level of interest.

4.1.3 RFP #3: Streambank and Soil Stabilization Projects - ***$235,000***

During our field reconnaissance visits, we discovered several hundred feet of somewhat eroded to severely eroded streambank in the agricultural neighborhood, primarily on Puhawai Stream, but also along Puʻuhulu Stream. One area on Puhawai Stream just makai of the Puʻuhulu St. bridge has eroded so much that the property owner has seen a 15 foot recession in her property line. Stabilizing these streambanks is a top priority.

Projects to implement include:

- Stabilization of 500 feet of eroded streambank with two rows of vetiver ($30,000)
- Vegetated Gabion Retaining Wall ($100,000)
- Vetiver Filter Strip ($105,000)

As described in the Watershed Management Strategies Plan, the non-invasive vetiver grass is recommended for stabilizing these eroded streambanks due to its root system being a superb soil and streambank stabilizer [(66)]. Vetiver installation for these non-agricultural purposes will require professional services to properly design the plantings and develop the temporary irrigation system needed to successfully establish the plants. 500 feet of streambank could be stabilized with two rows of vetiver.

For the specific area makai of the Puʻuhulu St. bridge, vetiver and other plants may be used in conjunction with gabions or other engineering methods to create a vegetated structural retaining wall to reinforce this severely eroded streambank. This will help control sediments and protect the adjacent home. For the gabion project, an engineering company will need to be consulted [67]. These two items should be implemented first.

In addition, at a later time, a 3,500 foot vetiver filter strip along the lower edge of Pāheʻeheʻe Ridge should be planted to slow down sheet runoff from the ridge during heavy rain events. Consultations with USACE and CWRM will need to precede installation of the first two projects and may require a Stream Channel Alteration Permit from the State Water Commission (CWRM) and grading and grubbing permits (City). The vetiver filter strip will require approval from the landowner, DHHL.

Estimated funding for Streambank and Soil Stabilization Projects, including staff, materials, plants, supplies, engineering design, permits and installation **= $235,000**

Implementation Schedule:

Issue RFP soon after completion of watershed plan. Implement projects #1 and #2 at beginning of the rainy season, fall 2015 (this will help with vetiver establishment and require less irrigation). Implement project #3 at the beginning of the rainy season, fall 2016.

4.1.4 RFP #4: Failing Cesspool Replacement Project - *$100,000*

The majority of parcels in the Māʻiliʻili Watershed have individual wastewater systems (IWS) due to lack of City sewer lines in this area. Aging and failing cesspools and septic tanks are a problem and at least one landowner has reported that rain events cause a neighboring cesspool to overflow. Cesspools have long been known to have little water treatment value and are often cited as a major source of water quality problems in Hawaiʻi [38] [79]. The long-term vision for the Māʻiliʻili Watershed (and Hawaiʻi in general) would be the replacement of all cesspools and failing IWS with Aerobic Treatment Units (ATU). The watershed coordinator (see RFP #1) will be able to organize and facilitate the implementation of this project.

As described in the previous section, ATUs provide a much higher level of water treatment than cesspools or even septic tanks, but they are also more costly [70]. Replacement of all cesspools and septic tanks with ATUs would not be feasible. However, this is a very important priority and in the long-run, additional funding should be leveraged to replace at least all cesspools with ATUs. In the near-term, at least one aging and/or failing cesspool located within 100 feet of a stream should be replaced with an ATU with the help of the settlement money and DOH should assist landowners with obtaining funding for these projects.

The Clean Water State Revolving Fund, the nation's largest water quality financing source, provides loans to Counties to install infrastructure and wastewater projects to help improve water quality (80). This may be a future funding mechanism.

Estimated funding for Replacement of at least one cesspool with Aerobic Treatment Unit **= $100,000**

Projects to implement include:

- Replacement of 1 or 2 aging and/or failing cesspools in close proximity to a stream

Implementation Schedule:

Issue RFP soon after completion of watershed plan. Implement cesspool replacement project in 2015.

4.2 Non- Priority Projects: Group B (5-10 years)

4.2.1 Fuel Break/Taro Lo'i at NAVMAG - *$5,000 (for 50ft x 10,000 ft fuel break)*
The Navy should coordinate internally or with the community to construct and maintain a fuel break to avoid future fires like the one in 2012, which moved into neighboring Wai'anae Valley causing widespread damage. Constructing a fuel break in the form of taro lo'i would be an exciting community-inclusive endeavor that could help benefit Native Hawaiians. If the Navy is unable to include the community on a project like this, a "traditional fuel break" in the form of a cleared strip should be maintained.

4.2.2 Fencing on Navy/DOFAW lands - *$164,000 to fence 100 acres (e.g. Navy's Pu'u Hāpapa SMA). $328,000 to fence 270 acres (e.g. Navy's Pu'u Ka'īlio SMA)*
The Navy should coordinate with DOFAW, WMWP and the Army to connect existing fences and create additional fenced enclosures.

4.2.3 Ungulate Control on Navy/DOFAW lands - *$5,000 for 100 acres (e.g. Navy's Puʻu Hāpapa SMA). $14,000 for 270 acres (e.g. Navy's Puʻu Kaʻīlio SMA)*
The Navy should coordinate with DOFAW, WMWP and the Army on ongoing ground and air ungulate control method. Special deliberation should be focused on the potential to allow community hunters to participate in pig eradication programs to provide an additional community benefit. This was briefly mentioned as a future strategy in the Navy's Integrated Natural Resource Management Plan (INRMP) [29].

4.2.4 Series of small detention ponds/check dams on Navy lands - *$ 1 million per pond (5 acre feet), $22,000 per check dam (25 ft x 10 ft x 18 ft)*
The Navy should coordinate with DOH and the watershed coordinator to identify depressions or relatively flat areas along stream channels to construct small detention ponds and/or check dams to reduce peak flood flows. These are easier to construct than a full sediment basin and will help reduce some of the sediment load and peak flows, potentially reducing flooding downstream.

4.2.5 Replacement of Aging/Undersized Culverts and Bridges in Residential Areas - *$740,000 estimated in Lualualei Flood Study for all necessary replacements*
As outlined in the Lualualei Flood Study, there are multiple culverts in residential areas in need of repair or replacement. The Army Corps of Engineers should coordinate with the City & County of Honolulu to implement the upgrades identified in the flood study (2).

4.2.6 Replacement of Cesspools in Residential Areas - ~ $ *30 million to replace all cesspools/septic tanks with ATUs, $12 million to replace all with septic tanks*
The watershed coordinator and DOH should coordinate with the community to identify priority cesspools for replacement and assist landowners with obtaining funding for these projects.

4.3 Non- Priority Projects: Group C (10-20 years)

4.3.1 Forest Stand Improvement on Navy/DOFAW lands - ~ *$1,000,000 for 100-acre area*
The Navy should coordinate with DOFAW to identify priority areas for invasive species removal and re-planting of beneficial species. One potential priority area could be the pocket of ʻiliahi (sandalwood) off of Dent Street, which could also become a candidate for an additional fenced enclosure.

4.3.2 Riparian Forest Buffers on Navy/DOFAW lands - *$30,000 for 1,000-ft vetiver buffer*
The Navy should coordinate with DOFAW to identify areas in need of forest buffers alongside streams. This could go hand in hand with item 4.1 after invasive species have been removed.

4.3.3 Riparian Herbaceous Cover on Navy/DOFAW lands - $*30,000 for 1,000 ft of vetiver*
The Navy should coordinate with DOFAW to identify stream reaches in need of riparian plantings. Priority focus should be on eroded areas. Native grasses, sedges and vetiver grass should be planted to provide an overall water quality benefit for the watershed.

4.3.4 Restoration and Management of Rare or Declining Habitats on Navy lands - *$44,000 for 100 acres (e.g. Navy's Puʻu Hāpapa SMA). $117,000 for 270 acres (e.g. Navy's Puʻu Kaʻīlio SMA)*
The Navy should continue to manage its restoration areas to support endangered native plants and animals and search for additional opportunities to expand their restoration programs.

4.3.5 Sediment Basin(s) on Navy lands - $*14 million (sized for 10% of 100-year storm)*
Due to the high costs associated with the excavation and construction of a large basin, this should come last after a series of other erosion and sediment control practices. If after implementation of all previously listed management strategies, monitoring and research suggests that there is still a sediment problem in the watershed, the Navy should consider constructing one or more sediment basins.

4.3.6 Baffle Box(es) in City Drainage System - ~ *$40,000 per baffle box*
The City & County of Honolulu should work with DOH to assess their current drainage system in the watershed and if appropriate, install a baffle box at the end of any pipes draining into the stream channel, to filter out sediments and other pollutants before entering the stream and ocean.

Note: *The U.S. Navy was given an opportunity to address the proposed management strategies and responded with "no further comments pending". Therefore, we cannot assume that they agree or disagree with any of the proposed implementation projects. However, it should be noted that several of these projects are in line with the Navy's INRMP, which confirms the need for water quality related management. Water quality is extensively discussed in the INRMP in regards to Pearl Harbor. However, during the next update to the INRMP, we suggest that the Navy include a detailed water quality component for their Lualualei and other installations as well.*

Table 19. Implementation Timeline

	2014				2015				2016			
Programs/Tasks	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4
RFP #1 - Community												
Issue RFP			x									
Contract with non-profit					x							
Implement activities					x	x	x	x	x	x	x	x
RFP #2- Ag BMP												
Issue RFP			x									
Contract with non-profit					x							
Implement BMPs					x	x	x	x	x	x	x	x
RFP #3 – Streambank												
Issue RFP				x								
Contract with provider						x						
Implement 3 projects							x	x			x	
RFP #4 – Cesspools												
Issue RFP				x								
Contract with provider						x						
Replace cesspool(s)							x	x				

4.4 Funding and Technical Resources

This watershed plan is unique in that resulting priority projects for implementation will be implemented using the settlement funds. Aside from the settlement funds, applicants for non-priority projects and programs will be eligible for funding under section 319(h) of the Clean Water Act. These funds are disseminated by CWB. Many additional funding sources are available, including NRCS programs for farmers and various EPA grants. See Table 19 for a list and description of these funding sources.

Table 20. Notes on Technical and Financial Resources

USDA/NRCS Programs [81]	
PROGRAM NAME	**PURPOSE**
ACEP – Agricultural Conservation Easement Program	ACEP provides technical and financial assistance to help conserve agricultural lands and wetlands and their related benefits. By enrolling land in an agricultural easement, the land is prevented from conversion to non-agricultural uses, protecting long-term viability of agricultural and conservation values.
AMA – Agricultural Management Assistance Program	Producers receive conservation technical and financial assistance to construct or improve water management or irrigation structures, use conservation practices and diversify their operations, including transition to organic farming methods. Eligible recipients can receive up to $50,000/fiscal year in AMA payments.
CREP – Conservation Reserve Enhancement Program	Landowners or lessees can choose to remove environmentally sensitive lands from agricultural production and enroll them in CREP to help promote restoration of degraded lands. Enrolling requires a 15-year commitment during which state and federal payments are received, in addition to cost-share for conservation practices.
CSP – Conservation Stewardship Program	The CSP helps agricultural producers maintain and improve existing conservation systems and adopt new conservation practices. Participants have a 5-year contract and earn annual payments for installing and maintaining conservation practices.
EQIP – Environmental Quality Incentives Program	EQIP was described by NRCS as “the main program for farmers in Hawai‘i”. Participants receive technical and financial assistance to implement conservation practices and/or develop a Conservation Plan. Payments are made after BMPs have been implemented and contracts vary in duration, up to 10 years.
FSA Loans – Farm Service Agency Loan Programs	The Farm Service Agency gives a variety of farm loans, including farm ownership loans (up to $800,000), farm operating loans (up to $800,000), and micro-loans (up to $35,000). These loans can be used for many activities and farm-related purchases, including equipment, labor and materials, as well as for installing conservation practices.
RCPP – Regional Conservation Partnership Program	RCCP is a new partnership program that combines the authorities of four former programs as enacted by the new Farm Bill of February 2014. NRCS would issue an RFP for partnership proposals and eligible organizations (such as agricultural producer associations, farmer cooperatives etc.) can apply for funding that is then used for eligible participants, i.e. farmers. For areas designated by NRCS as “partner project areas” or “critical conservation areas”, assistance can be obtained independent of a partner organization.

USEPA Programs	
CWSRF - Clean Water State Revolving Fund [80]	As the nation's largest water quality financing source in the form of low interest loan programs to individual states, the CWSRF has provided over $5 billion annually for water quality protection projects to help communities meet Clean Water Act goals. In Hawai'i, DOH administers these funds and local (county) governments are eligible to apply to fund various point and non point source projects.
Targeted Watersheds Grant Program [82]	This program is meant to facilitate community-based approaches to protect and restore the nation's watersheds. This is done via RFPs issued by EPA and awards go to local watershed organizations to build their capacity and fund implementation of projects.
Water Pollution Control Program Grants [83]	This program provides federal assistance to states and interstate agencies for ongoing water pollution control programs, including permitting, TMDL development, water quality monitoring and more.
DOD Programs	
Brownfields – Urban Waters Program [84]	This program is administered by USACE to help communities prevent, assess and safely clean up contaminated lands (i.e. "Brownfields") that can be safely re-used after remediation of the contamination.
Legacy Resource Management Program [85]	This program provides financial assistance to DOD to help preserve natural and cultural resources. Projects can include habitat preservation, archaeological studies, invasive species control and similar initiatives.
TECHNICAL RESOURCES	
UH – CTAHR Cooperative Extension Service [86]	Being a Sea Grant University, the UH Mānoa College of Tropical Agriculture and Human Resources (CTAHR) provides agricultural and natural resource extension services free of charge to local landowners, farmers and other community members in need of science-based information. There are multiple programs and projects implemented through the extension service and farmers and landowners are encouraged to reach out to CTAHR for assistance on anything related to farming, natural resources, conservation, soils, invasive species, aquaculture and other topics.
CTAP- NRCS Conservation Technical Assistance Program [87]	NRCS provides technical assistance to individual landowners, farmers, as well as states, organizations and other entities. Farmers and landowners are encouraged to contact NRCS at their Aiea district office to speak with a conservationist. NRCS can assist with a variety of technical and financial solutions.

5. Monitoring Plan

The purpose of the monitoring plan is to help CWB evaluate whether progress is being made towards attaining or maintaining water quality standards. This is accomplished by monitoring over time which interim milestones of each project/program have been achieved. Certain indicators of program success will help in this evaluation. The monitoring plan covers each of the four individual RFPs as well as a general monitoring component for water quality over time.

5.1 Monitoring Protocols

5.1.1 RFP #1: Community Watershed Projects - $150,000

The community watershed projects will likely be implemented by a non-profit organization that may choose to hire or assign a staff member as a "Watershed Community Coordinator" or similar title. This organization which will be selected via the state procurement process will be required to submit progress reports to CWB to provide information on performance and achievement of the program goals. At an estimated program cost of $150,000 over three years, it is recommended that the funds be allocated over time and tied to achievement of goals. In order to get such a program started, it may be necessary for the contractor to hire staff and purchase supplies, including water quality monitoring equipment and office supplies. An initial start-up payment of $30,000 should cover these needs. After that, CWB may choose to disseminate funds on a quarterly or other basis depending on performance. The following steps (i.e. milestones) and indicators will help CWB monitor the progression and effectiveness of the program. The suggested timeline is subject to change by CWB if necessary.

Interim Milestones:

1. CWB to create RFP (3rd Quarter 2014)
2. CWB to issue/advertise RFP on state procurement website (4th Quarter 2014)

3. CWB to receive proposals from interested parties (1st Quarter 2015)
4. CWB to review and score proposals received and meet with applicants if necessary (1st Quarter 2015)
5. CWB to select contractor and execute contract (2nd Quarter 2015)
6. CWB to receive monthly or quarterly progress reports from contractor that report on activities conducted and measure certain indicators of achieving goals. The contractor will have some discretion in structuring the timeline and order of their activities based on seasonal and other factors. For certain indicators, an increase in the number over time will indicate success. For example, if 5 people attend the first community water quality monitoring event and 10 people attend the next one and additional people join over time, this indicates an increase in community awareness and interest which will help achieve long-term goals.

<u>Indicators can include:</u>

1. Number of rain garden or other workshops held
2. Number of rain gardens or other measures installed
3. Completion of first water quality monitoring event
4. Number of volunteers that attended water quality monitoring events
5. Successful partnership arranged with Reef Check or other coral monitoring organization
6. Number of volunteers that attended coral reef monitoring events
7. Completion of community stream clean-ups
8. Number of volunteers that attended community stream clean-ups
9. Completion of a strategy for illegal dumping control and enforcement
10. Completion of anti-dumping activities including dialogue with various government entities that control enforcement and community partnerships
11. Completion of materials for educational school programs
12. Number of educational workshops conducted at Wai‘anae schools
13. Improvement or maintenance of water quality as analyzed by this program’s water quality monitoring component

<u>Adjustments:</u>

If for any reason the milestones are not achieved in a timely manner or if by the end of year 1 the organization is unable to provide the services required, CWB should cancel the contract and issue a new RFP for the remaining program funds. If the contractor faces difficulties achieving their milestones, they should communicate with CWB to address potential improvements or adjustments to the implementation as soon as possible.

5.1.2 RFP #2: Agricultural Education and BMP Implementation Program - $200,000

The Agricultural Education and BMP Implementation Program will likely be implemented by a non-profit or other organization that provides agricultural implementation services. This organization which will be selected via the state procurement process will be required to submit progress reports to CWB to provide information on performance and achievement of the program goals. At a an estimated program cost of $200,000 over three years, it is recommended that the funds be allocated over time and tied to achievement of goals. In order to get such a program started, it may be necessary for the contractor to hire staff and purchase supplies such as plants and office supplies. An initial start-up payment of $30,000 should cover these needs. After that, CWB may choose to disseminate funds on a quarterly or other basis depending on performance. The following steps (i.e. milestones) and indicators will help CWB monitor the progression and effectiveness of the program. The suggested timeline is subject to change by CWB if necessary.

Interim Milestones:

1. CWB to create RFP (3rd Quarter 2014)
2. CWB to issue/advertise RFP on state procurement website (4th Quarter 2014)
3. CWB to receive proposals from interested parties (1st Quarter 2015)
4. CWB to review and score proposals received and meet with applicants if necessary (1st Quarter 2015)
5. CWB to select contractor and execute contract (2nd Quarter 2015)
6. CWB to receive monthly or quarterly progress reports from contractor that report on activities conducted and measure certain indicators of achieving goals. The contractor will have some discretion in structuring the timeline and order of their activities based on seasonal and other factors. For certain indicators, an increase in the number over time will indicate success. For example, if 5 people attend the first nutrient management workshop series and 10 people attend the next one and additional people join over time, this indicates an increase in program effectiveness because more people are being provided with services that will help improve water quality.

Indicators can include:

1. Successful partnership agreement with an organization that can provide translation and facilitation services for work with foreign basil farmers
2. Completion of first workshop for basil farmers
3. Number of farmers attending workshop
4. Number of people attending follow-up workshops
5. Number of basil farms reached
6. Number of other farmers signed up for BMP services
7. Number of BMPs installed on farms
8. Number of high priority farms near waterways that have expressed interest in or have implemented BMPs
9. Number of farms that have offered to host demonstration events
10. Measurable improvement or maintenance of water quality over time
11. Successful implementation of Phase 1 of the project (Phase 1 will focus on parcels bisected by or within 100 feet of a stream)
12. Start of Phase 2

Adjustments:

If for any reason, the milestones are not achieved in a timely manner or if by the end of year 1 the organization is unable to provide the services required, CWB should cancel the contract and issue a new RFP for the remaining program funds. If the contractor faces difficulties achieving their milestones, they should communicate with CWB to address potential improvements or adjustments to the implementation as soon as possible.

5.1.3 RFP #3: Streambank and Soil Stabilization Projects - $235,000

The Streambank and Soil Stabilization Projects will likely be implemented by an engineering company, erosion control company, vetiver design and installation company or similar organization. This organization which will be selected via the state procurement process will be required to submit short written reports to CWB to provide information on the completion of project installation and any potential problems. At an estimated implementation cost of $235,000 for three separate but related projects, it is recommended that after completion of each project, the required funds be disbursed to the contractor. The following steps (i.e. milestones) and indicators will help CWB monitor the progression of the implementation. The suggested timeline is subject to change by CWB if necessary.

Interim Milestones:

1. CWB to create RFP (1st Quarter 2015)
2. CWB to issue/advertise RFP on state procurement website (1st Quarter 2015)
3. CWB to receive proposals from interested parties (2nd Quarter 2015)
4. CWB to review and score proposals received and meet with applicants if necessary (2nd Quarter 2015)
5. CWB to select contractor and execute contract (3rd Quarter 2015)
6. Contractor to install projects #1 and #2 (vetiver streambank stabilization and gabion retaining wall) during rainy season (4th Quarter 2015 and 1st Quarter 2016)
7. Contractor to install project #3 (vetiver filter strip) at the beginning of rainy season (4th Quarter 2016)
8. Contractor to provide short written report with pictures to CWB to prove successful installation and/or CWB to monitor via field visit.

Indicators can include:

1. Successful establishment of vetiver rows and irrigation system for streambank stabilization
2. Continued survival of vetiver system over the course of the rainy season
3. Continued survival of vetiver system after initial establishment period
4. Reduction in erosion
5. Successful design of gabion retaining wall
6. Successful construction of gabion retaining wall
7. Survival of retaining wall to be monitored after large storm events
8. Successful establishment of vetiver filter strip and irrigation system
9. Continued survival of vetiver filter strip over course of rainy season
10. Continued survival of vetiver filter strip after initial establishment period
11. Reduction in sheet flow from Pāheʻeheʻe Ridge

Adjustments:

If for any reason, the milestones are not achieved in a timely manner or if by the end of year 1 the organization is unable to provide the services required, CWB should cancel the contract and issue a new RFP for the remaining program funds. If the contractor faces difficulties achieving their milestones, they should communicate with CWB to address potential improvements or adjustments to the implementation as soon as possible.

5.1.4 RFP #4: Failing Cesspool Replacement Project - $100,000

The implementation of the Failing Cesspool Replacement Project should be facilitated and organized by the watershed coordinator (see RFP #1) in collaboration with DOH Wastewater Branch (WWB). The reporting on the status and progress of this project can be part of the watershed coordinator's overall progress report to CWB or could be reported by the engineering company or contractor that will install the wastewater system. Interim milestones and indicators to monitor are as follows.

Interim Milestones:

1. CWB to create RFP for engineering/contractor services (1st Quarter 2015)
2. CWB to issue/advertise RFP on state procurement website (1st Quarter 2015)
3. CWB to receive proposals from interested parties (2nd Quarter 2015)
4. CWB to review and score proposals received and meet with applicants if necessary (2nd Quarter 2015)
5. CWB to select contractor and execute contract (3rd Quarter 2015)
6. Contractor to meet/collaborate with watershed coordinator and WWB to identify highest priority cesspools that need replacement.
7. Contractor in collaboration with watershed coordinator and WWB identify 1-2 properties selected for implementation
8. Engineering Design completed
9. Permit process completed
10. Cesspool(s) replaced with Aerobic Treatment Unit(s)

Indicators can include:

1. Successful identification of problematic cesspools
2. Successful collaboration with landowner that is willing to participate
3. Successful project implementation

Adjustments:

If for any reason the milestones are not achieved in a timely manner or if by the end of year 1 the organization is unable to provide the services required, CWB should cancel the contract and issue a new RFP for the remaining program funds. If the contractor faces difficulties achieving their milestones, they should communicate with CWB to address potential improvements or adjustments to the implementation as soon as possible.

5.1.5 General Water Quality Monitoring over time to determine if goals are being met

Over time, the implementation of the above-described projects and programs is expected to reduce pollutant loads in the watershed. Water quality standards are expected to be met. To monitor the overall effectiveness of the implementation projects, CWB should analyze water quality data and trends over time. To date, no ongoing water quality sampling and monitoring has been conducted in the Māʻiliʻili Watershed. Only a very limited amount of data are available, including data from the sampling conducted as part of this watershed plan (see section 2.3.1.2.). The long-term goal should be for CWB to monitor water quality not just at selected beaches and streams, but throughout the islands. However, this may not be financially feasible and the Clean Water Act therefore allows states to use water quality data supplied by other organizations such as volunteer monitoring data to determine impairment of a watershed. If CWB is not able to start their own monitoring at this location, they will have to exclusively rely on the data provided by the volunteer water quality monitoring to be conducted as part of RFP#1. If the implemented projects and programs are successful, then a reduction in pollutant loads is expected over time. The watershed coordinator in charge of the volunteer monitoring program and data dissemination should work closely with the organization implementing RFP#2 to see correlations between water quality and implementation of agricultural BMPs as these are expected to have a significant impact on water quality if sufficient BMPs are installed. If water quality standards are exceeded, the state should use these data to add the stream reach or beach to the state's 303(d) list of impaired waters, thus facilitating the future development of a TMDL for this watershed.

Interim Milestones:

1. Volunteer water quality monitoring program started
2. First round of data and water quality report submitted to CWB by watershed coordinator
3. Additional data and reports submitted to CWB over time
4. Longer term trends in water quality analyzed and correlations identified between water quality and BMP installation
5. Potential DOH water quality monitoring of the project watershed
6. Potential listing or de-listing of waterbodies on the 303(d) list

Indicators can include:

1. Measurable reduction in pollutant loads over time

Adjustments:

If for any reason the milestones are not achieved in a timely manner or if the quality of the data is questionable, CWB should work closely with the watershed coordinator to improve performance and data collection. CWB should also consider monitoring at a minimum, the water quality at Maili Beach.

5.1.6 Water Quality Monitoring Standard Operating Procedures (SOPs)

Every government agency or non-governmental group involved in water quality monitoring has to follow certain standard operating procedures (SOPs) regarding health and safety, personnel requirements, equipment maintenance and calibration, sampling procedures, chain of custody for water samples, data/records management and quality control. Most state agencies have their own SOP manual that outlines the specific requirements for their programs, including the Hawaiʻi DOH Beach Sampling Protocol and the Heʻeia Sampling Plan [(88) (89)]. Non-governmental organizations wishing to perform water quality monitoring can use government SOPs for reference and/or develop their own procedures. There are several useful documents available that will help people develop a water quality monitoring program as outlined in the RFPs. The most comprehensive and Hawaiʻi-specific document is a guide developed by the Mālama Kai Foundation, in collaboration with various governmental and non-governmental organizations entitled “TAKING CARE OF HAWAI‘I’S WATERS – A Guide for Getting Started in Volunteer Monitoring”. This document contains basic watershed and water quality scientific information and outlines a variety of topics on how to develop a program, from coordinating and managing volunteers, to getting the right equipment, to following the proper sampling procedures. The document has sample chain of custody and sampling forms in the appendices and should serve as a useful guide for the implementers of RFP #1 [(90)].

Additional documents of potential use are the EPA “STANDARD OPERATING PROCEDURE FOR CHAIN OF CUSTODY SAMPLES” [(91)] and for more detailed information similar to the Mālama Kai report, EPA has a report titled “Volunteer Stream Monitoring: A Methods Manual” [(92)]. These can be downloaded from the following web pages:

http://www.epa.gov/region6/qa/qadevtools/mod5_sops/misc_docs/r1_chain-of-custody.pdf

http://www.epa.gov/owow/monitoring/volunteer/stream/stream.pdf

5.2 Non- Priority Projects: Groups B & C

The implementation of any of the projects listed in group B and C will be a challenge as it will require the collaboration of multiple agencies and large landowners, including the U.S. Navy. The Navy has thus far shown very limited interest in implementing any of the proposed management practices, so it is unfeasible at this point to suggest a monitoring protocol for implementation of these long-term measures. However, it can generally be said that if and when these practices do go into effect, an improvement in water quality should be observable. CWB should encourage the implementation of the long-term projects when the time comes. General milestones that would apply to most of these projects include:

- Initial dialogue/meeting with Navy and other relevant agencies/stakeholders/landowners regarding the proposed project
- Interest expressed by landowner/stakeholders to implement project
- Landowner/stakeholders commit to implementation
- Follow-up meetings to discuss funding sources
- Possible submission of proposals to obtain funding
- Receipt of grants/other funds
- Implementation process begins

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Mahalo to all who contributed to the development of this report.