West Honolulu Watershed Study

Final Report

Prepared For:

Honolulu Board of Water Supply
Department of Land and Natural Resources, Engineering Division
U.S. Army Corps of Engineers, Honolulu District

Prepared By:

Townscape, Inc. and
Eugene P. Dashiell, AICP
May 2003

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DEPARTMENT OF LAND AND NATURAL RESOURCES
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WEST HONOLULU WATERSHED STUDY
ACKOWLEDGEMENTS

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LIST OF ACRONYMS USED

BMP	Best management practice
BWS	Honolulu Board of Water Supply
CCH	City and County of Honolulu
CFS	Cubic feet per second
COE	U.S. Army Corps of Engineers (Federal)
CPRD	Coastal Protection and Restoration Division (NOAA)
CRM	Concrete, rubble, masonry
CWB	Clean Water Branch (DOH)
CWP	Center for Watershed Protection
CWRM	Commission on Water Resource Management (State)
CZARA	Coastal Zone Act Reauthorization Amendments
CZMP	Coastal Zone Management Program (State)
DAR	Division of Aquatic Resources (DLNR)
DDC	Department of Design and Construction (CCH)
DFM	Department of Facilities Maintenance (CCH)
DLNR	Department of Land and Natural Resources (State)
DOFAW	Division of Forestry and Wildlife (DLNR)
DOH	Department of Health (State)
DOT	Department of Transportation (State)
DPP	Department of Planning and Permitting (CCH)
DWSRF	Drinking Water State Revolving Fund
EIS	Environmental Impact Study
ENV	Department of Environmental Services (CCH)
EPA	Environmental Protection Agency (Federal)
GWPP	Ground Water Protection Program
HTMC	Hawai‘i Trail and Mountain Club
KMWP	Ko‘olau Mountains Watershed Partnership
MGD	Million gallons per day
NAWQA	National Water Quality Assessment (USGS)
NDPES	National Pollutant Discharge Elimination System
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resource Conservation Service (USDA)
SCS	Soil Conservation Service (USDA NRCS)
TMDL	Total Maximum Daily Load
TNC	The Nature Conservancy
UH	University of Hawai‘i
USDA	United States Department of Agriculture (Federal)
USFS	United States Forest Service (USDA)
USFWS	United States Fish & Wildlife Service (Federal)
USGS	United States Geological Survey (Federal)
WHW	West Honolulu Watershed
WHWS	West Honolulu Watershed Study
WRRC	Water Resources Research Center (UH)

WEST HONOLULU WATERSHED STUDY
EXECUTIVE SUMMARY

Study Objective: To provide a holistic, comprehensive analysis of watershed data, problems and issues and to conceptualize and describe potential watershed restoration projects and actions. Important distinction: this watershed analysis is a study; it is not a "watershed plan" that prescribes a sequence of priority actions.

Study Sponsors: This study was jointly sponsored by:

- State of Hawai'i, Department of Land and Natural Resources
- City and County of Honolulu, Board of Water Supply
- U.S. Army Corps of Engineers

Study Team: Townscape, Inc., Prime Consultant
Eugene P. Dashiell, AICP, Sub-Consultant

Contract Amount: $150,000.00

Study Duration: October 2001 to May 2003

Study Area: The 21,416-acre "West Honolulu Watershed," consisting of the ahupua'a of Moanalua, Kahauiki, Kalihi, Kapālama, Nu'uanu, and Pauoa. This area of approximately 33.46 square miles equals about 5.5 percent of the land area of the island of O'ahu.

Study Methodology: Principal Study elements were:

- Collect, read, and evaluate all available data and reports on water resources and related concerns within the watershed;
- Interview and consult with federal, state, and city agencies that have jurisdiction over specific watershed elements;
- Interview major private landowners;
- Conduct a series of walks and field reconnaissance surveys;
- Identify critical problems, issues, and needs relating to watershed restoration and flood control;
- Develop conceptual ideas and descriptions for projects and programs that could be implemented to respond to specific watershed problems;
- Compile draft report;
- Public and agency review of draft report;
- Finalize study report.

Study Area Profile

Extent: Mauka-Makai: from the top of the Koʻolau Mountains to and including the near-shore receiving waters: Honolulu Harbor and Keʻehi Lagoon, and including Sand Island.
East to West: from the eastern ridgeline defining Pauoa Stream Valley to the western ridgeline defining Moanalua Stream Valley, which also marks the boundary between the Honolulu and ʻEwa Districts.

Acreage:

Nuʻuanu/Pauoa Stream Watershed:	6,550 acres
Kapālama Stream Watershed:	2,140 acres
Kalihi Stream Watershed:	3,976 acres
Moanalua Stream Watershed:	8,750 acres

Land Use: Approximately 40 percent urban land uses, including downtown Honolulu, Chinatown, Honolulu Harbor, Sand Island, Nuʻuanu Valley, Kalihi-Pālama, Māpunapuna industrial area, Kamehameha Schools, Fort Shafter, Tripler Army Medical Center, and a portion of Honolulu International Airport. The remaining 60 percent of the watershed is forest reserve/State Conservation District land.

Ownership: The five largest landowners in the watershed and the approximate acreage of their land holdings are:

- State of Hawaiʻi
  Department of Land and Natural Resources: 3,535 acres
- City and County of Honolulu
  Board of Water Supply: 1,315 acres
- Damon Estate: 3,708 acres
- U.S. Army: 1,112 acres
- Kamehameha Schools: 619 acres

Population: The 2000 Census numbers for population within this watershed totaled about 125,000 people. Future population numbers may increase if the trend of increasing urban densities within the Honolulu urban core continues. The watershed also experiences a daily influx of workers to the downtown Honolulu Business District, Honolulu Harbor, industrial and commercial establishments in Kalihi-Pālama and Sand Island, and the many public and private schools in the area.

Neighborhood Boards: There are a total of seven Neighborhood Boards whose areas are wholly or in part within the boundaries of this watershed:

- NB #12: Nu‘uanu/Punchbowl
- NB #13: Downtown
- NB #14: Liliha/‘Ālewa
- NB #15: Kalihi-Pālama
- NB #16: Kalihi Valley
- NB #17: Moanalua (Moanalua Valley Homeowners Assn.)
- NB #18: Āliamanu/Salt Lake

Groundwater: The Board of Water Supply maintains a total of nine active wells within the West Honolulu Watershed. There are also a number of private wells and wells owned and operated by the U.S. Army. The aquifers within this watershed have a sustainable yield of about 42 million gallons per day of potable water, which equals approximately 25 percent of the total potable water requirements for the island of O‘ahu.

Stream Flow: Nu‘uanu Stream and Kalihi Stream are designated “perennial streams,” i.e., streams with measurable stream flow year-round. The other streams within the watershed – Pauoa Stream, Kapālama Stream and Moanalua Stream – are designated “intermittent streams,” with no measurable flow during the dry summer months.

Pre-Contact Conditions: Old maps and historical narratives, as well as traditional Hawaiian stories and legends, indicate that Nu‘uanu and Kalihi Valleys were primary food-producing areas for *kalo* and other crops, and that the shoreline of this watershed was extensively developed with many fish ponds. We can infer from the prominent fishponds that freshwater stream flows were important, and that the quality of stream waters was good. During the time of King Kamehameha, the population of the watershed might have numbered some 20,000 Hawaiian people.

Watershed Problems: Through review of the available data, interviews with agencies and major landowners, and our knowledge of watershed processes, the Study team identified critical watershed problems, issues and needs. These problems include many that are characteristic of small streams within densely developed urban areas, as well as some problems that are unique to Hawai‘i and/or to this watershed. Many of these problems are inter-related, as the dynamics of watershed hydrology and ecology are intricately intertwined. Problems include:

1. Erosion of soils from steep ridge slopes and resulting sedimentation of streams and near-shore waters;
2. Degradation of conservation area forests by feral pigs;
3. Degradation of conservation area forests by invasive non-native plant species and of stream mouth areas by aggressive mangrove thickets;
4. Contaminated runoff from streets and roads, and from urban land areas where pesticides and herbicides are used;
5. Degraded water quality of streams and receiving waters from contaminated runoff and from garbage and debris deposited directly into the streams;
6. Significant stream flooding in the lower reaches of Kalihi Stream and Moanalua Stream during major storm events;
7. Eroding stream banks due to the increased volume and velocity of storm runoff from urbanized areas;
8. Destruction of natural stream channels through the construction of concrete drainage channels and storm drains;
9. Loss of native stream biota due to degraded water quality and alteration of stream channel physical characteristics;
10. Loss of near-shore stream biota due to the degraded water quality of streams flowing into the near-shore zone;
11. Potential public safety hazards associated with the non-standard design of Nu‘uanu Reservoir;
12. Conflicts between resource use and use policies, for example, providing for pig hunting versus protection of forest ecology;
13. Potential contamination of potable wells located in or near densely urbanized areas;
14. Lack of coordinated public agency actions to address critical watershed problems and issues;
15. Lack of public awareness, understanding, and involvement in addressing critical watershed problems and issues.

Recommended Projects: In response to the identified problems, issues, and needs, the Study team conceptualized and wrote up a number of recommended projects. These projects are listed by general category below. The remainder of this report consists of more detailed descriptions of the recommended projects. Each project is presented using a standard format that provides information on:

- Problem Statement
- Project Background
- Project Objectives
- Preliminary Project Scope
- Agencies Involved and Project Cost
- References

Four types of recommended actions are presented here:

1. "Project" – actions involving construction activities
2. "Program" – ongoing set of activities and investigations
3. "Plan" – a document that sets forth a set of objectives, strategies and action priorities, including identification of action entities and their responsibilities for implementing the plan
4. "Study" – a research and analysis effort for one or more topics or processes

Costs for the twenty recommended projects were estimated based on best professional judgment of the study team. Five cost ranges were used:

- $50,000 to $100,000
- $100,000 to $250,000
- $250,000 to $500,000
- $500,000 to $1,000,000
- $1,000,000 to $3,000,000
- More than $3,000,000

The recommended projects are thus:

A. <u>Ahupua'a-Based Watershed Recommendations</u>

01. West Honolulu Watershed Partnership
02. "Demonstration Watershed" Program
03. West Honolulu Watershed Expanded Trails Study
04. West Honolulu Watershed Comprehensive Restoration and Management Plan
05. West Honolulu Watershed Center

SECTION 1
WEST HONOLULU WATERSHED STUDY OVERVIEW

1.1 PURPOSE

The intent of the West Honolulu Watershed Study (WHWS) was to assess the condition of the watershed, identify water resource problems, investigate possible solutions, and recommend projects, studies, and other corrective measures that would improve overall watershed health. This study did not assess conditions through the collection of primary scientific data, but rather through an analysis of existing information, consultations with relevant agencies and stakeholders, and field reconnaissance.

The study area is located on the south shore of the island of O‘ahu, and is comprised of the Moanalua, Kalihi, Kapālama, and Nu‘uanu watersheds. The West Honolulu Watershed (WHW) region was selected because this area’s streams and near-shore waters have been identified as having elevated levels of metals, pesticides, nutrients, and sediment loading problems. This watershed is also a major groundwater recharge area for the Honolulu Board of Water Supply (BWS) wells. Heavy urbanization and human modification contribute to the flood hazard in the area, particularly along the Moanalua and Kalihi Stream discharges.

The purpose of this study was accomplished through a review of all available literature on water resources in the project area, consultations with various agencies and stakeholder groups, recommendations of projects based on these inquiries, and matching the appropriate watershed improvement programs with each watershed issue.

The purpose of utilizing a watershed-based approach is to consider all factors related to a particular system so that improvement efforts are complementary and not conflicting. Although this effort is not a “plan,” it has many characteristics of a planning process, such as review of existing information, consultation with involved agencies, problem identification and description, conceptualization of projects addressing the identified problems, and a prioritization of those projects over the long term to achieve the overall objective of watershed improvement. As this report may contribute to a management plan for the watershed, it seeks to facilitate a balance between urban uses and watershed protection.

The context used to frame this “holistic” investigation of the WHW is what is known as the “ahupua‘a concept.” This traditional Hawaiian concept of land management generally follows the conventional watershed delineation as a starting point, and expands to the offshore waters and the outer reefs as part of the watershed system. The ahupua‘a system accounts for the influence of

man as a major component of the greater watershed system. A further explanation of the ahupua'a concept is provided in Section 3 of this report.

1.2 OBJECTIVES

The objectives of this planning study include the identification of problem areas related to watershed dynamics in the West Honolulu region. All of the many components that contribute to the natural functions of the watershed have been considered, although there are three main objectives based on the specific mission of the study sponsors. These are:

1. to reduce the sediment build-up in area streams, including contaminated sediment;
2. to identify projects that improve flood control;
3. to protect and enhance groundwater resources.

In addition to these objectives, the WHWS also considered the related objectives of:

4. improved surface water quality;
5. increased recreation and public access opportunities;
6. stream ecosystem improvement, with an emphasis on native aquatic species.

Detailed descriptions of proposed projects were developed in an effort to address each of the study objectives. The proposed descriptions may be found in Section 4.

1.3 STUDY SPONSORS AND METHODOLOGY

The study was jointly funded by the U.S. Army Corps of Engineers, Engineer District, Honolulu (COE, or "Corps"), the State Department of Land and Natural Resources (DLNR), and the City and County of Honolulu Board of Water Supply, through the Corps' "Planning Assistance to States Program," Section 22 of the Water Resources Development Act of 1974. This program provides authority for the Corps to assist states, local governments, and other non-Federal entities in the preparation of comprehensive plans for the development, utilization, and conservation of water and related land resources.

This year-long study was initiated in October of 2001 and involved the research of available literature related to water resources in the project area; field reconnaissance work; consultations with agencies, experts, and stakeholders in the watershed region; identification of watershed issues; identification of data gaps; preparation of project descriptions and cost estimates, and identification of possible agency participation for each project.

An in-depth literature review and analysis were conducted. Internet and library searches were complemented by inquiries made to agencies involved with watershed matters to obtain the most comprehensive collection of studies, data, and narrative literature on watersheds in both a general

sense and specific to the project area. This, combined with the interviews with agencies and stakeholders, was done to achieve the most complete understanding of existing and desired conditions in the watershed as possible.

Field reconnaissance work included several vehicular and walking surveys of the project area. The objective of these tours was to gain an overview of the watershed from areas that could be driven to, which covers approximately 50 percent of the watershed area. Several hikes into the conservation district were also completed in the early stages of the Study to gain a first-hand understanding of problems associated with erosion, debris in the stream channel, vegetation types, feral ungulate damage, and recreational opportunities beyond the urban district. For Moanalua and Kalihi Valleys, tour guides from the Hawai'i Trail and Mountain Club (HTMC) volunteered to lead Study team members along trails and stream courses and shared their experience of these and surrounding valleys in the watershed. After the first round of draft projects was conceptualized, a return trip to the field helped to verify the physical location of specific projects.

Consultations with agencies, stakeholders, and watershed experts covering the Study objectives occurred between October 2001 and May 2002. Agencies concerned with watershed issues were consulted in the early stages of the WHWS, and were again consulted for follow-up inquiries and project verification. Stakeholders included landowners such as the Damon Estate and special interest groups like the HTMC. Water resource experts consulted were Dieter Mueller-Dombois for information about watershed flora and Aly El-Kadi for a progress report on the Hawai'i Source Water Assessment Program.

An initial list of watershed issues was developed. Issues were identified from existing information sources, field surveys, consultations, and brainstorming sessions among team members. A full discussion of these issues is provided in Section 2 of this report. A review of the existing data revealed areas in the watershed record that require additional study. The project and study descriptions were based on these gaps and the results of other actions conducted in the earlier stages of this Study. Cost estimates were developed for these projects through research on existing funding sources for watershed initiatives, information provided by experts and agencies, and best professional judgment.

1.4 AGENCIES CONSULTED

In order to maximize gathering of information related to the study area as well as to watersheds in general, a series of interviews and meetings were conducted in the early stages of the study to: (1) inform agencies engaged in watershed-related activities about the purpose and objectives of the WHWS, (2) gather available general and project-area-specific data and reports, (3) investigate project funding sources, and (4) identify possible future partners for watershed management.

Agencies at the Federal, State and local level governments were contacted and interviewed, as listed in Table 1.1.

Table 1.1 Agencies Consulted During the West Honolulu Watershed Study

Organization	Date Consulted
United States Geological Survey	1 October 2001
City and County of Honolulu Department of Environmental Services	17 October 2001
State of Hawai‘i Department of Health, Environmental Planning Office, Clean Water Branch	18 October 2001
State of Hawai‘i Department of Land and Natural Resources, Division of Aquatic Resources	23 October 2001
United States Environmental Protection Agency	8 November 2001
United States Department of Agriculture, Natural Resources Conservation Service	13 November 2001
City and County of Honolulu Board of Water Supply, Geo-Hydrology Department	29 November 2001
State of Hawai‘i Department of Land and Natural Resources, Division of Forestry and Wildlife	20 December 2001
Ko‘olau Mountains Watershed Partnership	20 December 2001
Estate of Samuel Mills Damon	4 April 2002

The WHWS is intended to serve as a prototype for subsequent watershed studies throughout the State, with the awareness that the process will continue to evolve as the understanding of Hawaiian watershed issues develops. Many of the same agencies will be involved in partnerships and provide support for other Hawai‘i watersheds.

SECTION 2
WEST HONOLULU WATERSHED STUDY PROJECT AREA

A ***watershed*** is defined as the area of land that is drained by a particular stream or river system. In some cases, such as the WHW region, it is all of the area that drains into a common receiving water body. It is usually called by the name of the stream or river that it contains. For example, the Kalihi Watershed is the area that is drained by Kalihi Stream, including its tributaries such as Kamanaiki and Ka‘ewai Streams. The smaller tributaries may also be designated as watersheds and would include any smaller tributaries that drain into them. Recent management practices in forestry, fisheries, and water quality have focused more and more on the watershed as a management unit. This is a practical and effective way to manage natural resources due to the interconnected nature of a watershed. Knowledge about the watershed and what is going on within it can provide managers and landowners with information for making decisions about various activities, such as development, road building, and other land uses. In this way, natural resources can be better managed to serve the needs of people and ecosystems alike, utilizing those resources today while preserving and enhancing them for use and enjoyment by future generations.

2.1 PHYSICAL DESCRIPTION

The WHWS area, referred to in this report as a watershed “region,” covers over 20,000 acres. The region is comprised of four watershed units: Moanalua (8,750 acres), Kalihi (3,976 acres), Kapālama (2,140 acres), and Nu‘uanu (6,550 acres). The sub-watersheds of Ke‘ehi and Salt Lake are included as part of Moanalua Watershed as they both drain into Moanalua Stream. Sand Island is considered part of the Nu‘uanu Watershed. The major land uses of the watershed at the beginning of the 20th Century were agriculture and aquaculture production. With the increase in development of Honolulu Harbor beginning in the early 1900’s, taro production and the presence of coastal fishponds gradually declined and disappeared by World War II.

Climatic Conditions: The climate of the WHW area varies considerably from the crest of the Ko‘olau Mountain Range to the coastline. The lower elevations can be generally described as semi-arid, with a mean annual rainfall of around 20 inches. Rainfall increases further inland with the middle portion of the study area receiving about 80 inches of rain per year, and over 120 inches per annum in the upper reaches of the watershed. The heaviest rains are due to winter storms that generally occur between October and April. While the effects of terrain on storm rainfall are not as great as on trade wind showers, large differences over small distances do occur due to topography and position of rain clouds. Prevailing winds in the WHW area are the northeasterly trade winds, with a mean wind speed of 11.4 mph. The average low temperature is about 70°F and

the average high temperature is 84.4°F. Lower average temperatures are found in the upper conservation areas. There are about 31 days where the temperature is at least 90°F. West Honolulu has high levels of sunshine. Solar radiation along the coast and in the lower sections of the developed area averages around 500 calories per square centimeter per day. The range for the upper areas is between 300 and 350 calories/cm^2/day. The percent of possible sunshine is 71 percent. Approximately half of the days can expect to be partly cloudy and approximately 1/3 of the days are clear, 1/3 are cloudy and 1/3 have precipitation of 0.01 inch or more. The normal relative humidity averages about 64.8 percent in June to 77.2 percent in January.

***Geology**:* The Koʻolau Mountain Range is one of the two principle volcanic rock aquifers on Oʻahu. The sequences of coastal plain and valley fill deposits form local aquifers, but these are of little importance due to their limited capacity. The fresh groundwater flow regime of the basal aquifer floats on the underlying saltwater with variation in the hydrostatic balance due to semi-permeable, hydrogeologic structures, such as eruptive feeder dikes, sedimentary valley fills, and former erosional surfaces filled with younger lava flows. These barriers impede and divert lateral groundwater flow and impound ground water at heights greater than would occur in the absence of these barriers. Dense concentrations of dikes from eruptive rift zones constitute the Koʻolau volcano. This phenomenon creates what is known as dike-impounded groundwater, which combined with the draw from the basal aquifer, provides the groundwater for the WHW (Hunt, 1996). However, this yield is not enough to meet the potable demand for urban West Honolulu. Therefore, some importation of water is necessary from the adjacent Pearl Harbor aquifer. Sustainable yields for the City and County of Honolulu Board of Water Supply (BWS) wells in the WHW region are listed in Table 2.1. Nearly 23 million gallons per day (mgd), or 25 percent of the daily yield of the Island of Oʻahu, comes from the aquifers in the WHW region

Table 2.1 WS Sustainable Yields for WHS Aquifers

Aquifer System	Sustainable Yield (mgd)
Moanalua	18
Kalihi	9
Nuʻuanu	15
Total	**42 million gallons per day (mgd)**

Source: BWS, 2002

Streams and Near-Shore Waters: Revised EPA 303(d) Impaired Water Bodies List: Section 303(d) of the Clean Water Act requires that states periodically submit EPA lists of waters for which existing technology-based controls are not stringent enough to attain or maintain state water quality standards and for which total maximum daily loads (TMDLs) must be prepared. The State of Hawai‘i submitted its most recent Section 303(d) list in 1998 and the EPA approved that list on August 13, 1998. However, on September 5, 2001, in *Hihiwai Stream Restoration Coalition et al. v. Christine Todd Whitman*, the EPA's approval of Hawai‘i's 1998 list was ruled to be in error. The EPA was ordered by the Federal District Court to reconsider the 1998 list. In its November 15 reconsideration decision, the EPA approved Hawai‘i's listing of 19 water bodies and associated priority rankings. This revised list included 92 additional water quality limited segments as well as additional pollutants for 15 of the 19 waters already listed by the State. The EPA identified additional water bodies and pollutants for inclusion on the 1998 list. The following water bodies in the West Honolulu Watershed project area are as follows:

Impaired Water Bodies in the West Honolulu Watershed

Stream	Pollutants	Basis for Listing	Priority
Moanalua Stream	nutrients, turbidity, trash	visual assessment	M
Kalihi Stream	nutrients, turbidity, trash	visual assessment	M
Nu‘uanu Stream	nutrients, trash	visual assessment	M
Salt Lake	turbidity, trash	visual assessment	M
Honolulu Harbor and Shore Areas Nearshore waters to 30' from 1 mile NW of Honolulu Harbor-Sand Island Channel to Waikiki Beach	nutrients, pathogens, metals, turbidity, suspended solids	prior listing	L
Sand Island Point #2	turbidity nitrogen	numeric assessment	L
Sand Island Point #3	turbidity nitrogen	numeric assessment	L
Ke‘ehi Lagoon Lagoon and near-shore waters to 30' from Lagoon mouth to Pearl Harbor	nutrients, turbidity, suspended solids	numeric assessment	L

Ke‘ehi Lagoon Point X	enterococci nitrogen, chlorophyll a, phosphorus	prior listing	L
Kapālama Canal	nutrients, turbidity, trash	visual assessment	M

- Waters listed in **bold** type were listed by the State; remaining waters were added by EPA.
- **Pollutants** column identifies the specific pollutants for which the water bodies were found to exceed applicable water quality standards.
- **Basis for Listing** column identifies the basis for individual listing decisions. As described in the Staff Report, waters were listed based on prior listing, visual assessments, and/or numeric assessments.
- **Priority Ranking** column indicates the priority ranking for TMDL development associated with an individual listing decision (H indicates high priority, M indicates medium priority, and L indicates low priority for TMDL development).

West Honolulu Watershed Native Species List: The following list of native species observed in the West Honolulu Watershed Study area is an excerpt of the Hawaii Stream Assessment database, provided by DLNR-Division of Aquatic Resources. There is no listing for Kapälama Canal.

Nu‘uanu Stream

Scientific Name	Common Name	Year Observed
Lentipes concolor	‘o‘opu hi‘ukole	1989
Stenogobius hawaiiensis	‘o‘opu naniha	2000
Eleotris sandwicensis	‘o‘opu ‘akupa	2000
Kuhlia sandvicensis	aholehole	2000
Neritina granosa	hihiwai	2000
Theodoxus vespertina	hapawai	1998
Atyoida(*atya*) *bisulcata*	opae kala‘ole	1989
Macrobrachium grandimanus	opae‘oeha‘a	2000
Mugil cephalus	‘ama‘ama, mullet	2000
Chelon engeli	summer mullet	2000

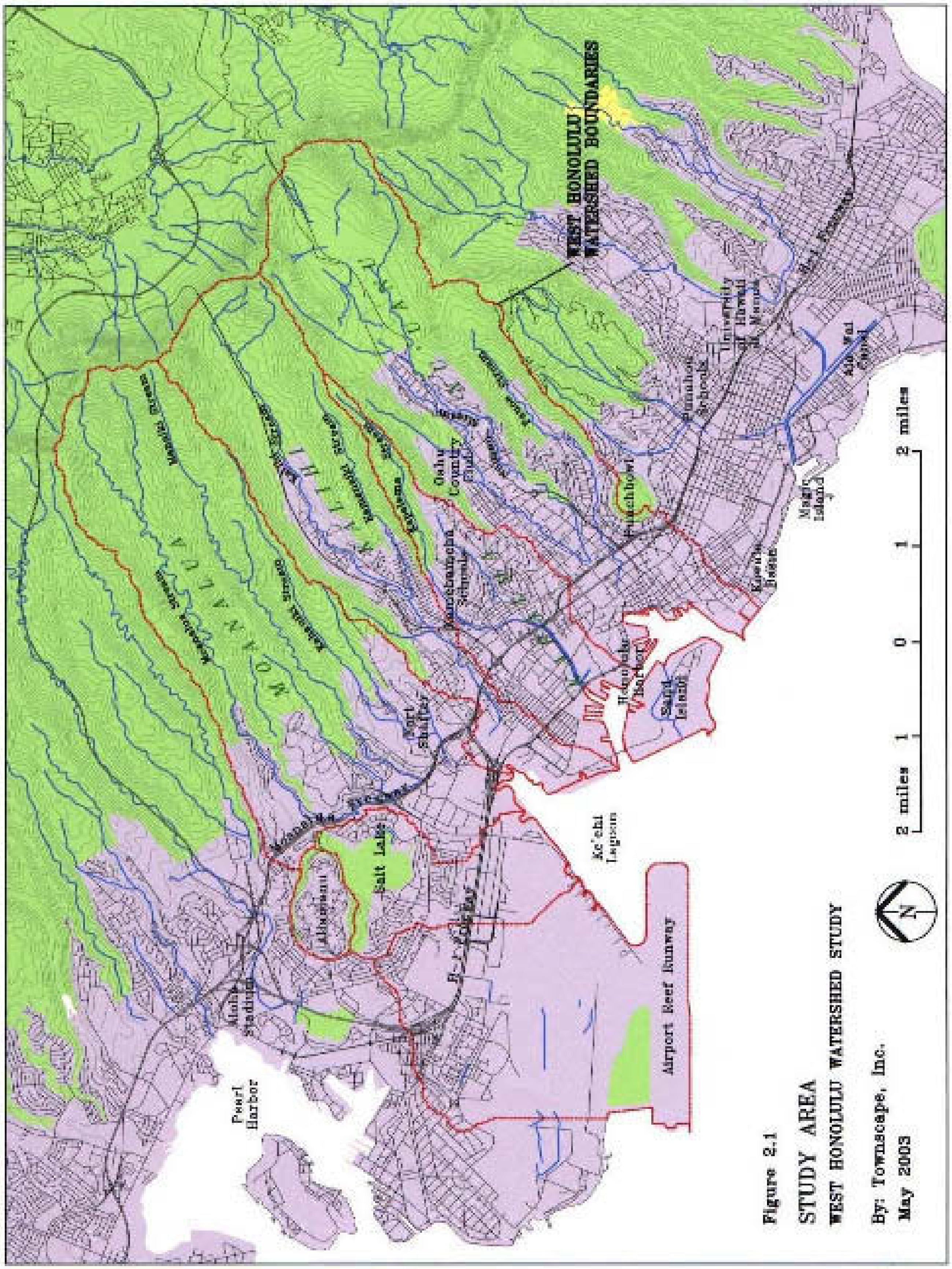
Moanalua Stream

Scientific Name	Common Name	Year Observed
Lentipes concolor	‘o‘opu hi‘ukole	1990
Awaous guamensis	‘o‘opu nakea	1997
Stenogobius hawaiiensis	‘o‘opu naniha	1997
Eleotris sandwicensis	‘o‘opu ‘akupa	2000

Kuhlia sandvicensis	aholehole	1997
Theodoxus vespertina	hapawai	2000
Macrobrachium grandimanus	opae‘oeha‘a	1997
Mugil cephalus	‘ama‘ama, mullet	1999
Sphyraena sp.	Kaku, barracuda	1990
Ferrissia sharpi	leaf litter limpet	1997

Kalihi Stream

Scientific Name	Common Name	Year Observed
Lentipes concolor	‘o‘opu hi‘ukole	1989
Awaous guamensis	‘o‘opu nakea	2001
Stenogobius hawaiiensis	‘o‘opu naniha	1997
Eleotris sandwicensis	‘o‘opu ‘akupa	1997
Kuhlia sandvicensis	aholehole	1997
Atyoida(*atya*) *bisulcata*	opae kala‘ole	2001
Macrobrachium grandimanus	opae‘oeha‘a	


WEST HONOLULU WATERSHED BOUNDARIES
Pearl Harbor
Aloha Stadium
Salt Lake
Airport Reef Runway
Ke'ehi Lagoon
Honolulu Harbor
Sand Island
Punchbowl
Magic Island
Ala Wai Canal
2 miles
2 miles
Figure 2.1
STUDY AREA
WEST HONOLULU WATERSHED STUDY
By: Townscape, Inc.
May 2003

2.2 URBAN DISTRICT

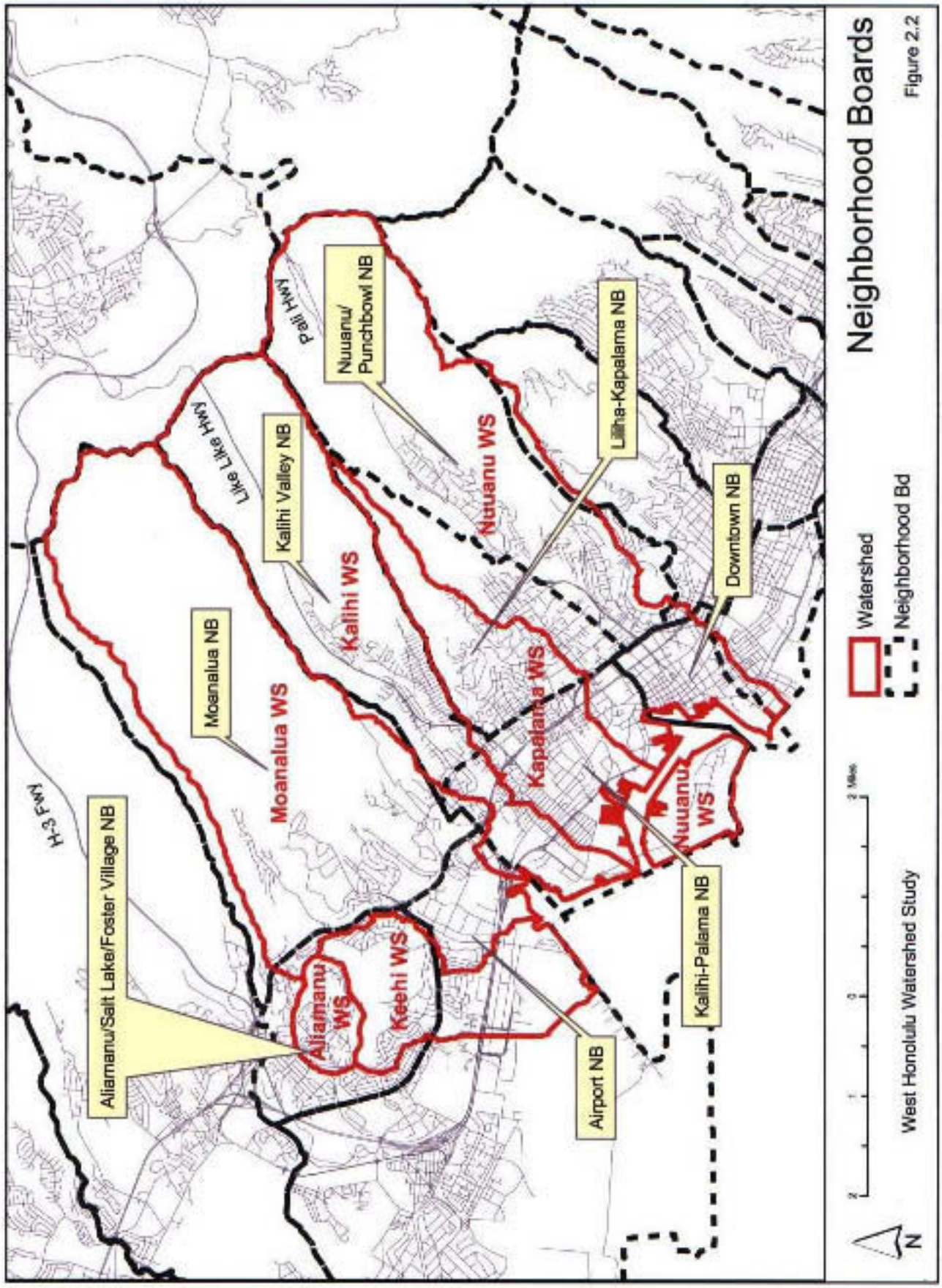
Much of the lower areas of the WHWS area may be considered "fully developed." The coastline has undergone significant alterations in the past century, including massive dredging operations and development of coastal fill lands. Industrial and residential uses have been developed to a relatively high density. Channelization of the streams in the project area has encouraged increased development adjacent to these stream courses, thus increasing their vulnerability to flooding. The conveyance of floodwaters has been modified by the construction of narrower, harder channels that increase the volume and speed of the water flowing to the ocean. Urban development increases the impervious cover of the landscape through parking lots, roofs, and streets, which are designed to direct water to streams rather than infiltrate into the ground. The level of urban coverage is directly proportional to the amount of permeable surfaces in the watershed. Impermeability also increases the storm water volumes in urban streams, which further increases the flood hazard potential.

Ke'ehi Lagoon (center) and Honolulu Harbor (top)

The high volume of vehicular traffic in the region increases the amount of metals that are introduced into the storm water systems and streams in the watershed from brake pads, tires, and engine fluid leaks, particularly in areas where traffic congestion is highest. The urban industrial and residential segments of the WHW region have stressed the natural processes of stream ecosystems. Residential and commercial property lines are generally to the center of a bordering stream, which prevents maintenance and inspection of stream courses and allows for the dumping of waste and negligence. Much of the coastal areas are utilized for harbor facilities and heavy industrial use. The negative impacts of these land uses have had a significant effect on the quality of the receiving waters.

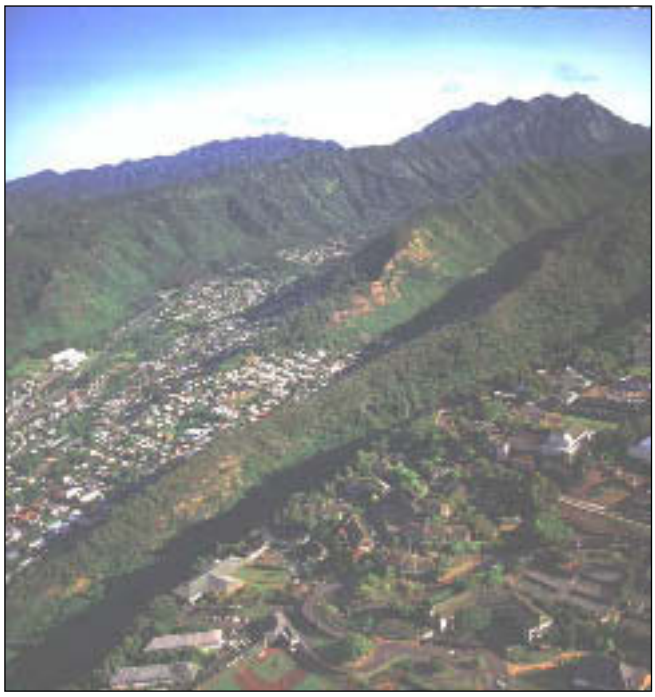
The WHW encompasses all or part of seven neighborhood boards. See Figure 2.2 for a map of neighborhood board boundaries.

NB#12	Nu'uanu/Punchbowl
NB#13	Downtown
NB#14	Liliha/'Ālewa
NB#15	Kalihi-Pālama
NB#16	Kalihi Valley
NB#17	Moanalua (Moanalua Homeowners Association)
NB#18	Āliamanu/Salt Lake


Neighborhood Boards
Figure 2.2
Watershed
Neighborhood Bd
West Honolulu Watershed Study
N
H-3 FWY
Pali Hwy
Like Like Hwy
Aliamanu/Salt Lake/Foster Village NB
Moanalua NB
Kalihi Valley NB
Nuuanu/ Punchbowl NB
Liliha-Kapalama NB
Downtown NB
Kalihi-Palama NB
Airport NB
Moanalua WS
Kalihi WS
Nuuanu WS
Kapalama WS
Nuuanu WS
Aliamanu WS
Keehi WS

2.3 CONSERVATION DISTRICT

The upper watershed areas in West Honolulu are within the forested Conservation District. The Conservation District alone is sometimes equated with the "watershed" as the primary zone of groundwater recharge, as opposed to the more inclusive definition that addresses the entire hydrologic system. Public entry is either prohibited or highly restricted. The forested upper conservation areas were planted largely with exotic species in the 1930's to encourage rainfall and to improve groundwater resources. The species selected were generally recent introductions to the islands and were not evaluated for their long-term impact on ecosystems and watershed performance. Some species are water-aggressive, meaning they consume a substantial amount of water, which transpires into the atmosphere rather than infiltrating into the aquifer. Other species may possess allelotrophic characteristics, which leave plant toxins in the soil that inhibit the growth of other plant species. Related to this negative impact of alien species is the characteristic of high canopy trees such as Rose Apple (*Syzygium jambos*) that block out sunlight required by understory plants to become established. This leaves the forest floor exposed to the impact of water droplets from the upper canopy and results in high runoff and erosion rates, contributing to sedimentation downstream. Nutrient loading in the form of nitrogen is due to the decay of vegetation in the conservation district. Although the upper areas are generally off-limits to the public, there is visual evidence that these areas are used as dumping grounds for large discarded items as well as for litter from highways that pass over streams running through the conservation areas. Some of the upper conservation areas in Moanalua and Nu'uanu Valleys are either public or private hunting areas. Feral pigs and other mammals are carriers of leptospirosis and cryptosporidiosis, bacterial and protozoan illnesses respectively, which are hazards to public health.



Conservation-urban boundary, Kalihi Valley

2.4 WEST HONOLULU WATERSHED AREA SUB-WATERSHEDS

There are seven significant water features in the project area: Moanalua Stream, Kalihi Stream, Kapālama Canal, Nu‘uanu Stream, Nu‘uanu Reservoir No. 4, Salt Lake, and Ke‘ehi Lagoon/Honolulu Harbor. The principal watersheds are as follows:

2.4.1 Moanalua Watershed

The Moanalua Watershed covers almost 9,000 acres of the West Honolulu region. The dominant land use is conservation, which covers more than half of the land area. Between the Conservation District and the Moanalua Freeway are residential, golf course, and park uses. The area between the Freeway and the coastline is the Māpunapuna industrial park. Āliamanu Crater and the Salt Lake Basin are residential areas. Biotic characteristics of the watershed are comprised of a mix of alien and native plant and tree species in the upper watershed, mostly alien species through the residential zone, and relatively devoid of trees in the industrial zone.

Moanalua Stream is the westernmost watercourse in the study area. The stream itself has very little flow until the middle reaches around Moanalua Gardens, where the tributaries of **Manaiki, Kahauiki,** and other smaller streams contribute stream flow volume. **Salt Lake** (Āliapa‘akai) and the drainage from Āliamanu Crater are included in the watershed region as its surface water contributes to the flow of Moanalua Stream. Salt Lake is the volcanic crater of a late-stage eruption tuff cone, with high salinity due to its elevation relative to sea level. The area, including nearby Āliamanu Crater, has been extensively developed into residential apartments and multi-family homes. The Honolulu Country Club accounts for much of the modifications to Salt Lake. The Lake has been declared an impaired water body by the U.S. Environmental Protection Agency (EPA) under Section 303(d) of the Clean Water Act. During flood conditions, Salt Lake empties into Moanalua Stream at Mokumoa Street via an underground outflow, which in turn drains into the receiving waters of Ke‘ehi Lagoon.

Salt Lake

Moanalua Stream follows a natural course through the conservation district and becomes a concrete-lined channel just above Moanalua

Valley Park. It is unlined through the Moanalua Golf Course and some portions of Moanalua Gardens, with some concrete sections in the gardens. Manaiki Stream joins Moanalua Stream in the Gardens just above the Freeway overpass. Below Moanalua Gardens around the point of the tidal threshold, the stream banks are stabilized with a concrete, rubble, and masonry (CRM) revetment up to the mouth of the Stream at Keʻehi Lagoon. This impervious revetment has not prevented mangrove from becoming established along the lower portions of the Stream. Kahauiki Stream, which runs through Fort Shafter Military Reservation, intersects with Moanalua Stream a short distance below the Kikowaena Street overpass.

Water quality in Moanalua Stream is impacted by industrial activities and runoff from many urban roadways, particularly below Moanalua Freeway. Salt Lake is affected by street runoff as well as sediment and nutrient loading within the basin. The receiving water is Keʻehi Lagoon, which also receives the flow of Kalihi Stream and a drainage canal that collects runoff from part of the airport industrial area.

Flooding of Moanalua Stream frequently occurs in the low-lying area of Māpunapuna, which is in the 100-year flood hazard zone. There were 13 flood events in the last century, the largest of which was in 1930 with a flow of 4,580 cubic feet per second (cfs). The flood of April 19, 1974, did not result in a large flow (1,070 cfs), but runoff at lower elevations resulted in considerable damage downstream. A portion of Moanalua Road was covered by three feet of water, which halted traffic for hours.

Moanalua Stream, at Nimitz Highway

2.4.2 Kalihi Watershed

The Kalihi Watershed makes up about 20 percent, or 4,000 acres, of the WHW. It features a somewhat higher ratio of urban coverage than the Moanalua Watershed, due in part to the existence of Likelike Highway running through Kalihi Valley and the Koʻolau Mountains to Windward Oʻahu. The forested upper watershed is under the jurisdiction of the BWS and is closed to the public. The majority of tree species in the Conservation District are exotics planted in the 1930's during the watershed improvement era. There is no public hunting in Kalihi, and thus there

is a feral pig population. There is also a colony of wallabies in the upper valley. The urban area consists of dense residential uses in the transitional zone and industrial and port activities in the lower and coastal zone.

Kalihi Stream is the only stream in urban Honolulu that has a natural streambed throughout its entire course. The stream features two major tributaries – **Kamanaiki Stream**, which joins Kalihi Stream near Nihi Street, and **Ka‘ewai Stream**, which intersects near Likelike Highway. As with Moanalua Stream, the mouth of the Stream at Ke‘ehi Lagoon is densely overgrown with mangrove. The tidal line of Kalihi Stream is significantly lower than Moanalua Stream, just above Kamehameha Highway/Dillingham Boulevard. The stream banks have been stabilized with CRM walls between Bannister and School Streets. The reaches below Bannister Street through an industrial area are not stabilized and are vulnerable to erosion.

Water quality in Kalihi Stream is impaired from trash and debris as well as from industrial and street runoff. Groundwater is pumped from Kalihi Station on North King Street and from Kalihi Shaft. Pumping operations at the Jonathan Springs well were discontinued due to the presence of elevated levels of dieldrin.

As with Moanalua Stream, much of the lower reaches of Kalihi Stream are in the 100-year flood hazard zone due to insufficient channel capacity and restrictive bridge openings. Kalihi also has a history of flooding, with the floods of 1930 (12,400 cfs) and 1974 as the most significant recorded events.

Kalihi Stream in the Conservation District

2.4.3 Kapālama Watershed

The Kapālama Watershed is the smallest watershed in the WHW area with just over 2,000 acres. The watershed does not extend to the crest of the Ko‘olau Range, and its drainage is confined to Kapālama Canal and one tributary. The upper extent of the watershed is forested in a heterogeneous mix of alien and native tree species. The urban coverage resembles that of Kalihi, with residential uses in the transition area and industrial and port activities along the coast.

Kapālama Canal was constructed in 1961 in response to recurring flood damage to the urban areas. The Canal loosely follows the original lower course of **Niuhelewai Stream** to the receiving waters of **Honolulu Harbor**. The upper reach of the existing Niuhelewai tributary runs along the east boundary of Kamehameha Schools. The stream runs underground for a certain distance until it daylights below School Street and then intersects with Kapālama Canal just above the H-1 Freeway. Kapālama Stream features a relatively natural course in the upper areas until it reaches the vicinity of the main gate of Kamehameha Schools, and then flows underground to Kapālama Street, where it is channelized with CRM revetment to North King Street. From North King Street to its mouth at Honolulu Harbor, the banks are not stabilized and there is visible evidence of bank erosion. As with the stream mouths of Moanalua and Kalihi, the lower portions of the Canal are lined with mangrove. The tidal threshold is between the H-1 Freeway and the junction with Niuhelewai Stream. No portion of the Canal is currently designated in the 100-year flood hazard zone.

Water quality data for the Canal is limited, with information over 20 years old. At that time, there were elevated levels of fecal coliforms, which implied that there were illegal or inadequate sewage connections in the vicinity of the Canal. Since there is no record that improvements have been made along the Canal, it can be assumed that the problem continues today.

Unprotected banks of Kapālama Canal below N. King St.

2.4.4 Nu‘uanu Watershed

The Nu‘uanu Watershed is somewhat unique in West Honolulu based on the shape of the Valley, the existence of Nu‘uanu Reservoir No. 4, and the resultant nature of the stream flow of Nu‘uanu Stream. As with Kalihi Valley, there is a major Highway that runs through the length of the Valley to the windward side of the island. This, along with the relatively level valley floor, has allowed development over more than half of the valley. Most of the urban development is residential, with some commercial uses in the lower reaches and port activities at the receiving waters of Honolulu Harbor. The conservation district around the reservoir area is forested with introduced and some native species. Water quality in Nu‘uanu Stream contains elevated levels of organochloride pesticides and trace elements, which have been detected in water, fish tissue, and sediment samples at higher levels than in other West Honolulu streams.

Nu‘uanu Stream through Lili‘uokalani Gardens

Nu‘uanu Stream runs from the Nu‘uanu Reservoir No. 4 dam to Honolulu Harbor, the flow of which is regulated by the Reservoir. The Reservoir has provided a unique development pattern in this part of the WHW area. The stream is in a natural channel until it reaches the developed area around Lili‘uokalani Gardens. From School Street to the mouth at the harbor, the banks are stabilized with a CRM revetment and the tidal extent reaches about the midpoint of THE Foster Botanical Gardens area. There are numerous tributaries to the stream, the most significant of which are **Pauoa** and **Waolani Streams.** The flood hazard associated with Nu‘uanu Stream is located above the School Street Bridge and extends about 1/3 mile. Waolani Stream features a similar flood hazard zone mauka of its junction with Nu‘uanu Stream. Due to the regulated flow of Nu‘uanu Stream, many of the residential areas have taken advantage of the predictable water level and have developed up to the unprotected banks. A potential flood hazard is thus associated with the possible failure of the 100-year old earthen dam at Nu‘uanu Reservoir No. 4.

Nu‘uanu Reservoir No. 4 is a man-made water body four miles from Downtown Honolulu in the back of Nu‘uanu Valley. Several small streams feed into the Reservoir. Its original purpose was to provide water to the growing city of Honolulu; however groundwater well development soon thereafter preempted that need. It was utilized for the production of electricity until the 1930’s when it was reconstructed to address significant leakages in the dam structure. Since then, it has only served as a flood control

Nu‘uanu Reservoir No. 4

structure and recreational fishing attraction, open seasonally since the 1970's. Despite a 1999 BWS Dam Safety Inspection report that deemed the dam to be safe, there is some uncertainty as to the structural integrity of the 100-year-old dam and the liability it represents for the Board of Water Supply, the owner of the dam.

Ke'ehi Lagoon and **Honolulu Harbor** are the receiving waters for the drainages of the WHW and have been significantly modified for more than a century. Coastal expansion from dredge deposit activities has altered the near-shore bottom and coastline for use as harbor and industrial activities and contributes to the ongoing impairment of these near-shore waters. However, despite these modifications, the freshwater streams of the West Honolulu region support native anadromous species, such as 'o'opu (Hawaiian goby) and 'ōpae (native freshwater shrimp), indicating that habitat conditions have not degenerated to the point that the natural biota have been eliminated. The receiving waters are a primary indicator of the health of the entire watershed region. The water quality in the receiving waters is variable, depending upon the circulation of the Harbor. The water quality and sediment build up is of most concern near the stream mouths of the West Honolulu region. As mentioned in the descriptions of Kalihi and Moanalua Streams, mangrove has become established in the lower reaches of these streams at Ke'ehi Lagoon.

2.5 HISTORIC CONDITIONS

One of the objectives of this Study is to restore, to the extent possible, the natural ecosystem of the project area. In order to do this, it is important to have an idea of what the natural landscape was like before man altered it to what it is today. While it is impossible to determine true "pristine conditions," a review of historical narratives and maps and native Hawaiian oral traditions can provide some understanding of the historical ecosystem and may direct future planning efforts.

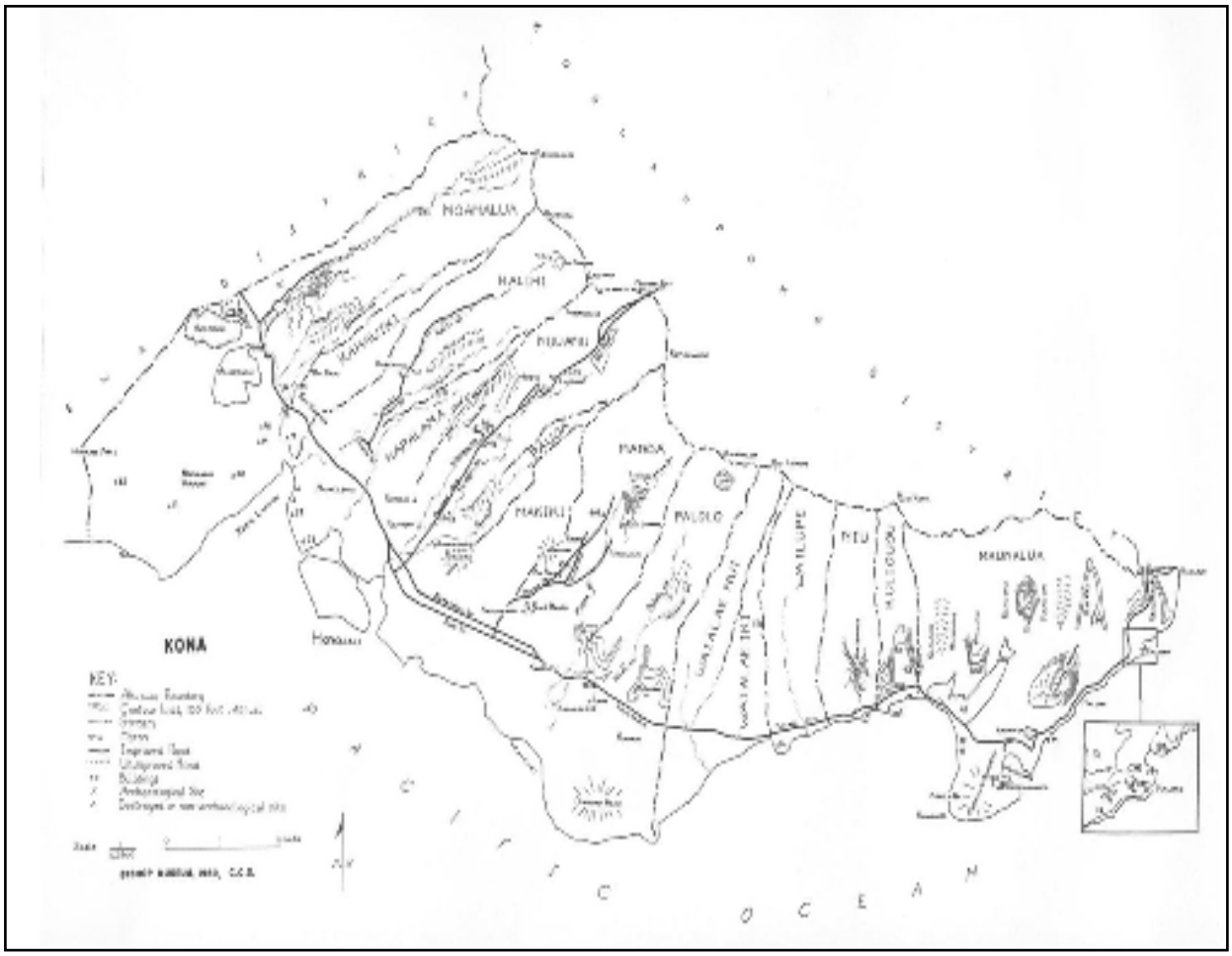
2.5.1 Kona District, O'ahu Island

The West Honolulu Watershed Study (WHWS) includes six traditionally defined ahupua'a: Moanalua, Kahauiki, Kalihi, Kapālama, Nu'uanu, and Pauoa, all of which are in the Kona District of O'ahu. On O'ahu, the term Kona refers to the area extending from Moanalua to Maunalua (Hawai'i Kai).

The densest populations on O'ahu were in those areas adjoining Waikīkī. Ali'i, Hawaiian chiefs, typically held residences at or near Waikīkī. In early times, Waikīkī was bordered by the great taro fields of Mānoa and the surrounding areas of Pauoa, Nu'uanu, Waolani, Kapālama, Kalihi, and Moanalua, which according to most accounts was one continuous spread of taro land and fishponds. These areas were abundant with rain, perennial streams, springs, pools, lush interior valleys, broad slopes and well-watered low lands, fishpond areas, harbors, beaches, and lagoons.

Kona, O‘ahu was considered the area richest in natural resources and most pleasant for abundant and comfortable living.

Figure 2.3 Kona District, O‘ahu Island, circa 1959



Source: Sterling and Summers. 1978. Sites of Oahu. Bishop Museum Press.

2.5.2 Moanalua Ahupua‘a

Moanalua marks the most westerly ahupua‘a of the Kona District on O‘ahu. Moanalua was also considered to be the center of hula and chanting during the reign of the O‘ahu Mō‘ī (ruler) Kākuhihewa in the 1600’s. The name literally means two (lua) and encampment (moana). It

refers to encampments that were located near taro patches where travelers bound for Honolulu from ʻEwa rested. It is said that the taro leaves at Moanalua were so large that the keepers of the loʻi (irrigated terraces) groped in the dark under the leaves to pull taro for their chiefs.

Another account interprets the place name as moana, meaning vast expanse of either land or sea, and lua, meaning two, hence the name referred to the great expanse of level land and reef matched by the great expanse of sea. The loʻi in the first definition were unique in that ʻĪemi Spring bubbled up within them. The spring was called ʻĪemi, literally meaning "less great," because the taro and offshoots grew close together.

2.5.3 Kahauʻiki Ahupuaʻa

Kahauʻiki ahupuaʻa is located between Moanalua and Kalihi. Literally meaning the small hau tree, Kahauʻiki was also a stream that irrigated extensive taro terraces.

There were two known fishponds, or loko iʻa, in Kahauʻiki. Loko iʻa were man-made enclosures in which fish and other aquatic organisms were raised and harvested. **Weli fishpond** was approximately 30 acres in size and was located between Kahauʻiki and Mokumoa Island. Most of the walls were natural earth embankments, and it was separated from Kaikikapu (Kaihikapu in other sources) fishpond by a roadway. **Kaikikapu fishpond** was 20 acres in area, with a 900-foot wall that extended from Mokumoa Island to Moanalua.

2.5.4 Kalihi Ahupuaʻa

The ahupuaʻa of Kalihi is situated between the ahupuaʻa of Kahauʻiki to the north and Kapālama and upper Nuʻuanu to the south. It is an amphitheater-headed valley typical of leeward Oʻahu, with Kalihi Stream as the primary waterway. The shallow fringe area was used by traditional Hawaiians for fishponds, but the old lagoon has since been mostly filled by sediments.

The settlement of Kalihi Valley indicates intense use of the uplands and the convergence of numerous streams creating tidal flats and estuaries in the lowlands. Historic accounts of the area tell of extensive loʻi terraces on either side of Kalihi Stream, several fishponds, fine soils, and broad plains of grass.

Kalihi's near-shore area, now the shore of Kalihi basin, was shallow and ideal for building fishponds. The loko iʻa located in Kalihi, as well as those in the surrounding ahupuaʻa, were productive fisheries that were utilized during the early historical period and into the 20th century. Also located near the shore were salt pans, with one salt field located adjacent to Apili fishpond.

Table 2.2 Kalihi Fishponds

ame, Location, and ge	Description
1. Ananoho, Kalihi Acres: 52 Type: Loko Kuapā A fishpond of littoral water whose sides facing the sea consist of a stone or coral wall usually containing one or more sluice grate.	An oval-shaped pond 52 acres in area. The walls approximate 4700 feet in length and average 6 feet in width. They are primarily of coral and average 3 feet in height. There are now two houses on the wall but houses and mākāhā (gate) are modern. No visible surface remains but location is known.
2. Au‘iki, Kalihi Acres: 12 Type: Loko Kuapā	A small adjoining pond partly filled. It is 12 acres in area with a 900 foot wall. No visible surface remains but location is known.
3. Pāhou‘iki, Kalihi Acres: 14 Type: Loko Kuapā	The smallest of the pahou fishponds, being 14 acres with a wall 1,050 feet in length. The wall is of coral, with one house and two makaha now. No visible surface remains but location is known.
4. Pāhounui, Kalihi. Acres: 26 Type: Loko Kuapā	A 26 acre pond with a wall 2,600 feet long. The walls are of coral with one house and two makaha. It adjoins but does not open to Apili pond. No visible surface remains but location is known.
5. Apili, Kalihi Acres: 28 Type: Loko Kuapā	Apili is 28 acres, with a wall of 1,500 feet long. Apili literally, snared or stuck. The pond was famous for superior flavor of its fish, particularly the awa, which, eaten raw, esteemed a rare treat. No visible surface remains but location is known.

2.5.5 Kapālama Ahupua‘a

Kapālama is situated between the ahupua‘a of Nu‘uanu to the south and Kalihi to the north. Unlike the river valleys of Kalihi and Nu‘uanu, Kapālama contained two smaller streams, Kapālama and Niuhelewai. The associated flood plain became a part of the Honolulu plain between Iwilei to the south and Kalihi to the north. The makai (seaward) area, currently known as Kapālama Basin, is part of the Honolulu Harbor protected shoreline (Borthwick, et al., 1997). Traditionally, Kapālama offered desirable environmental conditions for traditional Hawaiian subsistence practices. The well-watered flood plain allowed for the development of extensive lo‘i systems, as well as a protected shoreline and fringing reef that permitted easy ocean access to productive near-shore fisheries, affording intensive marine exploitation (Borthwick, et al., 1997).

Kotzebue, from the Russian Ship Riurik, relates the following description of Honolulu, including Iwilei, of lower Kapālama in 1816:

> To the south, it is bounded by the ocean. Artificial fields planted with taro root, which might very well be called lakes, attracted my attention...In precisely the same manner that the Islanders keep river fish here, they keep sea fish in the sea itself,

> where they sometimes take advantage of the surrounding reefs. By building a coral-stone wall from the latter to the shore, they form convenient stews in the ocean (Spear quoting Baratt 1988: 208).

Loko i‘a dotted the Honolulu shoreline. Whenever possible, fishponds were incorporated into the traditional production system. The lo‘i kalo of Kapālama provided nutrient-rich, fresh water needed to reduce salinity, producing an algae-rich environment, which in turn would feed the fish species being raised in the near-shore waters.

Table 2.3 Kapālama Ahupua‘a

pond Name, Location, and Acreage	Description
1. Maka‘akukahi, Kapālama Acres: No information Type: Loko Wai, an inland freshwater fishpond, which is usually either a natural lake or swamp that can contain ditches connected to a river, stream, or the sea, and which can contain sluice grates.	Reported in literature but no precise location is known.
2. Nameless, Kapālama Acres: No information Type: Loko Pu‘uone, an isolated shore fishpond usually formed by the development of barrier beaches building a single, elongated sand ridge parallel to the coast and containing one or more ditches and sluice grates.	No visible remains but location is known.
3. Nameless, Kapālama Type: Loko I‘a Kalo An inland fishpond utilizing irrigated taro plots.	No information provided in report.

Sources: U.S. Fisheries Report, 1903; DMH Planners, Inc., 1989; and Handy, 1940.

Lo‘i kalo lands were converted to rice fields in the 1880’s and were eventually filled in to create land for housing and industrial subdivisions. This land use change was facilitated by the construction of the Kapālama Canal, which channelized the only two streams located in Kapālama and allowed for sub-street storm drain runoff.

In 1925, additional harbor expansion, engineered by the COE, specifically targeted the Kapālama area (Borthwick, et al., 1997). If the COE extended the Reserve Channel, referring to the west side of the harbor, the territory would build additional facilities at Kapālama Basin.

2.5.6 Nu‘uanu Ahupua‘a

Nu‘uanu extends from the southern coast of O‘ahu inland to the crest of the Ko‘olau Range, encompassing all of Nu‘uanu Valley[1]. The valley is one of the two great cuts on the leeward side of the Ko‘olau volcano carved by streams flowing from its summit, with the coastal area including Iwilei and Honolulu Harbor. Flowing from the upper valley area towards the flood plain are the two major streams, Nu‘uanu and Waolani.

The name Nu‘uanu refers to the chilling wind that blows over the pali from windward O‘ahu into the valley below; nu‘u, refers to height, and anu, means cool (Puku‘i, 1974). There are several poetic sayings about Nu‘uanu that refer to the rain and wind common to the area.

Kūwili and Kawa fishponds were located at the shore areas of Nu‘uanu. Between 1885 and 1890 rice fields began to replace taro plots along the banks of Kūwili fishpond. By the end of 1891, B.F. Dillingham and his two interrelated companies, the O‘ahu Railway and Land Company and the Hawaiian Dredging Company, had filled in Kawa Pond and the reef area to form the O‘ahu Railway and Land Company wharves. Kūwili pond was intermittently filled with dredged materials from Nu‘uanu Stream and Honolulu Harbor. By 1901 the pond was completely filled.

Table 2.4 Nu'uanu Fishponds

Fishpond Name, Location, and Acreage	Description
1. Kawa, Nu‘uanu Acres: No information Type: No information	No Information
2. Kūwili, Nu‘uanu Acres: No information Type: Loko Pu‘uone, an isolated shore fishpond usually formed by the development of barrier beaches building a single, elongated sand ridge parallel to the coast and containing one or more ditches and sluice grates.	No visible remains,but location is known.

Sources: U.S. Fisheries Report, 1903; DMH Planners Inc., 1989 and Handy, 1940

The Russian explorer Kotzebue noted the state of cultivation of the valleys above the town of Honolulu in 1821:

> The cultivation of the valleys behind Hanarura is remarkable; artificial ponds support, even on the mountains, the taro plantations, which are at the same time fish ponds; and all kinds of useful plants are cultivated on the intervening dams (Klieger, 1994).

[1] The ahupua‘a of Honolulu, on the leeward side of the Ko‘olau Mountain Range, now includes Nu‘uanu Valley, as well as Pacific Heights, Pauoa Valley, Tantalus, and a portion of Waikīkī. The coastal width spans Kapālama Stream to the western edge of Mānoa Valley. This section will highlight Nu‘uanu Valley and its near-shore areas.

Missionary Hiram Bingham described the Honolulu Plain from the top of Punchbowl in 1847:

> . . .having its fish ponds and salt-making pools along the sea shore, the village and fort between us and the harbor, and the valley stretching a few miles north into the interior, which presented its scattered habitations and numerous beds of kalo in its various stages of growth . . . Through this valley several streams descending from the mountains in the interior, wind their way some six or seven miles, watering and overflowing by means of numerous artificial canals, the bottoms of kalo patches, and then, by one mouth, fall into the peaceful harbor (Bingham, quoted in Ono, 1992).

2.5.7 Pauoa Ahupua‘a

Pauoa is the ahupua‘a between Nu‘uanu and Makiki. While Kawena Puku‘i does not provide a meaning to this particular place name, Lyons explains that Pauoa is an “ear,” or refers to a side valley to Nu‘uanu.

What is now termed Honolulu was originally an area of flat land between the makai ends of Nu‘uanu and Pauoa valleys and the harbor. The lower district from Nu‘uanu Avenue to Alakea Street and from Hotel Street to the harbor sea was known as **Kou**, which was considered to be a major fishing village. The village itself seems to have extended westward from Pākākā Point (currently Aloha Tower, Pier 11), along Māmala Bay, to the fishponds formerly located at the mouth of Nu‘uanu Stream and eastward to the current location of Alakea Street. The point served as a canoe landing.

During the final days of rule by O‘ahu chiefs (during the seventeenth and eighteenth centuries), the village of Kou was the site of a major temple, Pākākā heiau[2], dedicated to Kūho‘one‘enu‘u. This heiau was probably used during the rule of the great O‘ahu Mō‘ī Kākuhihewa. Kamakau (1992) relates the following information about the heiau and its associated areas:

> I had heard of the famous place of O‘ahu from Makuaka‘ūmana and came to see them for myself. Kou was the harbor, Māmala the entrance, Pākākā the heiau. Pūowaina was the place where men were burned, puhi kanaka; Hekili was the oven, imu pīka‘o, where chiefs captured in war were parched…Honolulu was the ahupua‘a, a good and pleasant land that faced to the south. Most of it was fertile land with running water and springs that constantly irrigated the pond fields that surrounded the clusters of houses. The customary rain was the Kūkalahale and the Ki‘owao rain came down from the uplands, drenching the blossoming plants (Tales and Traditions).

[2] The term Pākākā means low and broad. Some speculate that the term Pā kākā, meaning courtyard for smiting is the spelling of the term.

According to Kamakau, menehune lived on **Pūowaina** and Pauoa was the pit for excrement. Hōlua sliding was a favorite past time of Hawaiians and Pūowaina was known for hōlua sliding. Punchbowl crater was also famous in ancient times as a locality for sweet potato. Planting was considered especially good on the inland side near the present Hawaiian homestead of Papakolea.

Kewalo, a fishpond that included the surrounding land on the plains below King Street. It contains a spring, known as Ka wai lumalauma‘i (drowning waters) where people were first drowned prior to being taken to Kanelaau heiau.

‘Auwaiolimu means mossy stream. It was named after the occasion when two men went looking for Chiefess Kahalaopuna, who bathed there. One man looked into the stream and remarked on the amount of limu in the stream. The other man told him that there is no limu in the stream but rather it was mud. So muddy was the water that the two men could not even see the Chiefess.

Uluhaimalama Royal Garden
This flower garden in Pauoa is located above the Stream and below the Chinese Cemetery. The land belonged to Queen Liliu‘okalani. Prince Kawānanakoa and Prince Kalaniana‘ole both planted indigenous plants there. All of the indigenous plants were symbolic, having a meaning to kahuna: Kou, hala polapola, kukui, ‘awa, papa‘a and kea sugar cane, uhaloa, popolo, ‘ape and pilimai sugar cane.

2.5.8 Honolulu Harbor

Honolulu Harbor, translated by Puku‘i in Place Names of Hawaii (1974) to mean “sheltered harbor,” was created by freshwater flows from Nu‘uanu Valley into the ocean. The flow of fresh water inhibited coral growth forming a basin, which would eventually form the harbor. Also taking shape as a result of fresh water flows were channels that were etched out through the coral reef. Sand eventually began to accumulate on a shallow off-shore reef, forming what would later become “Quarantine Island,” now referred to as Sand Island. Fishponds dotted the coastline toward the west from Nu‘uanu Stream to Ke‘ehi Lagoon.

In 1905, the COE widened Kapālama Channel and dredged both Kapālama Channel and Basin. At the same time, Quarantine Island was filled and developed. Kewalo Basin, approximately 55 acres, was constructed to ease congestion in Honolulu Harbor and provide docking for lumber schooners. Channel widening, dredging and support facilities construction continued into the post war period.

2.5.9 Planning Implications

Traditionally, Moanalua, Kahauʻiki, Kalihi, Kapālama, Nuʻuanu, and Pauoa ahupuaʻa all shared water-rich environments that contributed to the broader based agricultural functions of the Kona district of Oʻahu. Abundant rain, perennial streams, lush interior valleys, and well-watered low lands supported extensive agricultural practices of the district. In turn, productive wet land taro cultivation provided nutrient rich waters that flowed through complex ʻauwai, or ditch systems, which eventually fed numerous fishponds that lined the coastal areas of all three ahupuaʻa. The Kalihi fishponds managed to survive into the early 20th Century.

The lowlands were abundant with fresh water. This is evidenced by the abundant taro cultivation, as well as the brackish-water fishponds that were known for their productivity. Additionally, fresh water flows inhibited coral growth in the near-shore waters, which created Honolulu Harbor and channels in the coral reef. The WHW area had a generous supply of clean, fresh water that should be perpetuated.

Near-shore waters were productive fisheries. Accounts from Kapālama note that a fringing reef protected the shoreline and allowed access to productive near-shore fisheries. Numerous fishponds also suggest conditions favorable to food fishes that should be restored for recreational and/or subsistence fishing.

The Kona District on Oʻahu was known for loʻi kalo and fishponds. The archaeological record, historic narratives and maps document numerous taro fields and fishponds. In addition to producing food, these loʻi and loko iʻa served a secondary purpose of filtering sediments from the streams before they reached the near-shore waters. This is suggested by the muddy waters of ʻAuwaiolimu (see section on Pauoa ahupuaʻa) not negatively impacting the productive near-shore fisheries. Since then, the old lagoon in Kalihi (see section on Kalihi ahupuaʻa) has been filled with sediments.

The natural and cultural environments of Kalihi, Kapālama, and Nuʻuanu ahupuaʻa were set apart from other ahupuaʻa. Cool trade winds blew over the Koʻolau Mountain Range. There was abundant rain, perennial streams, springs, lush interior valleys, and well-watered low lands and harbor areas. Within these ahupuaʻa were critical trail networks that linked localities between east to west, and north to south. Rapid urbanization associated primarily with harbor activities either destroyed or severely altered the natural environment. The task still remains however, to care for the island environment. Community-based efforts are underway to clean Kalihi stream. Efforts such as these should be supported and expanded to include the reintroduction of native biota where appropriate in streams and their associated mauka areas.

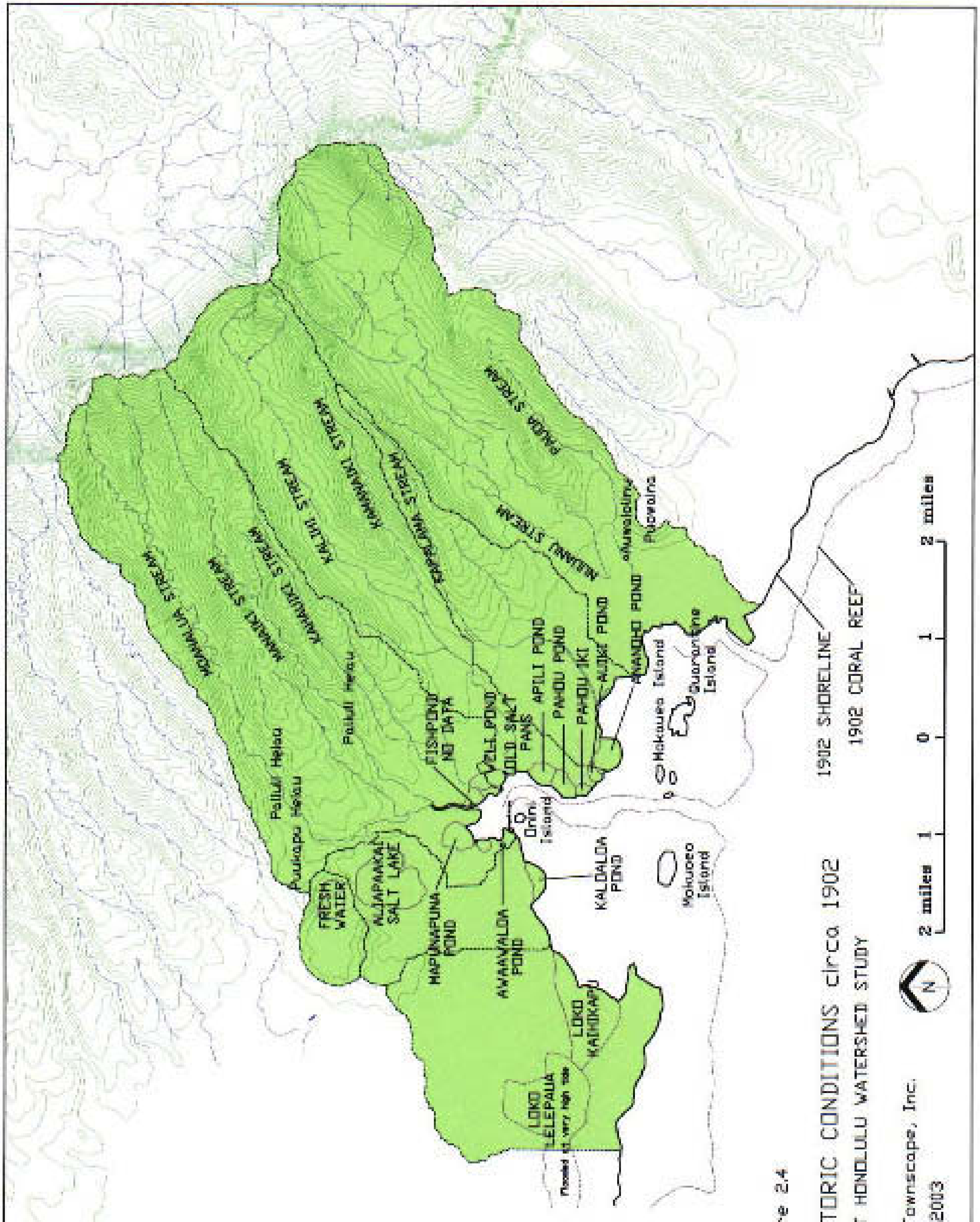


Figure 2.4

HISTORIC CONDITIONS circa 1902

WEST HONOLULU WATERSHED STUDY

By: Townscape, Inc.
May 2003

SECTION 3
DATA INVENTORY, CRITICAL ISSUES AND GUIDING PRINCIPLES

The scope of the WHWS included a thorough analysis of available narrative and scientific studies and reports pertaining to water resources related to the Moanalua, Kalihi, and Nu‘uanu drainages. Other materials that cover watershed science in Hawai‘i and elsewhere that had a direct bearing on the study were also included as resources contributing to this study. A comprehensive bibliography of the reviewed materials can be found in Appendix A of this report, and summaries of selected studies and reports are located in Appendix B. Although there have been a number of studies that involved the WHW region, many of these reports were prepared several decades ago, and they are not representative of existing conditions in the watershed. Piecing together data sets across a wide range of scientific interests and over time creates an incomplete or inaccurate picture of the state of the watershed. Thus, there is a need to continue detailed and regular monitoring and analyses of the natural processes of the WHW.

3.1 DESCRIPTION OF AVAILABLE WRITTEN MATERIALS

A total of 66 studies and reports were collected as part of this investigation, of which 48 were reviewed and briefly summarized so that the main points of the report could be quickly communicated. Of the reports that contained scientific data on water resources specific to the region, critical reviews were developed in a single-page format. There were 18 of these more detailed reviews conducted during the study. The 17 that were not reviewed are cited in the general reference list in Appendix A.

General references included such publications as *Hawaii’s Native and Exotic Freshwater Animals,* by Annette Tagawa and Mike Yamamoto (2000), which describes natural habitats for all aquatic organisms in the State of Hawai‘i. An example of a study concerning design alternatives for urban streams on the mainland is the *Lower Silver Creek Watershed Project*, by the Santa Clara Valley Water District (1994). These general references are considered resources for certain projects and may be listed in Section F of the project descriptions but were not reviewed in detail as part of this study.

Reports that were reviewed at the summary level included such titles as *Dam Safety Inspection, Nu‘uanu Reservoir No. 4,* prepared by Ernest K. Hirata and Associates (1993). This report is specific to the study area and precedes a report conducted in 1999 that expands on the earlier information. The document was reviewed because some of the information is still applicable and broadens our understanding of the issues relating to the dam.

The limited amount of data identified for the WHWS area was critically reviewed for its value for providing an understanding of the existing conditions of the watershed. These reports contained information vitally important to the formation of the project recommendations contained in this report. An example of this type of report is the *Keʻehi Lagoon Recreation Plan Final Environmental Impact Study*, prepared by Edward K. Noda and Associates, Inc. (1989). This report included in its investigation water quality data compared to standards in effect at the time of the study. Shortcomings in the report are discussed in the comments section of the review.

3.2 SUMMARY OF FINDINGS AND RECOMMENDATIONS FROM TECHNICAL REPORTS

The WHWS was originally intended to produce detailed descriptions of projects recommended in previous reports. However, due to the lack and/or age of the data record, other criteria, such as agency interviews and field surveys, were utilized to conceptualize projects that were geared toward improving environmental conditions in the watershed based on the objectives of the WHWS. The following pages provide a summary of the most relevant references, including the key findings gleaned from the documents.

3.2.1 ***Water Budget and the Effects of Land Use Changes on Ground Water Recharge.*** 1996. Patricia J. Shade and William D. Nichols: The report concluded that urbanization in southern Oʻahu increased runoff by and estimated 18 percent, or 23 mgd.

3.2.2 ***Occurrence of Organochloride Pesticides in Stream Bed Sediment and Fish from Selected Streams on the Island of Oʻahu, Hawaiʻi.*** 1998. USGS, Ann M. Brasher and Stephen S. Anthony: The study concluded that organochloride pesticides are transported from agricultural and urban sources primarily through soil erosion and runoff, and continue to persist in Oʻahu's aquatic ecosystems although they are no longer in use.

3.2.3 ***Manaiki Stream Flood Control Project Ala Mahamoe Street to Mahiole Street, Moanalua, Honolulu, Oʻahu, Hawaiʻi.*** 1979. William Hee and Associates, Inc.: The report proposed segmented walls at 5 locations to minimize erosion during flood conditions and expanding bridge/culvert at Mahiole Street to minimize inundation impacts.

3.2.4 ***Erosion and Sediment Control Guide for Hawaiʻi.*** 1981. United States Department of Agriculture (USDA): The guide recommended erosion and sediment control principles: select lands with drainage characteristics that are suitable for the intended use; schedule installation of permanent vegetation and infrastructure capable of handling storm runoff before removing vegetation cover; retain, protect, and supplement natural vegetation where feasible; expose the smallest practical area of land at any one time; expose land for the shortest practical period of time; use temporary plant cover and structures to control runoff

during construction; provide for increased runoff caused by altered soils and surface conditions; remove heavy sediment loads from runoff waters by using debris, sediment, or catchment basins; enhance development and reduce runoff by using trees, natural vegetation, and attractive physical features; avoid development in floodplains, natural water courses, and constructed channels; and ensure regular maintenance of conservation practices and/or measures.

3.2.5 ***Hawai'i Stream Assessment: A Preliminary Appraisal of Hawaii's Stream Resources***. 1990. Hawai'i Cooperative Park Service Unit, Commission on Water Resource Management (CWRM): The report concluded that the State's surface water resources are limited, fragile, and in need of immediate protective management. Potential future actions include: (1) maintaining and enhancing the Hawai'i Stream Assessment by initiating studies, workshops, and the development of master plans; (2) developing long-term stream management strategies by adopting a Hawai'i Stream Policy that protects important natural, cultural and recreational values, establishing a Hawai'i Stream Plan with General Guidelines and a Protected Streams Program; and (3) implementing interim actions to preserve management options.

3.2.6 ***Ko'olau Mountains Watershed Partnership Management Plan***. 2002. Ko'olau Mountains Watershed Partnership (KMWP): The plan recommended management activities include: (1) threat management of invasive non-native plant species, feral ungulates, and other non-native animals, human activities, aquatic pollutants, and wildfire; (2) water resources and watershed management; (3) biodiversity protection; (4) cultural resources management; (5) education, awareness and public outreach via media and public education, community outreach and education, volunteer opportunities and community partnerships; and (6) administrative coordination and communication. Monitoring is also recommended to determine the relationship between forest health and water quality and quantity, management program indicators, and administrative coordination and communication indicators.

3.2.7 ***Statewide Capital Improvements Program Flood Control Projects***. 1994. DLNR. Fukunaga & Associates: The report's recommended management activities included the Kalihi Stream Improvement Study that proposed 8,400 feet of channel improvements upstream from the stream mouth, a system of levees, concrete-lined rectangular and trapezoidal channel sections, and trapezoidal sections with rip-rapped side slopes, but was considered too costly to implement (benefit-to-cost ratio of 0.5).

3.2.8 ***Annual Report to the 21st Legislature 2001 Regular Session on Act 152 SLH 2000 Relating to Watershed Protection***. DLNR. 2001: The Act created a Watershed Protection Board to develop a watershed master plan for the protection of watershed resources. The

report recommended focusing on the ahupua‘a as the unit of planning for a management plan and for the identification of watershed partnerships.

3.2.9 ***Kapālama Canal Conceptual Plan Study***. 1980. R. M. Towill Corporation: The study recommended increasing channel capacity by constructing vertical CRM walls along 3,200 linear feet of the canal and constructing platforms for fishing and launching of small hand-carried boats, a pedestrian promenade with shade trees and picnic facilities, a mini-park on the former incinerator site, and an H-1 pedestrian overpass at Kohou Street.

3.2.10 ***Draft Reconnaissance Report for Flood Control Moanalua Stream***. 1979. COE: The report recommends two improvement categories: structural and non-structural measures. Because of constraints of topography and availability of land and economics, there is a limited range of alternatives. A channel concept is proposed to alleviate potential flood damage. Floodwall types include sheet piling and T-walls. Concrete invert lining, bank revetment, and floodwalls are being considered from Moanalua Freeway to Ke‘ehi Lagoon with emphasis on the West Bank, creating a “controlled inundation” of the lands to the east of the Stream, including Shafter Flats.

3.2.11 ***Phase II Dam Safety Investigation Nu‘uanu Reservoir No. 4***. 1999. Ernest K. Hirata & Associates: Nu‘uanu Reservoir No. 4 was found to meet the requirements for hydraulic and stability analyses based on standards established by DLNR, Dam Safety Section. With the exception of some potential flooding downstream of the dam, which might occur under extraordinary conditions, there do not appear to be any immediate hazards to the health, safety, and welfare of the public. Should a consistently followed monitoring program show any degradation of the embankment dam, as evidenced by increased seepage flow quantities, increased turbidity in seepage flows, or embankment deformation/cracks, the hazard should be immediately re-assessed. Recommended management activities included: (1) keep spillway, embankment, and seepage areas free of vegetation to facilitate observation of conditions; (2) develop collection pools and install flow-measuring weirs at selected seepage areas; (3) maintain of monitoring equipment; (4) maintain pool elevation at or below 995.

3.2.12 ***Storm Drain and Street Cleaning Effectiveness Report: City and County of Honolulu Municipal Separate Storm Sewer System NPDES Permit #HI0021229***. 1999. Department of Environmental Services (ENV): The report recommended that in order to combat water and air pollution problems, street cleaning needs to be combined into an integrated storm water management program, including source control, public outreach, and enforcement.

3.2.13 ***Analysis of the Rainfall-Runoff Relationship in Moanalua Valley, O'ahu, Hawai'i.*** 1981. Patricia J. Shade: The report concluded that concrete-lined channels increase peak floodwater flows.

3.2.14 ***Improving Salt Lake Waterways to Implement Resolution 01-265, CD1, FD1***. 2002. ENV, Department of Health (DOH): A long-range plan to improve and maintain the Salt Lake Waterways will require a partnership of all watershed stakeholders: Honolulu Country Club, CCH, State, U.S. Army, and the surrounding community. Improvement efforts include the removal of unwanted vegetation and sediment, maintenance of the waterways, and a watershed-wide pollution prevention program, including Best Management Practices (BMPs) (catch basin filters, vegetated swales, stream bank restoration, and rainfall detention facilities), education, and enforcement. Estimated costs for sediment dredging and disposal of Salt Lake and its waterways is $11,000,000.

3.2.15 ***Evaluation of the Surface-Water Quantity, Surface-Water Quality, and Rainfall Data Collection Programs in Hawai'i.*** 1994. USGS, Richard Fontaine: The current surface water quantity database only adequately addresses 2 of 14 specific issues and related goals of the program. Alternatives identified to address those deficiencies include new and expanded data collection, use of regional regression analyses, hydrologic and hydraulic modeling, and analysis and publication of existing data. Stream-gauging stations are needed on an additional 47 streams. Limitations of the surface water quality program included lack of data regarding suspended sediment, land use effects, quality of stream discharge into oceans, background water quality, and non-point sources of contamination; and the need for improved coordination between the numerous agencies involved with surface water quality issues.

3.3 GAPS IN THE DATA RECORD

One of the objectives of the WHWS was to identify areas in the data record that required improvement or updating. Due to the diverse character of watershed information and the age of many of the existing references, it was difficult to systematically identify "data gaps" for the WHW.

A qualitative discussion of our review of the literature is more applicable due to the nature of the available references. For instance, although water quality studies were conducted in the early 1990's for Ke'ehi Lagoon, the type of variables that are of interest, such as heavy metals, suspended solids, and fecal coliforms, were not included in some of the earlier analyses. There are pieces of information for most data types that are desired as indicators for watershed health; however, they are not as in-depth and continuous as would be needed to provide a comprehensive picture of water quality over time. A systematic evaluation of water quality, sediment

composition, and existence of contaminants in fish tissue at several points along a particular stream would provide information about the relative point of pollutant entry into the system and the effectiveness of BMPs within the watershed region.

Flood control improvements in WHW area streams need to be better defined and their respective feasibilities established by the flood control authority, i.e., COE.

Water supply protection and enhancement is awaiting the Source Water Assessment Program to be completed in late 2003.

Water quality monitoring should look at current native species population surveys as indicators of watershed quality, and also consider the potential beneficial and negative impacts of improved public access into the upper watershed areas for the purposes of cultural perpetuation and community stewardship of the conservation districts.

These gaps in the data record are manifested in the form of the various studies proposed by the WHWS, as described in detail in Section 4.

3.4 SUMMARY OF CRITICAL ISSUES

A number of important issues have been identified through the investigation of existing conditions within the watershed region. These issues follow the three main objectives of the WHWS and expand into the related objectives of this watershed investigation. These issues also provide the basis for recommended actions to be taken to improve the general health of the watershed and create the framework for the guiding principles, which in turn provide the foundation for the various projects and actions recommended as part of this Study.

As a whole, the watershed is at a critical stage in its overall health. The area has suffered from years of industrial activity and modification, leaving all of the water courses in a condition that has prompted the EPA to declare them impaired under their 303(d) listing.

Illegal dumping of solid wastes and intentional and inadvertent leakages of contaminants into stream courses create a health hazard for swimming or fishing in the WHW Region. With regards to sedimentation, the Conservation District may contribute as much as 75 percent of the sediment load of the streams in the project area, which reduces water quality as well as increases the urban stream flood hazard potential. Water quality conditions are also impacted by feral pigs, which can spread leptospirosis, a pathogen that affects both animals and humans.

The extensive urbanization of the WHW has continued to degrade the integrity of the watershed. Trash and debris are major aesthetic, habitat, and water quality problems. A sample of water and sediment quality data is presented in Table 3.1.

The structural condition of the dam at Nu‘uanu Reservoir No. 4 continues to be in question. There could be a risk of catastrophic damage to residences and businesses in Nu‘uanu and the downtown Honolulu area. The 100-year flood hazards in the lower reaches of Kalihi and Moanalua Streams are increased by the presence of mangrove, which has reduced channel capacity by utilizing accumulated sedimentation as a rooting medium by as much as 50 percent in some reaches of Moanalua Stream. Nu‘uanu Stream is flood prone only in the area where the unregulated flow of Waolani Stream intersects with Nu‘uanu near a restrictive bridge opening at School Street, but the flooding may be significantly worse in the event of dam failure at Reservoir No. 4. Water quality continues to be poor from polluted runoff from streets, which accumulates in the fine sediment that comes to rest in the shallow gradient areas of slower moving streams. This sediment reaches levels of contamination that require special disposal methods.

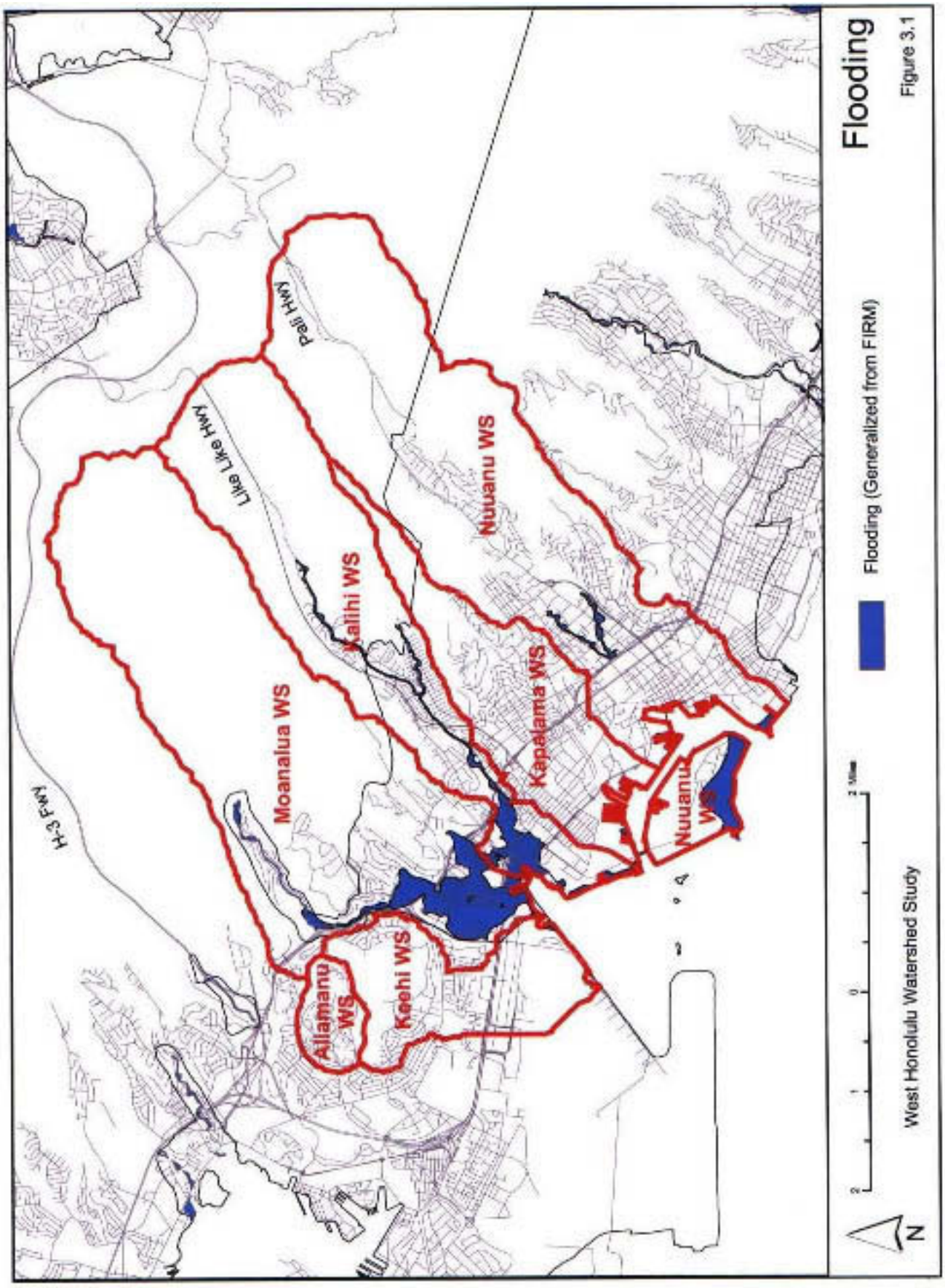
Moanalua Stream sediment build-up and mangrove, south of Moanalua Freeway.

Groundwater samples have been shown to contain traces and, in some cases, elevated amounts of contaminants, including the termiticides chlordane and dieldrin, which can cause health disorders. Petroleum and other sources of contamination are present in the substrate of the lower coastal reaches of the watershed and may influence shallow groundwater resources that affect the surrounding areas during hyper-saturated episodes. O‘ahu depends on groundwater resources for most of its freshwater needs. Increases in urbanization reduce the infiltrative capacity of the watershed, and the reduction of irrigated agriculture on O‘ahu further reduces groundwater recharge.

TABLE 3.1 Trace element and inorganic and organic carbon concentrations in streambed sediment from selected streams on the Island of O'ahu, Hawai'i, 1998 & 2000.
Data released SOURCE: U.S.G.S
November 8, 2001

[Concentrations in micrograms per gram (mg/g) dry weight unless otherwise specified; %, percent]	**Kalihi Stream at Kalihi**	**Kalihi Stream near Honolulu**	**Nuuanu Stream above Waolani Street at Honolulu**	**EPA Region 9 PRGs***
USGS station	16229300	16229000	16235100	
Date	07/18/00	10/17/00	09/16/98	
Aluminum (%)	8.3	9.3	5.9	76,000
Arsenic	**6.6**	**2.4**	**4.5**	**.39**
Barium	240	250	320	5,400
Beryllium	1.2	1.4	1.7	150
Cadmium	1.4	0.4	1.0	37
Calcium (%)	1.9	1.1	1.6	9
Chromium	**380**	**550**	**390**	**210**
Cobalt	47	61	47	4,700
Copper	240	210	180	2,900
Iron (%)	10	14	9.3	23,000
Lead	200	66	220	400
Lithium	14	12	13	1,600
Manganese	1200	1700	1600	1,800
Mercury	0.25	0.15	0.33	23
Nickel	200	210	190	1,600
Phosphorus (%)	0.260	0.190	0.220	1.6
Selenium	2.4	1.8	2.1	390
Silver	0.9	0.5	1.1	390
Sodium (%)	0.430	0.210	0.300	1.2
Strontium	220	170	240	47,000
Thallium	1	1	1	5.2
Tin	10	4	6	47,000
Uranium	1.3	1.2	1.3	16
Vanadium	260	400	200	550
Zinc	640	280	480	23,000

***PRG – Preliminary Remediation Goal, should be used as a guideline until site-specific standards are determined**


Flooding
Figure 3.1
Flooding (Generalized from FIRM)
West Honolulu Watershed Study
Moanalua WS
Kalihi WS
Nuuanu WS
Kapalama WS
Nuuanu WS
Kaehi WS
Aliamanu WS
Likelike Hwy
Pali Hwy
H-3 FWY
N

Cumulatively, these existing conditions in the watershed are indicators of land use patterns that conflict with the long-term health of the watershed. Although substances that are known to be health hazards, such as dieldrin and chlordane, have been banned, their legacies have an ongoing detrimental effect on the watershed. There are also future hazards to be concerned about, including introduced plant and animal species that further disrupt ecosystems, and the introduction of other known pathogens such as giardia, that are restrictive to outdoor recreation. The varied and extensive sources of watershed contamination suggest that a comprehensive approach to watershed restoration and ongoing management is needed to improve both ground and surface water and to include other variables in the watershed equation.

Existing land use is an issue related to stream maintenance jurisdiction, the ability to implement corrective actions in the watershed, and the need to form partnerships in watershed management and restoration projects. The major landowners in the WHW region are listed in Table 3.2 below.

Table 3.2 West Honolulu Watershed - Major Landowners by Ahupua'a

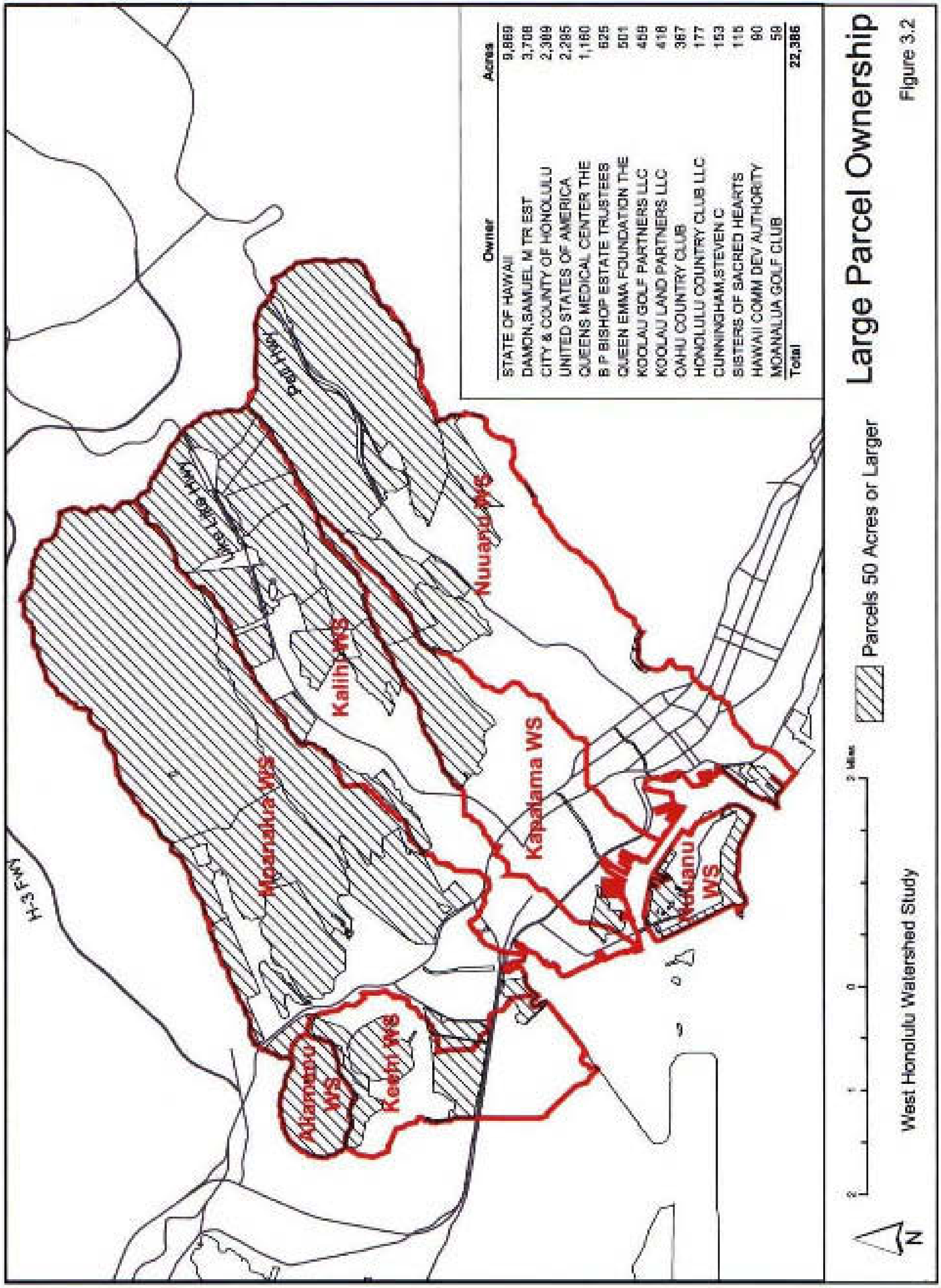
Moanalua		Kalihi		Kapalama		Nu'uanu	
Owner	**Acres**	**Owner**	**Acres**	**Owner**	**Acres**	**Owner**	**Acres**
Damon Estate	3,708	C&C Honolulu	1,112	KS	619	State of Hawai'i	2,306
U.S.A. (Fort Shafter)	1,036	State of Hawai'i	466			C&C Honolulu	203
State of Hawai'i	763	Steven Cunningham, et. al.	153			U.S.A.	76
Moanalua Golf Club	59	Sisters of Sacred Hearts	115			Dowsett Highlands Prop.	46

3.4.1 EPA Impaired Water Bodies

In November 2001, the EPA-issued report on "impaired" water bodies and contamination problems for Hawai'i included all of the water bodies in the WHW. The sources of contaminants will need to be identified, and Total Maximum Daily Load (TMDL) limits for certain key nutrients and contaminants will need to be defined. This will provide a stream-specific threshold that must be attained through a watershed restoration plan. This action by the EPA has substantiated DLNR's finding that sediments that must be dredged to maintain channel capacity contain metals or chemicals that are higher than background levels.

3.4.2 Sediment Build-up in Stream Channels

The rules to evaluate dredge material for ocean disposal are complex and costly to apply, requiring extensive testing technology not available at this time in the State of Hawai'i. Dredging proponents could partner with regulators to develop a process to simplify regulatory approval for regular maintenance dredging. Regulatory delays could increase the vulnerability of business and residential properties to flood damage due to already insufficient channel capacities. Beneficial use of dredge material should be investigated.



Owner	Acres
STATE OF HAWAII	9,889
DAMON,SAMUEL M TR EST	3,708
CITY & COUNTY OF HONOLULU	2,389
UNITED STATES OF AMERICA	2,285
QUEENS MEDICAL CENTER THE	1,160
B P BISHOP ESTATE TRUSTEES	625
QUEEN EMMA FOUNDATION THE	501
KOOLAU GOLF PARTNERS LLC	459
KOOLAU LAND PARTNERS LLC	418
OAHU COUNTRY CLUB	367
HONOLULU COUNTRY CLUB LLC	177
CUNNINGHAM,STEVEN C	153
SISTERS OF SACRED HEARTS	115
HAWAII COMM DEV AUTHORITY	90
MOANALUA GOLF CLUB	59
Total	22,386

3.4.3 Flood Control

The lower reaches of Kalihi and Moanalua Streams are within the 100-year flood hazard zone, as is the area above the intersection of Nu‘uanu and Waolani Streams. The causes of these hazards have been identified as insufficient channel capacity and the backwater effect of restrictive bridge openings. A further flood hazard exists due to the uncertain condition of the 100-year old earthen dam at Nu‘uanu Reservoir No. 4. Kalihi and Moanalua Streams present design challenges if stream restoration actions are included in these projects. Such actions could include low-flow channels, maintenance features to avoid damage to aquatic species habitats, provision of maintenance dredging, general beautification, and provisions for accessibility and safety. Previous flood control studies have focused on proposals that rely on impervious concrete revetments and channelization. Alternatives should be sought to these singular purposes, and sometimes deleterious flood control options, to encourage native species migrations, infiltration in streams, and riparian plantings.

3.4.4 Reduced Rainfall Infiltration into the Water Supply

The upper Conservation District is the major groundwater recharge area. This area is undergoing increased erosion and possibly a decrease of infiltrative capacity due to the presence of wild pigs and the dominance of exotic tree species. A single-layered canopy forest does not provide the rainfall impact protection of a multi-level forest community, which also acts to capture rainfall that would otherwise run off into streams. Pig wallows de-vegetate stream banks, which further aggravate runoff problems. Higher rainfall runoff equates to less water infiltrating into the ground water supply. With increased urbanization, storm water runoff increases as a direct result of more impervious surfaces. A 1996 Unites States Geological Survey (USGS) report estimated that urbanization in southern O‘ahu has led to an increase in runoff of about 18 percent, or 23 mgd. Furthermore, the decline in irrigated agriculture has also contributed to reduced groundwater recharge.

3.4.5 Contamination of Ground Water

Dieldrin and chlordane, termiticides formerly used for ground treatment, have been detected in some BWS wells. Although these chemicals are now banned, the potential impact of residuals is not known, and there may be a threat from new, presently unknown chemicals or other contaminants. As most of the

Moanalua Well #2

groundwater wells in the WHW region are located in the urban district, there are a multitude of threats to groundwater quality from incompatible land uses. Source water protection is a critical issue to be addressed in this study in the form of recommendations to ensure that safe drinking water is supplied to the City and County of Honolulu.

3.4.6 Native Species Habitat

This issue includes both aquatic species that are jeopardized by the decline in fresh water and marine ecosystem quality, and the critical habitat of the O‘ahu ‘elepaio, as feral pigs contribute to standing water that supports the propagation of mosquitoes carrying avian malaria. Native species have evolved in harmony with the characteristics of the Hawaiian climate and geography and are integral to a healthy ecosystem. The presence of aggressive alien species such as mangrove displaces native species that complement the physical and biological function of ecosystems within the watershed. Reduction of contaminants and innovative stream channel modifications for flood control are key strategies for preserving mobility of anadromous species in the watershed.

3.4.7 Public Access

Access enables community stewardship, and the demand for outdoor recreation opportunities continues to increase.

Public access to Moanalua Valley is only allowed by special permission of the private landowners of the Valley. Access to upper Nu‘uanu Valley is restricted to permit-entry due to its designation in the Conservation District. Kalihi Valley is a “closed watershed,” meaning that no public access is permitted in the upper conservation area. Public accessways can be a means to encourage stewardship of these lands that are otherwise being entered illegally and used as dumping grounds for trash, abandoned vehicles, and discarded appliances. Preventing entry into these areas creates a sense of detachment that allows for environmental abuse and degradation. Access into the upper conservation areas is also part of certain traditional ceremonial, gathering, nurturing, and religious rites of Native Hawaiians, and is a key component of the ahupua‘a concept. Managed access to the upper watershed areas by the general public is important in allowing volunteer groups in the community to conduct reforestation, stream restoration, and clean ups. Increasing involvement and reducing

indifference in the communities is the approach to watershed improvement, whereas continued exclusion of the public will perpetuate alienation between people and the land.

3.4.8 Water Quality Monitoring

Accurate assessments of surface water quality in the watershed provide a key indicator of the overall health of the watershed. However, the high costs of comprehensive water quality monitoring have precluded the compiling of a complete data record that could be used for a variety of watershed related programs, including sediment control, native species habitat enhancement, and recreational opportunities such as boating, swimming, and fishing.

3.4.9 Neighborhood Beautification

The streams and waterways in the WHW region have been utilized as conveyances of storm water rather than aesthetically pleasing natural features of the communities in which they exist. Restoration of these waterways may increase the attractiveness of the entire area as well as provide the opportunity for increased stewardship and appreciation. Nu‘uanu Stream is the exception to the poor regard of streams in the area; however, there are still opportunities for restoration and improved management in public areas such as Lili‘uokalani Gardens Park. The approach to beautification should complement the other needs identified in the watershed region, such as flood control, native species habitat improvement, and pedestrian access.

The issues discussed above give further confirmation to the need for a comprehensive effort to address fundamental problems in the watershed. Long-term watershed restoration begins with awareness, which means education of young and older residents alike, and a continuous effort to improve all conditions that contribute to the health of the watershed.

3.5 “GUIDING PRINCIPLES”

Through the analysis of issues revealed in the WHWS, several themes of watershed management and protection have emerged that can be viewed as “guiding principles” for future action. These guiding principles serve as the philosophical framework for projects such as flood control, stream restoration, the formation of a watershed partnership, and others. These principles are evident in the project descriptions presented in Section 4, and are intended to serve as criteria for decision-makers in the ongoing design of these initiatives. The watershed is an all-encompassing entity that includes both the physical world and human social and economic dynamics. Consequently, the Study team has adopted the ahupua‘a concept as a culturally appropriate land management tool.

The projects and programs recommended in this Study reflect methods that have been proven to be effective in watershed restoration and management in Hawai‘i and elsewhere, in particular the concept of “watershed partnerships.” There are several agencies at various levels of government that include watershed activities as part of their organizational objectives. Another important aspect of watershed restoration activities is the citizenry that takes an active role as a stakeholder in the watershed. There is an increasing trend for volunteer groups from the immediate or general region to get actively involved in the improvement of the physical surroundings and water resources that they depend upon for survival. The roles of community groups and partnerships are key components in watershed restoration.

- **Adhere to ahupua‘a land management principles.** Some of the aspects of the ahupua‘a concept include taking into account all things within the ahupua‘a boundary, that extends from the mountain summit to the outer reef fringe, as the area of influence; access by local community members to resource areas; and a culturally appropriate and intergenerational focus for management of natural resources. The ahupua‘a concept is further described in Section 3.6.

Kalihi Stream has a natural bottom through much of the urban district.

- **Minimize the use of impermeable concrete in the construction of flood control and other structures.** Traditionally, flood control in Hawai‘i has equated to the construction of concrete-lined trapezoidal or box-shaped channels that convey storm waters as quickly as possible through the landscape. These structures were built with little regard for the needs of native aquatic species, pedestrian access by citizens who live near the streams, or the function of natural stream courses in filtering impurities and regulating water temperature. Flood control technologies continue to improve in Hawai‘i and elsewhere and techniques should address other watershed-related principles, while maximizing public safety. As the antithesis of concrete, vegetation contributes to improved watershed performance through infiltrative capabilities. This is true not only for Kalihi Stream in

the lower, unstabilized banks near its mouth, but also for other West Honolulu stream segments that feature concrete revetments that are otherwise devoid of trees and plantings. Appropriate riparian plantings combined with permeable interlocking blocks or rock-filled gabions can perform as infiltrating waterways as well as stabilized floodwater channels. Inappropriate vegetation such as mangrove contradicts other guiding principles of watershed restoration and management, such as promoting native species habitat. Encouraging native riparian vegetation of stream banks captures sediment, provides habitat suitable for native species, and is more aesthetically pleasing than solid concrete or CRM revetments.

- **Abatement of polluted areas rather than "cap and build."** There is a trend for "site improvement" projects to seal and vent areas in the lower watershed that have been identified as contaminated, as evidenced in the recent Home Depot and Costco developments in Iwilei. This is contradictory to the ahupua'a concept that seeks to preserve and even enhance the environment for the use and enjoyment of future generations. Therefore, remediation is the preferred method of addressing contaminated areas.

- **Improve native species habitats.** This is an indicator of the functionality of the entire ahupua'a, as species such as the native 'o'opu require a saltwater and upstream segment in their lifecycles. Also, there should be a trend in water bird habitat restoration as a key indicator of watershed and ecosystem health, as the area was once a habitat for such organisms.

Interlocking block design (above) allows for infiltration of stream water, vegetation growth, and erosion control (below)

- **Empower the citizenry through awareness, participation and stewardship.** This can be achieved from school-age children to the elder citizens of the community. In this way, adults may serve as models for children to form good stewardship habits that prevent attitudes of indifference toward the watershed that result in dumping of wastes and

degrading the water quality and aesthetic appearance of the landscape. Increasing public access is a key strategy to involve the citizenry in environmental stewardship.

- **Promote partnerships** at various scales, from a regional scale to a focused subwatershed at the valley or neighborhood level. Partnerships among landowners, government agencies and other stakeholders are currently the accepted means for addressing the complex and interrelated issues of watershed management, with several examples in effect in Hawai‘i and elsewhere. Partnerships should also be formed with educational programs that focus on promoting watershed understanding for residents of all ages.

- **Target the reduction of sediment and polluted runoff at the source.** Single-canopy forests in the Conservation District, together with erosion that occurs due to poor erosion-control techniques in developments, have resulted in sediment buildup in the WHW region stream courses. Feral animal control is an important strategy for reducing soil erosion. Soil and bank stabilization also reduces erosion, sedimentation, and subsequent flood hazards, as well as the need for abatement actions such as dredging and dredge disposal. Sediments also trap contaminants, which creates a regulatory and logistical problem for legal disposal. Eliminating metals from entering storm drains and eventually into streams protects stream water quality and provides for aquatic species habitat and human recreation and subsistence. A long-range goal would be the banning of brake pads and tires containing metals that eventually make their way into storm drains and streams. Similar efforts have been initiated in the San Francisco Bay Area with measurable success.

- **Protect and enhance the aquifer’s sustainable yield.** The reduction of irrigated agriculture on O‘ahu, the increase of urbanization and the related increase in impervious surfaces, and non-native vegetation that increases evapo-transpiration have resulted in a reduction in the amount of groundwater recharge into the basal aquifer. In the meantime, the demand for potable water continues to rise. With urbanization, also come threats from the percolation of contaminants into the groundwater. Watershed improvement projects should seek to increase permeability while controlling land uses that may have negative impacts on groundwater quality.

- **Monitor and protect streams, estuaries, and near-shore waters.** All surface water runoff eventually reaches the ocean, and all contaminants accumulate and concentrate in the receiving waters. The quality of this water and the quality of the habitat are indicators of the effectiveness of watershed improvement projects and overall watershed health.

- **Protect and restore the native forest** to address other watershed issues, such as erosion reduction and increased infiltration, and as a means to support the United States Fish and Wildlife Service (USFWS) designation of critical habitat for the O‘ahu ‘elepaio and the perpetuation of other species that rely on a native ecosystem. This also increases the cultural resource base as native forests supply materials that are traditional in Hawaiian culture.

- **Aesthetic enhancement of the watershed.** This principle is compatible with many of the aforementioned subjects and should be combined with improving flood control management practices, increase in stewardship of the watershed, and promotion of native species habitats, among others. An attractive watershed is usually synonymous with a healthy watershed.

3.6 THE AHUPUA‘A CONCEPT

During the past few years, the traditional Hawaiian land management system known as the *ahupua‘a* has been transformed from an interesting historic system to a model for holistic sustainability. The Hawai‘i State Legislature passed Act 152 in the year 2000, creating a Watershed Protection Board that recommended first and foremost the ahupua‘a as the focus of watershed planning. Community groups have acknowledged the traditional ahupua‘a boundaries as a clear definition of units of resource management. In addition, there are certain social concepts associated with the ahupua‘a concept that supports the resource management aspect in an expanded perspective of the watershed. The concepts that help to define the traditional ahupua‘a as they apply to watersheds include:

Graphic courtesy of Bishop Museum

- **The ahupua‘a boundary and the land-sea continuum.** The most common way to define the ahupua‘a is by establishing its physical boundaries, to provide a size and scale to the concept. By definition, the ahupua‘a is a land division that runs between the valley ridges from the mountaintop to the ocean and to the reef beyond. All resources within this boundary were the responsibility of those that lived within the particular ahupua‘a. The ancient

Hawaiians recognized the influence of the land on the coastal waters and the interrelationship between waters of adjacent ahupua‘a.

- **Access to a complete resource base.** As each ahupua‘a possessed nearly all of the resources needed for human survival, maintaining open access to these resources was a vital ingredient of a well functioning ahupua‘a. Some areas were *kapu* (not permitted) on a seasonal or permanent basis to commoners as a means for resource protection; however, those resource areas requiring management and enhancement by humans were not only available to those needing access, but were also their responsibility, or *kuleana*.

- **Reverence for water**. The ancient Hawaiians were fully aware that the conservation of fresh water was essential for their survival. The Hawaiian term for wealth demonstrates the value the ancient Hawaiians put on water: *waiwai*, or water in abundance. The *konohiki*, or chief land steward, carefully oversaw management of water from all of the streams and ‘*auwai* (irrigation ditches). Strict rules were enforced and severe penalties, including death, were imposed on those who violated the *kanawai*, or law of the water. Slowly, modern Hawai‘i residents are realizing that the land as well as humans become sick when the health of the water is neglected.

- **Respect for all living things.** Most living things had some kind of usefulness to ancient Hawaiians. They realized that in an island ecosystem, depleting a resource to below sustainable levels would result in the loss of that resource forever. Therefore, there was active management of populations of plants, animals, and even fish in the ahupua‘a as ongoing, day-to-day tasks. Based on the Hawaiian calendar, certain activities were *kapu* on certain days or seasons to allow the natural resource base to replenish itself. On days where fishing was prohibited, it was not uncommon to see fishermen out in their canoes feeding the wild schools of fish. Not only did this increase their stocks, but it also made the fish tame and facilitated easy catches on the days that fishing was permitted.

- **Coordination, cooperation, *laulima*.** Life in pre-European-contact Hawai‘i was successful in otherwise harsh conditions based on the fact that the Hawaiian culture emphasized helping one another. Not all Hawaiians would specialize in fishing, planting, or gathering cordage from the mauka areas, but those specialists would participate in mutual gift exchanges (*ho‘okupu*) with other specialists to gain the variety of needed resources for day-to-day life. In conducting regular ‘*auwai* maintenance, not unlike modern dredging activities, the entire village would participate in maintaining this common resource and

facility. The concept of working together is how the ancient ahupua‘a functioned and prospered.

- **Protocol and respect.** Most of the activities in the ahupua’a included some form of protocol to acknowledge respect for the occupants, spirits, or deities that inhabited an area that was being entered or for a resource that was being utilized. Protocols were a way to remind oneself that one was leaving one zone and entering another and, therefore, to act accordingly. The attitudes, behaviors, and, therefore, the impacts on the land were changed through such a realization. This realization is helpful to understand that actions in say the *kula* (plains) may not be appropriate for the *kahakai* zone, near the coast.

- **Intergenerational learning.** There was an emphasis on understanding the value of the resources within the ahupua‘a and on conserving those resources for the *keiki* and subsequent generations. Realizing that resource depletion means less for the children to live with, not only were the consumption of resources limited but the actual enhancement of those resources was practiced. The idea was to leave at least as much as what had been left for one’s use, if not more. This lesson, along with the resource, was passed from one generation to the next.

- ***‘Ohana*, among people and the organic connection between people and the land.** The central theme to the ahupua‘a is humanity and place. The value of kinship was strong as a means of helping each other make a living. The care for a child as future strength was as strong as the respect for the elderly as sources of knowledge. The kinship between Hawaiians was paralleled by their kinship with the land, which Hawaiian folklore relates as an actual genealogical connection. With humans caring for the land as an elder sibling, the nurturing and respect needed for the coexistence between man and the ‘*āina* that is needed today, as it was yesterday, can be achieved.

These are some of the aspects that constitute the ahupua‘a concept and provide the missing link between modern human activities dominant over the landscape and the way society should interrelate with the environment, as both exploiter and provider. It also gives people the proper perspective on the influence of their actions that conflict with a natural, healthy watershed, and provides long-range insights to recognize those impacts on the lives of future generations.

SECTION 4
DESCRIPTION OF RECOMMENDED PROJECTS

4.1 WHWS RECOMMENDATIONS

The following projects and studies are recommended to improve the overall quality of the WHW. The ideas for these projects were developed in accordance with the primary objectives of the study, the guiding principles, issues, and concerns that were raised through the various consultations, field investigations, and through recommendations contained in the literature and data record.

Several major issues are not addressed in this project section, including the petroleum contamination that exists in the Honolulu Harbor area generally between Dillingham Boulevard and the coastline. This issue is being addressed by a voluntary consortium of businesses in the area that includes petroleum companies and other enterprises that are involved in the handling and storage of hazardous substances; they are known as the Honolulu Harbors Participating Parties. This group is currently conducting an inventory of existing petroleum and petroleum by-product infrastructure and ground contamination in the Iwilei and Honolulu Harbor area. The next phase will be to create and initiate a petroleum clean up plan. The WHWS supports a clean-up effort rather than capping this yet undetermined amount of the petroleum contamination in this area, per the guiding principles discussed in Section 2 of this report.

There are four types of recommended actions presented in this section of the report: projects, plans, studies, and programs. A ***project*** refers to an action that involves some type of construction or physical action. For instance, a stream channel improvement project requires the physical stabilization of the banks through interlocking revetment blocks or through planting of stabilizing vegetation. A ***plan*** is a document that is intended to establish objectives, study existing conditions, analyze various strategies directed toward improving the existing conditions, identify parties that should be involved in improvement actions, and schedule a list of actions necessary to achieve the plan objectives. A ***study*** is an effort that seeks a greater understanding of a specific question, such as how to improve flood control or increase the sustainable yield. A ***program*** is an effort that provides an ongoing service or investigation with no foreseeable conclusion, such as a long-term water quality monitoring action.

The greater part of this section describes in detail the recommendations made in the WHWS. The write-up begins with the title and project reference number of the particular action, followed by information such as category (ahupua‘a-based watershed action, flood control, surface water quality, or water supply), type (project, plan, study, or program), and possible participating

agencies and authorities. Section A of the write-up presents the problem statement. Section B provides a narrative of the project background. Section C describes the objectives of the proposal. Section D contains a preliminary scope for the action. Section E features additional agency information and a cost estimate. Section F is a list of references related to the action. These descriptions are offered as preliminary information subject to change by the organization involved in the execution of the proposed action.

Cost estimates were developed for the recommended projects through research on existing funding sources for watershed initiatives, information provided by experts and agencies, and best professional judgment. The identification of lead agencies and other involved agencies for each project are recommendations and do not obligate a particular organization to conduct the study or project. Actual project initiations depend greatly upon new information, funding and/or staffing availability. Governmental funding sources for watershed restoration and protection have been increasing as science and politics converge on the realization that a broad-scope and long-range focus is needed to adequately protect water resources for this and subsequent generations. In early 2002, President George Bush announced that over $20 million in additional Federal funding had been earmarked for community-based watershed protection programs. Information on existing funding sources available at the time this report was prepared is summarized in Appendix C.

4.2 Detailed Project Descriptions

The project list by category is as follows:

A. <u>Ahupua‘a-Based Watershed Recommendations</u>

01. Establish West Honolulu Watershed Partnership
02. Establish “Demonstration Watershed” Program
03. West Honolulu Watershed Expanded Trails Study
04. West Honolulu Watershed Comprehensive Restoration and Management Plan
05. West Honolulu Watershed Center

B. <u>Flood Control Recommendations</u>

06. Kalihi Stream Restoration and Flood Control Study
07. Moanalua Stream Restoration and Flood Control Study
08. Nu‘uanu Stream Restoration and Flood Control Study

C. <u>Surface Water Quality Recommendations</u>

West Honolulu Watershed Sediment Load Reduction Actions

09. Kapālama Canal Channel Restoration and Improvements
10. Moanalua Stream Channel Improvements
11. Salt Lake Environmental Restoration Study
12. Urban Stream and Honolulu Harbor Dredge Disposal Action Plan
13. Kalihi Watershed Erosion Prevention/Infiltration Enhancement Project
14. Kalihi Watershed Invasive Fauna Control Project
15. Moanalua Watershed Invasive Fauna Control Project

West Honolulu Watershed Streambank Stabilization Projects

16. Kalihi Streambank Stabilization Project
17. Nu‘uanu Streambank Stabilization Project

Surface Water Quality Actions

18. West Honolulu Surface Water Quality Monitoring Program
19. Ke‘ehi Lagoon Estuary and Honolulu Harbor Monitoring Program

D. <u>Water Supply Recommendations</u>

Urban Groundwater Source Protection Plans

20. West Honolulu Watershed Source Water Protection Plan
21. Ko‘olau Mountain Infiltration Well Pilot Study

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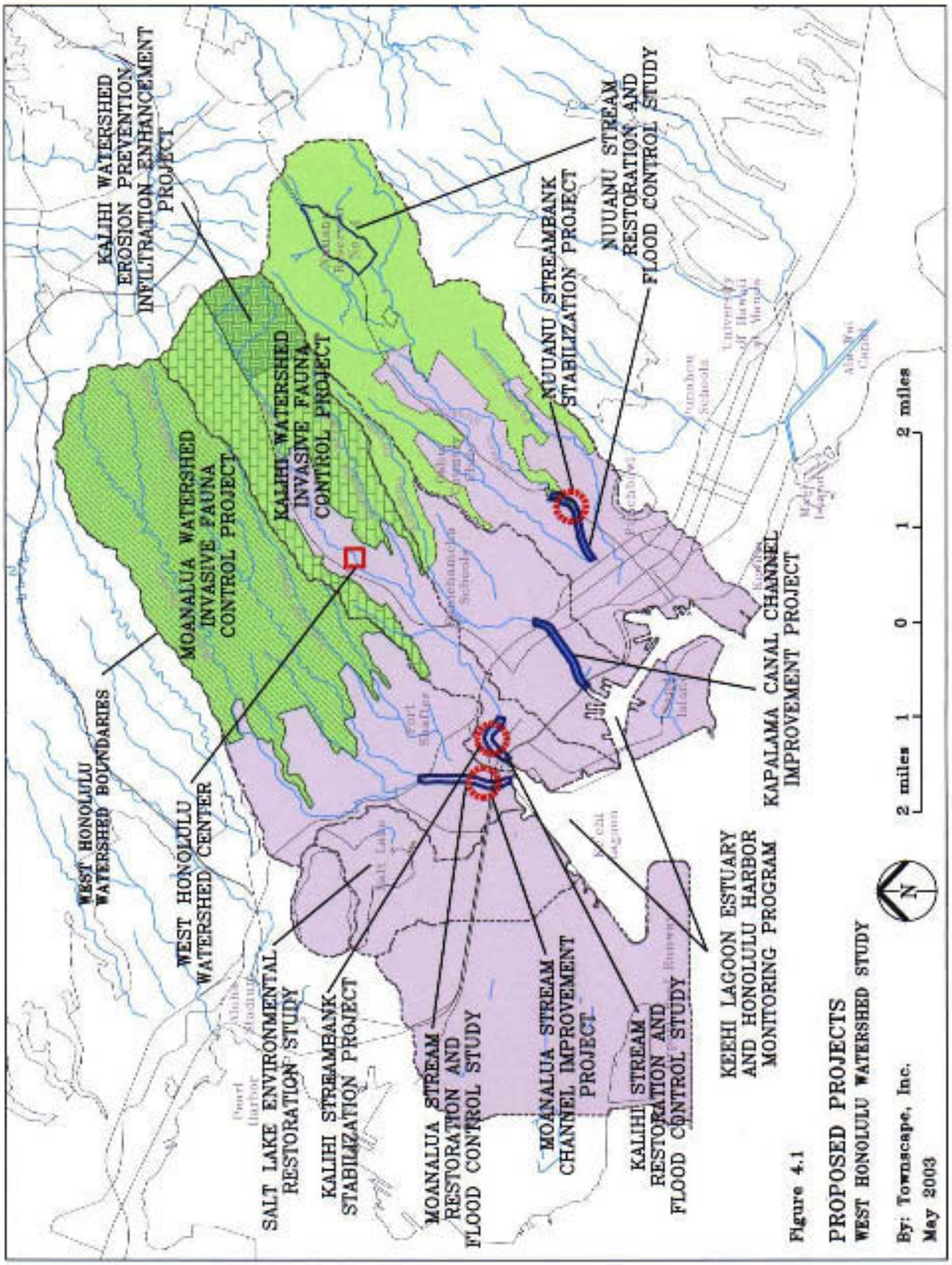
WEST HONOLULU WATERSHED BOUNDARIES
WEST HONOLULU WATERSHED CENTER
MOANALUA WATERSHED INVASIVE FAUNA CONTROL PROJECT
KALIHI WATERSHED INVASIVE FAUNA CONTROL PROJECT
KALIHI WATERSHED EROSION PREVENTION INFILTRATION ENHANCEMENT PROJECT
NUUANU STREAMBANK STABILIZATION PROJECT
NUUANU STREAM RESTORATION AND FLOOD CONTROL STUDY
SALT LAKE ENVIRONMENTAL RESTORATION STUDY
KALIHI STREAMBANK STABILIZATION PROJECT
MOANALUA STREAM RESTORATION AND FLOOD CONTROL STUDY
MOANALUA STREAM CHANNEL IMPROVEMENT PROJECT
KALIHI STREAM RESTORATION AND FLOOD CONTROL STUDY
KEEHI LAGOON ESTUARY AND HONOLULU HARBOR MONITORING PROGRAM
KAPALAMA CANAL CHANNEL IMPROVEMENT PROJECT
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Figure 4.1
PROPOSED PROJECTS
WEST HONOLULU WATERSHED STUDY
By: Townscape, Inc.
May 2003

Establish West Honolulu Watershed Partnership (Page 1 of 2)		**Project 01**
Category	*Project Type*	*Participating Agencies*
Ahupua'a-Based Watershed Action	PROGRAM	DLNR-Engineering Div., DOFAW; DOH; Natural Resource Conservation Service (NRCS); EPA; Coastal Zone Management Program (CZMP); BWS; KMWP; Damon Est.; TNC; others

A. Problem Statement

Currently, there is no single administrative organization that exists to oversee efforts to improve surface water quality, protect groundwater resources, address flood control needs, conduct public outreach programs, advocate watershed legislation, and to comprehensively address watershed issues for the WHW. Without long-range oversight and coordination of activities affecting the watershed, groundwater, surface water, and flood control conditions will continue to decline.

B. Project Background

There is a need for coordinated oversight of development projects and watershed restoration actions in the WHW region. Conflicting actions have led to the decline of conditions in the watershed. For instance, the conveyance of storm water through the Salt Lake Basin into Moanalua Stream has impacted water quality and has contributed to the contaminated sediment problem within the streambed. This creates a public health hazard as the stream is used for recreational and subsistence fishing. Sediment build-up reduces flood flow capacity, and provides soil for invasive mangrove to flourish, which further reduces floodwater capacity. The partnership could be modeled after other watershed organizations such as the Kailua Bay Advisory Council, the Ala Wai Watershed Association, the East Moloka'i Watershed Partnership, the West Maui Mountains Watershed Partnership, and others. An active partnership tasked with monitoring and promoting activities that affect the watershed would provide consistency to watershed protection, and a forum for the public to express concerns about development within the watershed.

C. Project Objectives

The objective of this program is to establish a watershed partnership to include appropriate representation from landowners, community stakeholders and public agencies to coordinate watershed planning and restoration in the West Honolulu region. This partnership would be the forum for communication among all groups and agencies involved in watershed-related activities. Their jurisdiction would cover the Moanalua, Kalihi, and Nu'uanu watersheds. The focus would be on water features that have been designated by the EPA as impaired water bodies, such as Ke'ehi Lagoon, Moanalua Stream, Kalihi Stream, Kapālama Canal, Salt Lake, and Nu'uanu Stream. The WHW Partnership would have the responsibility to formulate, execute and update the watershed management plan for the WHW region; act as a clearing house regarding watershed issues; oversee and coordinate water quality programs, dredging activities, involvement in monitoring clean up of contaminated areas, public access issues, invasive species control, and educational programs; and act as an advisory board and intermediary between the public and various relevant agencies concerning watershed activities. Annual funding for one or two staff positions will be needed to perform these many tasks.

Questions to consider during the process of forming this partnership include:

- Who are the landowners/stakeholders that should be included in the WHW Partnership?
- What will be the vision and mission of the partnership?
- What will be the policies and procedures for partnership deliberations and actions?
- How will the Partnership interface with the general public and various government agencies?

Establish West Honolulu Watershed Partnership (Page 2 of 2) Project 01

D. Preliminary Scope

The scope of this action is to initiate a Watershed Partnership to oversee and coordinate watershed matters of the West Honolulu region. Potential agency and community representatives may include the BWS, relevant Divisions of DLNR, CZMP, NRCS, EPA, ENV, the Department of Planning and Permitting (DPP), TNC, Kalihi Watershed 'Ohana, and the Friends of Kalihi and Kamanaiki Streams. Steps to organize this partnership include:

- Solicit potential participants and other interested groups.
- Establish goals and objectives.
- Compose vision and mission statements.
- Develop policies and procedures for deliberations and coordinated action.
- Create a public awareness program, including newsletters, a website, participation in public events, community stream walks, presentations in schools, volunteer work programs.
- Coordinate and oversee the development of a West Honolulu Watershed Management Plan.
- Institute all actions with a sustainable, long-range focus.

E. Agencies Involved and Project Cost

A possible lead partner for this program is DLNR - Engineering Division and DOFAW due to their engineering resources and jurisdiction in the upper watershed areas. The Honolulu BWS and the State DOH may provide additional leadership support. Other involved agencies may include the EPA, USGS, NRCS, CZMP, ENV, and DPP. Private entities may include the KMWP, TNC, and Damon Estate. Estimated cost to initiate this program is $50,000. Ongoing operational costs are estimated at $100,000 to $250,000 annually.

F. References

East Maui Watershed Partnership. 1991. East Maui Watershed Partnership Master Plan.
East Molokai Watershed Partnership. 1999. Agreement.
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West Maui Mountains Watershed Partnership. 2000. Draft Environmental Assessment for the West Maui Mountains Watershed Protection Project.
West Maui Watershed Management Advisory Committee. 1997. West Maui Watershed Owners Manual. DOH, EPA, NOAA.

West Honolulu Watershed Partnership

◀ A group of landowners, stakeholders, and agencies working together to improve conditions in the West Honolulu Watershed region.

Participation in community festivals and other awareness generating activities. ▶

Establish "Demonstration Watershed" Program (Page 1 of 2)		**Project 02**
Category	*Project Type*	*Participating Agencies*
Ahupua'a-Based Watershed Action	PROGRAM	BWS; CZMP; DLNR-DOFAW, CWRM; DOH-Clean Water Branch (CWB); University of Hawai'i (UH)-Water Resources Research Center (WRRC); EPA; USGS; USDA-United States Forest Service (USFS); KMWP; TNC

A. Problem Statement

There is no coordinated watershed research program in Hawai'i. Many of the research questions related to watershed science are broad in scope and long-term, which requires a coordinated effort over many years.

B. Project Background

Based on the complexity of watershed dynamics, a designated research watershed or series of watersheds should be selected to increase understanding and provide efficiency in monitoring various aspects of watershed processes. The piecemeal research of Hawaiian watersheds has contributed to the lack of understanding the unique way in which these watersheds function. For instance, one agency may be involved with measuring precipitation, whereas another may track stream flow. Other measurements are not conducted, such as water quality monitoring for Kalihi Stream. Coordinated programs by several agencies could ensure complementary data sets that would contribute greatly to an understanding of Hawaiian watersheds.

C. Project Objectives

The objective of the program is to select a watershed or a series of watersheds on O'ahu or the neighbor islands with typical Hawaiian geomorphology, an urban component, a perennial stream, a forested conservation area, and defined receiving waters for use as living laboratories to conduct watershed monitoring as well as BMP test projects. Issues requiring long-term study in the WHW region include erosion prevention/rainfall infiltration enhancement, introduced flora and fauna control, bioremediation techniques, source water protection-land use conflict analysis, sedimentation studies, monitoring of contaminants, monitoring the effects of human activity and access in upper watershed areas, and other issues.

Questions to be considered through the Demonstration Watershed Program would include, but not be limited to:

- What agencies would/should participate in a long-term, multi-tasked research effort?
- How could rights of entry to lands in a Demonstration Watershed be attained for the purpose of a long-term research effort?
- How should the various agencies coordinate efforts so that understanding may be gained through correlations among research programs?
- What are the selection criteria for watersheds to be included in this program?

Establish "Demonstration Watershed" Program (Page 2 of 2) Project 02

D. Preliminary Scope

The preliminary scope of this program is to establish one or a series of Demonstration Watershed sites on a long-term basis as living, outdoor laboratories. Various agencies and research groups would use these sites to monitor the dynamics of Hawaiian watersheds and test watershed restoration projects. Activities conducted as part of this program may include:

- Recruitment of agencies involved or interested in watershed research and management to participate in Demonstration Watershed Studies.
- Develop criteria for Demonstration Watershed site selections based on the objectives of participating agencies.
- Review of alternative candidate Demonstration Watershed sites and selection of the sites based upon established criteria.
- Develop protocols among participating agencies for policies and procedures.
- Initiate pilot projects.

E. Agencies Involved and Project Cost

The lead for the project could be a "Task Force" consisting of DLNR-DOFAW, DLNR-Commission on Water Resource Management (CWRM), and UH-WRRC. DOFAW's involvement is based on their mandate to improve watershed quality. The UH-WRRC makes recommendations to all agencies and organizations with responsibilities to manage the water/environmental resources in the State of Hawai'i. Other supporting agencies may include BWS, CZMP, DOH-CWB, EPA, USDA-USFS, USGS, KMWP, TNC, and others. Annual costs for the various programs within the Demonstration Watershed will depend on funding by participants, and would range from $250,000 to $500,000 or more.

F. References

Brasher, Anne M. and Stephen S. Anthony. 1998. Occurrence of Organochloride Pesticides in Stream Bed Sediment and Fish from Selected Streams on the Island of Oahu, Hawai'i, 1998. USGS Fact Sheet 140-00.

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Fontaine, Richard A. 1994. Evaluation of the Surface-Water Quantity, Surface-Water Quality, and Rainfall Data Collection Programs in Hawaii, 1994. USGS: Water Resources Investigations Report 95-4212.

Young, Reginald H. K. and Gordon Matsushita. 1973. Baseline Quality Data for Kalihi Stream. Technical Report No. 71. Water Resources Research Center. University of Hawaii at Mānoa.

Research Watershed

◀ Research would include such items as forest constitution and infiltration of precipitation.

Biotic Inventories based on stream type and level of alteration. ▶

West Honolulu Watershed Expanded Trails Study (Page 1 of 2)		**Project 03**
Category	*Project Type*	*Participating Agencies*
Ahupua‘a-Based Watershed Action	STUDY/PLAN/ PROJECT	BWS; DLNR-DOFAW, Na Ala Hele; United States Fish and Wildlife Service (USFWS)

A. Problem Statement

The general public is not allowed to access much of the upper watersheds; however, there is evidence that unauthorized persons are entering and negatively impacting the watershed. In response to this unregulated activity, a management strategy is needed that recognizes the increase in demand for outdoor recreation and education, as well as the need for resource protection, through increased stewardship and managed access.

B. Project Background

Much of the upper watershed area is not available for access by the general public and is being entered illegally, which compromises conservation efforts. There is an increasing demand for public entry into undeveloped natural areas. The O‘ahu Branch of the Na Ala Hele Trail and Access Program reports that there are ten existing trails in the WHW area that could be restored and used by the public, some of which may have been used by ancient Hawaiians for gathering. A managed series of parks and public accesses would address this demand and, at the same time, help to improve the understanding of the watershed area through public education and stewardship. Many of the existing trails on O‘ahu do not have an impact evaluation program in place and, therefore, damage to trails cannot be accurately assessed. There are also concerns regarding liability of the landowner for accidents that frequently occur on undeveloped lands due to hiker inexperience and natural hazards. Concern has been expressed by BWS regarding entry of pathogens such as giardia into Hawai‘i by hikers from the continental U.S. and elsewhere. The ahupua‘a concept features access to all resources from the mountains to the sea, and with access is the associated responsibility to maintain such resources.

C. Project Objectives

The objective of the study would be to analyze existing and potential public access corridors within the WHW region, particularly in the upper watershed areas. The reasons for addressing public access in the upper watershed areas include the increasing demand for recreational opportunities in the urban areas; the Public Access Shoreline Hawai‘i ruling, which includes mountain accesses; increased public awareness of these important natural areas; and to promote stewardship in the upper watershed. As in the ahupua‘a concept, trails span from the mountains to the ocean to provide access to residents and visitors to all public lands. The study would evaluate possible access to areas that are currently off-limits to the public due to designation as conservation areas. This study should also investigate potential impacts if human entry is permitted into the protected watershed areas for the purposes of recreation and maintenance of upper watershed areas.

Questions to be considered as part of this study include:

- What are the current impacts of public use of existing trails in the WHW?
- What are the potential impacts/benefits to water quality in the upper Conservation District if public access is permitted to areas that are currently off-limits?
- What are the existing trail routes that would minimize impacts in the upper watershed?
- What liability protection do the landowners (DLNR, BWS) need to permit managed public access into the presently closed watershed areas?
- What will be the management policies and procedures for trails into the upper watershed reaches?
- What type of monitoring will take place to quantify the impacts of access in the upper watershed areas?
- What is the cost of establishing and maintaining new trails and enforcing use rules?

West Honolulu Watershed Expanded Trails Study (Page 2 of 2) Project 03

D. Preliminary Scope

The preliminary scope for this project includes an evaluation of the use impacts on existing trails within the watershed, the identification of potential new public trail routes, and the actions required to enable managed access into the upper watershed areas. Included in this Study are estimated impacts of human entry into these new areas, mitigative measures to be taken to lessen any anticipated impacts, and a monitoring program to measure impacts caused by an increased human presence.

Study tasks will include:

- Perform detailed studies of use impacts on existing trails within the WHW.
- Coordinate a survey of the WHW with Na Ala Hele for possible accesses.
- Consult with all landowners regarding issues associated with public access.
- Consult with hiking clubs and other users for input on trail routes and management issues.
- Research low-impact trail construction methods.
- Create a management plan for trails and scenic areas.
- Develop a monitoring program for impacts created by increased access.
- Construct trails and scenic areas.

E. Agencies Involved and Project Cost

The lead agency for this project may be DLNR-DOFAW, the major landowner in the Conservation District. The Na Ala Hele Trail & Access Program is within this Division. Their recreation objectives are to: 1) Enrich recreation for all ages through trails and facilities; 2) Establish coastal and mountain trail networks; 3) Preserve archaeological and ecological values of trails; 4) Encourage a private/public state trail system; 4) Expand volunteer programs. The BWS is another major landowner in the watershed area and has an interest in protecting the primary groundwater recharge area. Support could also come from the USFWS. Estimated cost for this project is $100,000 to $250,000.

F. References

Department of Urban and Regional Planning. 2001. Hawaii Trail Analysis: Survey and Risk Management Data Profile. Planning Practicum. University of Hawaii.

DLNR. 1991. Na Ala Hele: Hawaii Trail and Access System Program Plan. Division of Forestry and Wildlife. Department of Land and Natural Resources. State of Hawaii.

Koolau Mountains Watershed Partnership. 2002. Koolau Mountains Watershed Partnership Management Plan. Final Draft.

Santa Clara Valley Water District. 1994. Lower Silver Creek Watershed Plan Update. USDA: NRCS.

Public Access

◀ Upper reaches of Kalihi Stream afford spectacular scenery in a natural setting.

Managed public access through trails and possibly a series of public parks through the watershed ▶

WHW Comprehensive Restoration and Management Plan (Page 1 of 2) Project 04

Category	*Project Type*	*Participating Agencies*
Ahupua'a-Based Watershed Action	PLAN	BWS; DLNR-DOFAW; DOH; COE; NRCS; CZMP

A. Problem Statement

There is no comprehensive management plan that coordinates existing and future watershed related activities for the West Honolulu Watershed region.

B. Project Background

There are significant populations of feral ungulates in the Ko'olau Mountains. Most of the forest reserve area in the Ko'olau Range is composed of alien plant species, which may or may not be conducive to optimal erosion prevention, bank stabilization, or water infiltration. The upper Conservation District contributes a significant percentage of the sediment build-up in streams in the lower portions of the watershed. The Ko'olau Mountains Watershed Partnership (KMWP), a group of landowners, has developed a management plan to guide stewardship in the upper areas of the Ko'olau Mountains. The WHW Management Plan will draw from projects and study outcomes identified in the WHWS, including but not limited to: Flood Control Studies of the various drainages in the watershed region, the WHW Public Access Study, WHW Invasive Fauna Control Program, Urban Stream Dredge Disposal Action Plan, and the Watershed Infiltration Enhancement and Erosion Prevention Project.

The lower WHW area is dominated by urban land uses. Petroleum and petroleum by-products have contaminated much of the Honolulu Harbor area. The Honolulu Harbor Participating Parties, with oversight by the DOH-Hazard Evaluation and Emergency Response, will conduct a contaminated sites inventory including an assessment of abandoned infrastructure, such as underground storage tanks and pipelines. Recreational activities occur along the coastline at Ke'ehi Lagoon and Sand Island State Park. Therefore, coordination of these diverse land uses and activities needs to occur to prevent potential public health hazards.

C. Project Objectives

The objective of the plan would be to identify and coordinate strategies to protect and enhance the groundwater recharge capacity, protect drinking water sources, reduce sediment loads and contamination, improve flood control, and generally restore the health of the WHW. The plan would be developed in two sections, mauka and makai, but would be coordinated as one plan in keeping with the ahupua'a concept. As the watershed is a significant source of potable water for the primary urban center, groundwater quality protection is needed, and optimal recharge is essential. The petroleum contamination in the Honolulu Harbor area is a primary concern in the makai area. Actions to be considered as part of the management plan would include erosion control, re-planting of eroding conservation areas, reduction of feral animal populations, stream revitalization, aquatic species restoration, pollution abatement, and policy related to public accesses throughout the watershed. The plan would also include evaluative measures to assure that strategies recommended in the Plan are effective.

Critical questions to consider during the development of this plan include:

- How will stream source areas be preserved and enhanced?
- How should feral ungulates be controlled to prevent erosion and the spread of leptospirosis?
- How will public access and/or illegal entry be managed to protect the watershed?
- How do invasive plant species affect infiltration/erosion in the upper watershed?
- How should the KMWP plan integrate with the WHW Management Plan?
- How can industrial land uses in the lower watershed be managed to prevent coastal zone damage?
- How will the Harbors 2020 Master Plan and other plans integrate with the WHW Plan?
- How will petroleum clean-up be conducted and how will the Plan prevent future contamination?

How will the plan provide guidelines for BMPs and other guidance for residences and businesses?

WHW Comprehensive Restoration and Management Plan (Page 2 of 2) Project 04

D. Preliminary Scope

The preliminary scope for developing this Plan is to define and coordinate the various aspects of watershed management in the WHW region. Actions will include but not be limited to:

- Consult with relevant agencies, landowners, and community groups concerned with activities in the upper watersheds of the project area.
- Define the major issues in the mauka and makai reaches of the watershed.
- Research strategies utilized in other watersheds in Hawai‘i and elsewhere to address the major issues in the mauka and makai watershed areas.
- Select preferred alternatives to address watershed issues.
- Construct a timeline for priority actions and programs that will address issues over time.
- Establish metrics to measure effectiveness of plan objectives and projects.
- Provide guidance for business and residential strategies for watershed redevelopment via site selection criteria and BMPs.
- Provide details on “who does what and how to fund.”
- Evaluate the feasibility of implementing a watershed management tax for ongoing funding.

E. Agencies Involved and Project Cost

A possible lead agency for this plan is NRCS, due to their involvement with watershed restoration plans. DLNR-DOFAW and BWS are the primary land managers and executors of the State Watershed Management program that works to protect and improve the condition of forests that benefit water supply. Their organizational objectives include helping to ensure water quality and quantity, preventing rapid runoff of storm flows and soil erosion, improving water infiltration into soil, and encouraging forestry activities on private land. Other agencies that may be involved in the plan include the CZMP, DOH, and COE. Stakeholders include the KMWP and the West Honolulu Watershed Partnership. As major private landowners, Kamehameha Schools and Damon Estate should be included in the planning process. Estimated cost is $250,000 to $500,000.

F. References

Act 152. SLH 2000 (HB 2835, HD2, SD2, CD1). “Relating to Watershed Protection.”
Bartram, Paul D. 1975. Land Use and Coastal Water Quality: Planning Purposes, Critical Areas Management. HI Environmental Simulation Laboratory.
CWRM. 1990. Hawaii Stream Assessment: A Preliminary Appraisal of Hawaii’s Stream Resources. Report R84. Hawaii Cooperative Park Service Unit.
DLNR. 1980. Statewide Silt Basin Investigation. State of Hawaii. Prepared by: Fukunaga & Associates, Inc. Honolulu: DOWALD.
DLNR. 1983. Flood Control and Flood Water Conservation in Hawaii. Vol. II (revised). General Flood Control Plan for Hawai‘i. Circular C93.
DLNR. 1983. Flood Control and Flood Water Conservation in Hawaii. Vol. I (revised). Flood and Flood Control. Circular C92. with FEMA.
DLNR. 1994. Statewide Capital Improvement Program Flood Control Projects Report R98. Honolulu: Fukunaga & Associates. Honolulu: DOWALD
DLNR. 1994. Flood Control and Flood Water Conservation in Hawai‘i. Vol. III: Agencies and Legislation. Circular C94 (Revised).
Koolau Mountains Watershed Partnership. 2002. Koolau Mountains Watershed Partnership Management Plan. Final Draft.
Noda, Edward K. & Associates. 1989. Keehi Lagoon Recreation Plan Final EIS. State of Hawaii Department of Transportation.
West Maui Watershed Management Advisory Committee. 1997. West Maui Watershed Owners Manual. DOH, EPA, NOAA.
West Maui Mountains Watershed Partnership. 2000. Draft Environmental Assessment for the West Maui Mountains Watershed Protection Project.

West Honolulu Watershed Management Plan

◀ **Makai -** Ke‘ehi Lagoon is a popular recreation area.

Mauka – ▶
Erosion in Moanalua Valley.

West Honolulu Watershed Center (Page 1 of 2)		**Project 05**
Category	*Action Type*	*Participating Agencies*
Ahupua‘a-Based Watershed Action	PROJECT	BWS; CZMP; DLNR-DOFAW; DOH; NRCS

A. Problem Statement

There is a need for an education center in the WHW region to educate children, to inform adults, to provide a physical location for the WHW Partnership, and to provide facilities for some watershed-based research. This watershed science center may be combined with a cultural learning site to effectively communicate the ahupua‘a principles related to watershed stewardship and management.

B. Project Background

Providing a physical location for ahupua‘a-based learning enables a permanent educational program to provide greater understanding of watershed dynamics in the community. A comparable facility is the Hawai‘i Nature Center located in Makiki Valley, which conducts an outdoor learning program for elementary school children and adults alike, as well as interpretive tours and demonstration projects. The proposed Watershed Center would provide a permanent educational institution to facilitate a long-term, sustained watershed restoration in the West Honolulu region. Cultural learning, vis-a-vis the ahupua‘a concept that combines human ecology and the natural environment, is an appropriate partner to learning about watershed science for all citizens and visitors. Possible locations include Kupehau Park in Kalihi Valley; Nu‘uanu Reservoir No. 4, Kamanaiki Valley adjacent to Kamehameha Schools, and Moanalua Gardens. This type of facility could well be located in another watershed, such as the Ala Wai Watershed.

C. Project Objectives

The objective of the project would be to identify participating agencies or organizations as well as a physical location to establish a watershed center in the WHW region. This project is intended to serve as a demonstration ground for such tasks as bioremediation of street runoff from highways, absorption rates of rainwater among various plant communities, and the interrelationship between surface and ground water.

Critical questions to consider during the development of the Watershed Center concept include:

- Who will take the lead role in the Watershed Science Center?
- Where should the Watershed Research Center be located?
- What type of educational programs should be developed as part of this Center?
- How can adults be incorporated into the program at the Watershed Center?
- What types of research projects should be based at the Watershed Research Center?

West Honolulu Watershed Center (Page 2 of 2) Project 05

D. Preliminary Scope

The preliminary scope for the development of the WHW Center is to define and coordinate the various aspects of constructing an education/research facility in the WHW region. Actions may include:

- o Consult with relevant agencies, landowners, school, and community groups concerned with education in the watersheds.
- o Establish funding sources for education and research programs.
- o Identify and evaluate alternative sites for the West Honolulu Watershed Center.
- o Conduct community meetings to receive input on alternative sites.
- o Establish a 501(c)3, non-profit group to maintain and expand programs at the Watershed Center.
- o Plan and design the facility.
- o Fund and construct the facility.

E. Agencies Involved and Project Cost

The lead agency for this project could be DLNR-DOFAW, as the primary landowner and based on their Watershed Management program that works to protect and improve the condition of forests that benefit water supply. This would address the educational component of their organizational objective, which includes helping to ensure water quality and quantity, preventing rapid runoff of storm flows and soil erosion; improving water infiltration into soil, and encouraging forestry activities on private land. Other agencies that may be involved in this plan include BWS, CZMP, DOH, and NRCS. As a major private landowner, depending upon the selected site, Kamehameha Schools or Damon Estate may also be involved in the Watershed Center. Estimated cost of the establishing the Watershed Center is $1 million to $3 million. Ongoing annual operational costs could be $100,000 to $250,000.

F. References

Act 152. SLH 2000 (HB 2835, HD2, SD2, CD1). "Relating to Watershed Protection."
Koolau Mountains Watershed Partnership. 2002. Koolau Mountains Watershed Partnership Management Plan. Final Draft.

West Honolulu Watershed Center

◀ A Center based in the area to educate area residents, visitors, and particularly school children about watershed science.

Center grounds would feature demonstration projects related to watershed management. ▶

Kalihi Stream Restoration and Flood Control Study (Page 1 of 2) Project 06

Category	*Project Type*	*Participating Agencies*
Flood Control	STUDY	DLNR-Engineering Division, Division of Aquatic Resources (DAR); COE; NRCS; DOH; USFWS; UH Environmental Center

A. Problem Statement

Kalihi Stream has been impacted and degraded by urbanization. One of the signs of this degradation is increased flood volumes and velocities. Flood hazards associated with Kalihi Stream are caused by insufficient channel capacity for the 100-year flood and the backwater effect from restrictive bridge openings. A study is needed to determine how to best address the floodwater capacity shortfall in the stream channel and beneath the various bridges that span Kalihi Stream, and to recommend solutions, within the context of an overall stream restoration program.

B. Project Background

The flood problem in the coastal and transitional zones of the Kalihi sub-watershed is due to insufficient channel capacity and to the backwater effect resulting from restrictive bridge openings that were under-designed for peak storm water flows. According to flood hazard maps, much of the coastal and transitional areas are in the flood hazard zone. A study conducted by COE in 1971 showed that channel improvements along the lower reaches would be economically feasible, however the project was not implemented because local authorities could not provide assurances of cost-share contributions. This study revealed that the capacity of Kalihi Stream in the lower reaches is about 8,500 cfs, whereas the flood of 1930 measured over 12,000 cfs. A 1975 COE report recommended 8,400 linear feet of channel improvements to the lower reaches of Kalihi Stream at a cost of about $7 million, which consisted of a system of levees and concrete-lined rectangular and trapezoidal sections with rip-rap side slopes. The project was not implemented due to a low benefit-to-cost ratio. The State General Flood Control Plan lists Kalihi as one of the planned programs, with improvements as proposed in the 1975 COE study. A 1994 Flood Control Capital Improvement Project report by Fukunaga & Associates for DLNR-DOWALD recommended a study to investigate cost effective alternatives to prevent flood damage and loss of life associated with the flood hazard along Kalihi Stream. This WHWS proposal recommends a study that investigates alternatives to the traditional rectangular and trapezoidal sections, and the incorporation of principles related to aquatic species habitat restoration and public access ways in flood control improvements. This larger "stream restoration" objective will potentially result in a higher benefit-to-cost ratio.

C. Project Objectives

The objective of the study is to determine feasibility of stream restoration measures and alternatives to address critical flood control issues associated with Kalihi Stream. The EPA impaired water bodies designation for Kalihi Stream requires the project to address environmental restoration in addition to flood control measures.

Study questions for stream restoration and flood control of Kalihi Stream thus include but are not limited to:

- What are the current flood control issues along Kalihi Stream?
- Where are the critical points along Kalihi Stream that require flood control improvements?
- How can flood control measures incorporate native aquatic species habitat needs and public access?
- Which flood control improvements are best for Kalihi Stream and surrounding land uses?
- What are the alternatives to increase flood control capacity?
- How can flood control design incorporate anadromous native species habitat to facilitate necessary migrations between the ocean and upstream areas?
- How can flood control design effectively incorporate pedestrian and bicycle access during low stream flow stages?

Kalihi Stream Restoration and Flood Control Study (Page 2 of 2) Project 06

D. Preliminary Scope

The preliminary scope of work for this study will include tasks necessary to determine stream restoration strategies and optimal flood control improvements for Kalihi Stream to address the 100-year flood. Tasks for this study will include but not be limited to:

- Review of all flood hazard maps and previous stream analyses.
- Conduct engineering survey of flood capacity along Kalihi Stream and bridge crossings: Nimitz Highway, Dillingham Boulevard, North King Street, H-1 Freeway, School Street, Likelike Highway, etc.
- Determine critical stream sections requiring flood control measures, specifically between Likelike Highway and Ke'ehi Lagoon.
- Incorporate accommodations for native species, public access, and other stream restoration measures, as appropriate, into the design of flood control strategies.
- Recommend flood control technologies for critical stream sections and bridge openings.

E. Agencies Involved and Project Cost

The agency responsible for initiating this study is DLNR-Engineering Division, Flood Control and Dam Safety Section, based on their role as the State agency responsible for flood control. The COE will conduct the study under the appropriate flood control authority. NRCS may also contribute to this study through their Watershed Protection and Flood Prevention Program. Whenever channel hardening is proposed for a water course, the project sponsor should work with supporting agencies, including DLNR-DAR, DOH, UH Environmental Center, and USFWS. Estimated cost of the first step "Reconnaissance Study" is $50,000 to $100,000. Thereafter, the full "Feasibility Study" would cost $500,000 to $1,000,000.

F. References

DLNR. 1972. Kalihi-Moanalua Flood Hazard Area. DOWALD.
DLNR. 1983. Flood Control and Flood Water Conservation in Hawaii. Vol. II (revised). General Flood Control Plan for Hawai'i. Circular C93.
DLNR. 1983. Flood Control and Flood Water Conservation in Hawaii. Vol. I (revised). Flood and Flood Control. Circular C92 FEMA.
DLNR. 1988. New Year's Eve Storm. December 31, 1987-January 1, 1988. Windward & Leeward East O'ahu. Post Flood Report. Cir. C-119.
DLNR. 1994. Statewide Capital Improvement Program Flood Control Projects Report R98. Honolulu: Fukunaga & Associates. DOWALD
DLNR. 1994. Flood Control and Flood Water Conservation in Hawaii. Vol. III: Agencies and Legislation. Circular C94 (Revised).
Nakamura, M. N. and Reginald Young. 1974. Estimation of Urban Stormwater Quality in Kalihi Stream Drainage Basin, Oahu, Hawaii: Technical Memorandum Report No. 45. From *Pollution in Hawaiian Watersheds.*
Sam O. Hirota, Inc. 1977. Flood Hazard Study, Kalihi and Kamanaiki Stream, Oahu, Hawaii. Department of the Army, POD, Corps of Engineers.
Taogoshi, R. D., et al. 2001. Water Resources Data, Hawaii and Other Pacific Areas, Water Year 2000, Vol. 1 USGS.
U.S. Army Corps of Engineers. 1971. Plan of Investigation for Flood Control and Allied Purposes, Kalihi Stream. POD.
U.S. Army Corps of Engineers. 1992. Urban Flood Control Study. Honolulu Hawaii. Final Reconnaissance Report. HED. Fort Shafter, HI.
Wong, Michael F. 1994. Estimation of Magnitude and Frequency of Floods for Steams on the Island of Oahu, Hawaii. USGS: Water-Resources Investigation Report 94-4052.

Kalihi Stream

◀ Low banks provide insufficient capacity for the 100-year flood for Kalihi Stream.

Restrictive bridge opening over Dillingham Blvd. ▶

Moanalua Stream Restoration and Flood Control Study (Page 1 of 2)		**Project 07**
Category	*Project Type*	*Participating Agencies*
Flood Control	STUDY	DLNR-Engineering Division, DAR; DOH; UH Environmental Center; USFWS; COE; NRCS

A. Problem Statement

Significant portions of the lower and transitional reaches of Moanalua Stream are within the 100-year flood hazard zone, and a backwater effect exists during high-flow conditions due to restrictive bridges openings under Nimitz Highway and the H-1 Freeway.

B. Project Background

Moanalua Stream and its major tributaries, Manaiki and Kahauiki, have a history of flooding. Flood volumes and velocities have been significantly increased by urban development. Some reaches of these urban streams have reinforced concrete channels. Māpunapuna, in the lower reaches of Moanalua Stream, is subject to drainage problems during heavy rains due to insufficient capacity and low elevation. The flood of April 19, 1974, caused $2.3 million in damages. Since that flooding event, some of the low-capacity bridges have been replaced. The COE proposed channel improvements to Moanalua and Kahauiki Streams, which were not implemented based on a low benefit-to-cost ratio. If the benefit-to-cost ratio is less than 1, the Corps cannot participate in a flood control project. The Corps can do channel improvements for restoration if applicable. Proposed improvements to Manaiki Stream in the late 1970's also were not implemented due to low priority and low flood damages. A visual survey of Moanalua Stream by the WHWS team revealed significant sedimentation of the channel as far upstream as the Moanalua Freeway, which is allowing the establishment of mangrove, further reducing floodwater capacity. Mangrove is the dominant riparian species below Kahauiki (Fort Shafter), creating a flood hazard and a detrimental impact on the Stream ecosystem.

C. Project Objectives

The objective of the study would be to identify and prioritize projects and their associated costs to address stream restoration and flood control issues associated with Moanalua Stream. The EPA impaired water bodies designation requires projects to address environmental restoration in addition to flood control measures.

Questions to be considered in the stream restoration and flood control study for Moanalua Stream include:

- What are the current flood control issues for Moanalua Stream?
- Where are the critical points along Moanalua Stream that require flood control measures?
- How can flood control measures incorporate aquatic species restoration, general stream restoration, and public access?
- What flood control measures are most appropriate for the unique characteristics of Moanalua Stream?
- How can the capacities of the stream channel and certain bridge openings be increased?

Moanalua Stream Restoration and Flood Control Study (Page 2 of 2) Project 07

D. Preliminary Scope

The preliminary scope of work for this study will include tasks necessary to determine stream restoration strategies and optimal flood control practices and technology for Moanalua Stream. Tasks for this study will include but not be limited to:

- Review of all available flood hazard maps and analyses.
- Conduct engineering survey of Moanalua Stream.
- Determine critical areas requiring flood control treatment.
- Recommend optimal flood control improvements for critical areas.
- Incorporate public access, native species habitat, and streambank restoration into flood control methodologies.

E. Lead Agency and Project Cost

The agency responsible for initiating this study is DLNR-Engineering Division Flood Control and Dam Safety Section, based on their role as the State agency responsible for flood control. The COE will conduct the study under the appropriate flood plain management program. NRCS may also contribute to this study through their Watershed Protection and Flood Prevention Program. Whenever channel hardening is proposed for a water course, the project sponsor should work with supporting agencies including DLNR-DAR, DOH, UH Environmental Center, and USFWS. Estimated cost of the first step "Reconnaissance Study" is $50,000 to $100,000. Thereafter, the full "Feasibility Study" would cost $500,000 to $1,000,000.

F. References

CCH, DPW. 1992. Manaiki Stream Flood Control Project Ala Mahamoe Street to Mahiole Street, Moanalua, O'ahu, Hawai'i

DLNR. 1972. Kalihi-Moanalua Flood Hazard Area. DOWALD.

DLNR. 1983. Flood Control and Flood Water Conservation in Hawai'i. Vol. II (revised). General Flood Control Plan for Hawai'i. Circular C93.

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U.S. Army Corps of Engineers. 1992. Urban Flood Control Study. Honolulu Hawaii. Final Reconnaissance Report (Main). U.S. Army Engineering District. Fort Shafter, Hawaii.

Wong, Michael F. 1994. Estimation of Magnitude and Frequency of Floods for Steams on the Island of Oahu, Hawaii. USGS: Water Resources Investigation Report 94-4052.

Moanalua Stream

◀ North of Nimitz Highway.

Through Moanalua Gardens. ▶

Nu‘uanu Stream Restoration and Flood Control Study (Page 1 of 2)		**Project 08**
Category	*Project Type*	*Participating Agencies*
Flood Control	STUDY	DLNR-Engineering Division, DAR; DOH; UH Environmental Center; USFWS; COE; NRCS

A. Problem Statement

The flood hazards associated with Nu‘uanu Stream and its major tributary, Waolani Stream, are related to insufficient stream capacity for 100-year flood levels above School Street and the potential threat of property damage and loss of life due to the non-standard design of the dam at Nu‘uanu Reservoir No. 4.

B. Project Background

Nu‘uanu Stream flow is regulated by the dam at Nu‘uanu Reservoir No. 4 and runs through densely developed urban areas. There is a need to investigate the extent of the flooding hazard and damage in the event of dam failure and the estimated impacts associated with intentionally breaching the dam. Economic impacts of each scenario should also be addressed in this study. There is also a need to identify ways to combine flood control with restoration of native species habitat as well as pedestrian access ways. The study should also investigate the feasibility of using Nu‘uanu Reservoir water for irrigation of City parks and green areas.

The dam at Nu‘uanu Reservoir No. 4 was built in 1910 and is located four miles upstream of downtown Honolulu. It was constructed primarily for water supply but was never used for that purpose. The dam was used for energy production until 1930 and after that to regulate the flow of Nu‘uanu Stream and for recreational fishing administered by the DLNR. The dam has a minor history of flooding, although two recent studies in 1993 and 1999 have stated that the dam meets DLNR requirements for hydraulic and stability analyses, as stated in the Guidelines for Safety Inspection of Dams, Ch. IV, Phase II Investigation. However, assurances have not been made to the effect that the dam will not fail. It was also stated that the dam does not meet current design standards. The earthen, redwood core dam is not actively maintained by the BWS and is covered with trees and other vegetation, which further compromises structural integrity. BWS presently keeps water levels low to minimize pressure on the dam.

C. Project Objectives

The objective of the study would be to identify methods to reduce flood hazards related to Nu‘uanu Stream, the dam at Nu‘uanu Reservoir No. 4, and Waolani Stream. Alternatives to address the insufficient stream flow capacity of Waolani and Nu‘uanu Streams should include methods that minimize the use of traditional flood control technology, such as rectangular and trapezoidal concrete channel sections. The study would also investigate alternative courses of action to address the flooding hazard potential that exists because of the non-standard dam at Nu‘uanu Reservoir No. 4, to include replacement of the dam with a structure designed to current flood control standards, breaching of the dam, and no action. This flood control study would also project impacts such as estimated loss of life and property damage in the event the dam fails. Flood control strategies should also consider the needs of native aquatic species, pedestrian access, and stream beautification.

Study questions for stream restoration and flood control of Nu‘uanu Stream include:

- Where are the critical points along Nu‘uanu Stream that require flood control measures?
- How can flood control practices incorporate aquatic species restoration, stream beautification, and pedestrian accessways?
- What is the expected flood hazard and impact on properties along Nu‘uanu Stream if the reservoir dam is breached?
- What is the estimated cost of constructing a flood control dam to replace the existing dam?
- What existing level of threat to public safety does the existing dam pose?
- What is the estimated loss of life and damage to Nu‘uanu and Honolulu if the existing dam fails?

Nu‘uanu Stream Restoration and Flood Control Study (Page 2 of 2) Project 08

D. Preliminary Scope

The preliminary scope of work for this study will include tasks necessary to determine optimal flood control improvements for Nu‘uanu and Waolani Streams. Tasks for this study will include but not be limited to:

- Review of all available flood hazard maps, Dam Safety Reports, and analyses.
- Conduct engineering survey of Nu‘uanu Stream.
- Determine critical areas requiring flood control improvements.
- Incorporate the guiding principles of native species habitat considerations, pedestrian accesses, and streambank restorations into the design of flood control measures.
- Identify the degree of flood hazard at Nu‘uanu Reservoir No. 4 in the event the dam fails, in terms of monetary loss and loss of life.
- Estimate the degree of property damage and increased flood hazard along Nu‘uanu Stream in the event the dam is breached.
- Conduct an engineering feasibility analysis to replace the existing dam with a structure that meets current dam design standards.
- Evaluate the feasibility of using Nu‘uanu Reservoir water for irrigation of City parks and green areas.

E. Agencies Involved and Project Cost

DLNR-Land Division, Flood Control and Dam Safety Section, may formally request the study as the local sponsor, as they are the State agency responsible for flood control. The COE may assist under the Flood Plain Management System program or the Planning Assistance to States program to evaluate the dam’s structural integrity. NRCS may also contribute to this study through their Watershed Protection and Flood Prevention Program. Whenever channel hardening is proposed for a water course, the project sponsor should work with supporting agencies including DLNR-DAR, DOH, UH Environmental Center, and USFWS. Estimated cost of the Study is $100,000 to $250,000. A full COE “Feasibility Study” would cost in the range of $1,000,000 to $3,000,000.

F. References

DLNR. 1983. Flood Control and Flood Water Conservation in Hawaii. Vol. II (revised). General Flood Control Plan for Hawaii. Circular C93.
DLNR. 1983. Flood Control and Flood Water Conservation in Hawaii. Vol. I (revised). Flood and Flood Control. Circular C92. FEMA.
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DLNR. 1994. Statewide Capital Improvement Program Flood Control Projects Report R98. Honolulu: Fukunaga & Assoc. Honolulu: DOWALD.
DLNR. 1994. Flood Control and Flood Water Conservation in Hawai‘i. Vol. III: Agencies and Legislation. Circular C94 (Revised).
Taogoshi, R. D., et al. 2001. Water Resources Data, Hawai‘i and Other Pacific Areas, Water Year 2000, Vol. 1 USGS.
U.S. Army Corps of Engineers. 1992. Urban Flood Control Study. Honolulu, HI. Final Reconnaissance Report (Main). U.S. AED. Ft. Shafter, HI.
Wong, Michael F. 1994. Estimation of Magnitude and Frequency of Floods for Steams on the Island of Oahu, Hawaii. USGS: Water-Resources Investigation Report 94-4052.

Nu‘uanu Stream

◀ Property improvements close to stream due to regulated flow through mauka residential area.

Nu‘uanu Reservoir No. 4, as seen from the crest of the dam. ▶

Kapālama Canal Channel Restoration & Improvements (Page 1 of 2) Project 09

Category	*Project Type*	*Participating Agencies*
Channel Improvements	PROJECT	Department of Facility Maintenance (DFM); DLNR-Engineering Division; COE

A. Problem Statement

The banks of Kapālama Canal are unprotected and experiencing serious erosion. Without stabilization, the banks will continue to erode and encroach on the rights-of-way of Kōkea and Kohou Streets. Flood capacity is reduced due to increased sediment load and mangrove that is becoming established in the lower reaches of the waterway.

B. Project Background

Kapālama Canal has sufficient capacity to accommodate floodwaters equivalent to the 100-year flood. However, both banks of the canal south of North King Street are not hardened and are eroding. In some of the lower reaches of the unchannelized canal, kiawe and mangrove trees are established along the banks and in the shallow portions of the canal itself. Benches and picnic tables have been constructed along the west bank of the canal, which attracts people to the edge of the banks. Much of this portion of the canal is bordered by Kohou and Kōkea Streets, which are utilized for on street parking by area businesses and students attending Honolulu Community College. Erosion of the streambank contributes to sediment build-up in the canal. Several proposals have been made in the past few years to improve the aesthetic quality of the Canal and improve pedestrian thoroughfares in the area. A study in 1974 concerning bacterial indicators in the Canal provided strong evidence that sewage contamination is occurring possibly from illegal household connections or cesspool leakage into the Canal.

C. Project Objectives

The objective of this project would be to stabilize the banks of Kapālama Canal, to remove mangrove, and to implement other channel restoration improvements as needed. It would include an evaluation of existing streambank stabilization techniques in Hawai‘i and elsewhere in order to select the preferred technique between North King Street and the mouth of Kapālama Canal. The project would incorporate flood control requirements and, where practical, public access improvements, native aquatic species habitats, and stream beautification strategies.

Considerations for project design would include but not be limited to:

- What successful stream bank stabilization projects could serve as a model for Kapālama Canal?
- What are the policy guidelines for implementation of this stream channel improvement project?
- What water quality, native species habitat, and public access considerations can be incorporated into the project?
- How will flood control designs be incorporated into stream channel improvements?
- How can mangrove be effectively eradicated from Kapālama Canal?
- What other channel restoration and improvements are needed?

Kapālama Canal Channel Restoration &Improvements (Page 2 of 2) Project 09

D. Project Scope

The scope of this project will encompass the reach of Kapālama Canal between North King Street and the Kapālama Basin of Honolulu Harbor. The background information in the plan will consist of research on existing techniques from Hawai'i and elsewhere where streambank stabilization efforts have been successful and may apply to Kapālama Canal. Tasks to be conducted as part this project will include but not be limited to:

- Conduct analysis of successful stream stabilization case studies in Hawai'i and elsewhere, and applicability to Kapālama Canal.
- Conduct assessment of streambank conditions and potential for stabilization along Kapālama Canal.
- Identify streambank stabilization actions that incorporate native aquatic species habitat requirements, flood control requirements and opportunities for general beautification and pedestrian access.
- Identify all required permits and procedures related to streambank stabilization.
- Design and construct streambank stabilization measures and other improvements.

E. Agencies Involved and Project Cost

The agency with primary responsibility for this project may be the City and County of Honolulu-DFM. Other agencies that may participate in this project include DLNR-Engineering Division, and COE. Since the canal provides sufficient flood capacity, the COE may assist with riparian restoration under Section 206. Estimated cost of the project is $1,000,000 to $$3,000,000.

F. References

DLNR. 1983. Flood Control and Flood Water Conservation in Hawai'i. Vol. I (revised). Flood and Flood Control. Circular C92 FEMA.
Johnson, J. M., Ells, M. D. & Young, R. H. F. 1974. Bacterial Indicators in Kapalama Canal, Oahu: Technical Memorandum Report No. 37. From *Pollution in Hawaiian Watersheds.*
Riley, Ann L. 1998. Restoring Streams in Cities: A Guide for Planners, Policymakers, and Citizens. Washington D.C.: Island Press.
Santa Clara Valley Water District. 1994. Lower Silver Creek Watershed Plan Update. USDA: NRCS.
Soil Conservation Service. 1981. Erosion and Sediment Control Guide for Hawaii. U.S.D.A.
Towill Corporation, R. M. 1980. Kapālama Canal Conceptual Plan Study. City and County of Honolulu, Department of Public Works.
Towill Corporation, R. M. 1980. Negative Declaration of the Kapalama Canal Flood Control, Landscaping and Beautification Project. City and County of Honolulu, Department of Public Works.

Kapālama Canal Channel Improvements

◀ Kapālama Canal banks below North King Street.

Erosion along west bank of Kapālama Canal. ▶

Moanalua Stream Channel Improvements (Page 1 of 2) Project 10

Category	*Project Type*	*Participating Agencies*
Channel Improvements	PROJECT	Department of Design and Construction (DDC); DLNR-Engineering Division; COE

A. Problem Statement

The lower reaches of Moanalua Stream are not stabilized and are contributing to sediment buildup and thus increased flooding risk in the Māpunapuna area. Mangrove is also becoming established as far upstream as the H-1 Freeway.

B. Project Background

The streams in the WHW project area have not been perceived as natural features to be appreciated, but rather, in most cases, have been converted from natural waterways to storm water drainage ways. The exception in the WHW region is Moanalua Stream as it flows through the Moanalua Golf Course and Moanalua Gardens. Below the Moanalua Freeway, the Stream course runs through the industrial area of Māpunapuna and the surrounding land is owned by three entities: the Department of Hawaiian Home Lands, the U.S. Army, and Damon Estate. The drainage from Āliamanu Crater and Salt Lake enters Moanalua Stream through an outflow at Mokumoa Street. The water quality from this outflow has affected stream and sediment quality. Although the banks along Moanalua Stream are stabilized with the use of CRM walls, flood capacity is insufficient for the 100-year flood. Mangrove has become well established in the lower and mid reaches of the stream, which reduces floodwater capacity and destroys the natural stream ecosystem. This project could be combined with Project No. 7, "Moanalua Stream Restoration and Flood Control Study."

C. Project Objectives

The objective of this project would be to analyze existing techniques used for stream channel improvements in Hawai'i and elsewhere, and to design and construct stream bank stabilization and other improvements for Moanalua Stream. The project would incorporate native species habitat needs, pedestrian access, and flood control requirements. Questions to be considered in the formation of this plan include:

- What successful stream channel improvement projects could serve as a model for Moanalua Stream?
- What are the policy requirements to implement stream channel improvements, such as mangrove eradication?
- What water quality, native species habitat, and public access considerations are to be incorporated into the project?
- How will flood control designs be incorporated into the channel improvement project?
- Are the major landowners (U.S. Army at Fort Shafter, Damon Estate, and the Department of Hawaiian Home Lands) willing to dedicate portions of their landholdings for the purpose of increasing floodway capacity, reducing the flood zone, and increasing development potential?
- How will mangrove be eradicated from Moanalua Stream, and what types of vegetated buffer strips are appropriate along Moanalua Stream?
- How can channel improvements keep sediment load below the established TMDL?

Moanalua Stream Channel Improvements (Page 2 of 2) Project 10

D. Project Scope

The scope of this project will encompass the reach of Moanalua Stream between the H-1 Freeway and the receiving waters at Keʻehi Lagoon. Tasks to be conducted as part this effort include:

- Conduct analysis of successful streambank stabilization case studies in Hawaiʻi and elsewhere, and applicability to Moanalua Stream.
- Conduct assessment of streambank condition and flood problem areas in Moanalua Stream.
- Identify stream restoration actions that incorporate the native species habitat requirements and pedestrian access needs.
- Identify all required permits and procedures related to streambank stabilization.
- Incorporate flood control designs identified in the Moanalua Stream Flood Control Study.
- Identify alternatives for addressing the mangrove problems within and along Moanalua Stream.
- Investigate the potential for permeable, interlocking revetments for the Moanalua Stream channel.
- Evaluate alternatives and identify appropriate streambank improvement.
- Design and construct streambank stabilization and flood control measures.

E. Agencies Involved and Project Cost

The agency with primary responsibility for this project is the City and County of Honolulu-DDC. Areas privately owned will fall under the responsibility of Damon Estate and others. Other agencies that may participate in this project include DLNR-Engineering Division, and COE. The COE may assist under Section 205 as a flood damage reduction project. Estimated cost of the project is more than $3,000,000.

F. References

Department of Environmental Services. April 1999. Storm Drain and Street Cleaning Effectiveness Report. City & County of Honolulu Municipal Separate Storm Sewer System NPDES Permit No. HI0021229.

Department of Environmental Services. February 2002. Improving Salt Lake Waterways to Implement Resolution 01-265, CD1, FD1. City and County of Honolulu, in cooperation with the Department of Health, State of Hawaii.

DLNR. 1983. Flood Control and Flood Water Conservation in Hawaii. Vol. I (revised). Flood and Flood Control. Circular C92 FEMA.

Riley, Ann L. 1998. Restoring Streams in Cities: A Guide for Planners, Policymakers, and citizens. Washington D.C.: Island Press.

Santa Clara Valley Water District. 1994. Lower Silver Creek Watershed Plan Update. USDA: NRCS.

Shade, Patricia J. 1984. Hydrology and Sediment Transport, Moanalua Valley, Hawaii. USGS. Water Resources Investigations Rpt. 84-4156.

U.S. Army COE. 1979. Draft Reconnaissance Report for Flood Control Moanalua Stream. Honolulu Engineer District.

Wong, Michael F. 1994. Estimation of Magnitude and Frequency of Floods for Steams on the Island of Oahu, Hawaii. USGS: Water-Resources Investigation Report 94-4052.

Moanalua Stream Channel Improvements

◀ Mangrove near the H-1/Nimitz Bridge.

Existing stabilization near Mokumoa Street area affords limited flood capacity. ▶

Salt Lake Environmental Restoration Study (Page 1 of 2) Project 11

Category	*Project Type*	*Participating Agencies*
Water Quality	STUDY	ENV; NRCS; U.S. Army

A. Problem Statement

Some of the contaminated sediment in Moanalua Stream originates from street runoff contained in Salt Lake outflow, which is an impaired water body according to the EPA 303(d) list. Without a deeper understanding of contamination sources and their mitigation, contaminated sediments will continue to be a problem in Moanalua Stream. Also, nutrient levels in Salt Lake and the outflow channel have caused excessive vegetation growth, which causes flooding and other problems in the area.

B. Project Background

The Salt Lake basin drains the Āliamanu area, the Honolulu Country Club, and the Salt Lake neighborhood. It is within the study area, as the receiving water body is Keʻehi Lagoon via Moanalua Stream. The City and County of Honolulu conducted a study on street cleaning effectiveness as part of their NDPES permit requirements. The study revealed that a significant amount of contaminants could be removed from streets instead of being allowed to enter the storm system and eventually Moanalua Stream. Āliamanu Military Reservation has a history of sewage spills that flow into Salt Lake, which may contribute to the degradation of that water body. Sediment buildup in the Lake is due to street runoff and runoff from vacant lands in the Salt Lake Basin. Nutrient loading may also be associated with golf course and/or City park maintenance. This study will contribute to either the de-listing of Salt Lake as an impaired water body, or satisfy EPA requirements to improve the water quality of 303(d) listed water bodies.

C. Project Objectives

The objective of the study is to identify the extent of degradation and to make recommendations towards the comprehensive environmental restoration of Salt Lake. The study would investigate the condition of the Lake itself, inflow sources, and the outflow channel drain near the corner of Likini Street and Ala Napunani. A second objective of this study is to identify a set of best management practices that will reduce the amount of contaminants entering the outflow channel that empties into Moanalua Stream at Mokumoa Street. A third objective of the study is to either de-list Salt Lake as a 303(d) impaired water body or to identify measures that will improve water quality.

Questions for the Salt Lake Environmental Restoration Study include:

- What is the current state of water quality and Salt Lake as an ecosystem?
- What are the probable sources of sedimentation and contamination?
- Should street sweeping and storm drain inserts be employed in the Salt Lake Basin?
- What kinds of educational programs can be targeted towards schools and residents?

Salt Lake Environmental Restoration Study (Page 2 of 2) Project 11

D. Preliminary Scope

The preliminary scope of work for this study will include an analysis of actions necessary for a long-term environmental restoration and maintenance program in the Salt Lake area that removes contaminants and sediments prior to their entering the storm water collection system. Tasks for this study will include but not be limited to:

- Establish the existing water quality conditions in Salt Lake and the outflow channel.
- Identify all probable sources of sedimentation and contamination.
- Evaluate street sweeping and storm drain inserts as a means to reduce contaminated sediment in the Salt Lake Basin and Moanalua Stream.
- Identify other methods of reducing contaminated sediment and other sediment in the Salt Lake Basin.
- Create ongoing educational programs targeted towards schools and residents.

E. Agencies Involved and Project Cost

A possible lead agency for this project is the City and County of Honolulu-ENV based on their responsibility to monitor the effectiveness of their pollution reduction efforts, as required per their NDPES permit. Technical assistance may be provided by NRCS through their Watershed Protection and Flood Prevention Program. U.S. Army involvement may be through addressing storm water runoff and sewage spills from Āliamanu Military Reservation. Estimated cost of the study is $500,000 to $1,000,000.

F. References

Department of Environmental Services. April 1999. Storm Drain and Street Cleaning Effectiveness Report. City and County of Honolulu Municipal Separate Storm Sewer System NPDES Permit No. HI0021229.

Department of Environmental Services. February 2002. Improving Salt Lake Waterways to Implement Resolution 01-265, CD1, FD1. City and County of Honolulu, in cooperation with the Department of Health, State of Hawaii.

Troutwine, Jack. 1974. A Biological Report on Aliamanu Crater and its Water Drainage to Keehi Lagoon. U.S. Army Engineer Division.

Wong, Michael F. 1994. Estimation of Magnitude and Frequency of Floods for Steams on the Island of Oahu, Hawaii. USGS: Water-Resources Investigation Report 94-4052.

Salt Lake Environmental Restoration

◀ Near Likini Street, vegetation growth in outflow channel.

Salt Lake, from the City park. ▶

Urban Stream & Honolulu Harbor Dredge Disposal Action Plan (Page 1 of 2) Project 12

Category	*Project Type*	*Participating Agencies*
Water Quality/ Flood Control	PLAN	DLNR; COE; DOH-CWB; Department of Transportation (DOT)-Harbors; CZMP; EPA; U.S. Navy

A. Problem Statement

Maintenance dredging of waterways has traditionally been conducted on an "as-needed" and "funding available" basis. This has led to dredging operations occurring on a less-than-adequate basis, which presents a flood control problem. A periodic, well-defined dredging program, including a long-term management strategy for dredge material disposal and/or treatment is required to adequately maintain all drainages in the WHW region. The South Oahu Ocean Disposal Site, located 3.8 miles off the Airport Reef Runway, has been the primary disposal area for dredged material since the early 1980's. However, in recent years, due to pressure from the public and more stringent guidelines for ocean disposal, agencies have been forced to look for alternative disposal sites and/or methods to treat contaminated dredge material.

B. Project Background

Soil erosion is the natural weathering of the earth's surface and is the primary source of sediment in Hawaii's streams and drainage ways. However, this natural process has been impacted by man-made alterations and adjustments to the environment. The wide and relatively flat canal bottoms of the lower reaches of streams in the WHW results in lower water velocities and therefore more sediment deposition. Streams, particularly those that have been modified for flood control and other purposes, must be periodically dredged to maintain storm water flow capacity. Dredging also restores channel depths and sediment trapping capacity and improves habitat for native aquatic fauna.

A long-term management strategy for dredge disposal/treatment is necessary to accommodate material from a regular maintenance dredging program. An essential component of the strategy is to identify suitable upland sites for the treatment and/or placement of dredged material. These sites will need to be carefully evaluated to determine if they are technically feasible, as well as environmentally, socially, and politically acceptable. Open communication with the public and regulatory agencies will be an essential component of the site selection process. In addition, processing/treatment technologies that could address contaminated dredged material and provide beneficial use products will be carefully evaluated.

The COE and EPA regulate dredging operations and ocean disposal. The State DOH regulates water quality and upland placement of dredged material.

C. Project Objectives

The primary objectives are to: 1) identify drainages in the WHW region that need to be routinely dredged, 2) determine logistical and regulatory steps for the dredging and disposal of dredged material, 3) identify alternative upland sites for treatment and/or placement of dredged material that are unsuitable for ocean disposal, and 4) evaluate processing/treatment technologies that could address contaminated dredged materials and provide beneficial use products. The above objectives will be incorporated into the dredging program plan. The plan would establish public disclosure protocol related to the periodic dredging disposal/treatment of dredged materials. Recommendations of the plan would include a maintenance dredging schedule for drainages in the WHW, alternative disposal sites, evaluation of processing/treatment technologies, and a sediment monitoring program.

Questions to consider in the formation of this plan include:

- What is the role of the COE's regional dredging team in the formation of a multi-jurisdictional dredging plan? Who are the other participants in this plan?
- How often should sediment surveys take place?

What bioremediation activities may be feasible for sediments that do not meet ocean-based disposal standards?

Urban Stream & Honolulu Harbor Dredge Disposal Action Plan (Page 2 of 2) Project 12

D. Preliminary Scope

The preliminary scope of this plan is a three-phased process that will cover streams and waterways that require periodic dredging, including Kapālama Canal, lower Kalihi Stream, lower Moanalua Stream, and to a lesser extent Nu'uanu Stream and Honolulu Harbor. Information contained within the plan may be used as a general resource for watersheds throughout the State. Tasks to be conducted as part of this plan include, but are not limited to:

Phase 1:

- Convene regional dredging team to advise the lead agency on dredging activities.
- Evaluate existing disposal sites for dredge material, including contaminated material.
- Research and evaluate existing dredging procedures that is required to minimize impact of the dredging activities on the streams and receiving waters.
- Determine alternative dredge disposal sites for various materials.

Phase 2:

- Research the required permits, approvals, and procedures to perform dredging and disposal of dredge material extracted from the streams in the project area.
- Create a regional dredging plan to monitor sediment levels and quality. Schedule and conduct regular dredging to maintain suitable storm flow capacities.

Phase 3:

- Test sediments at various locations along all stream courses in the WHWS project area.

E. Agencies Involved and Project Cost

The lead agency for the project may be the EPA, as they manage dredge disposal sites. Supporting agencies may include the DOH-CWB, DOT-Harbors, DLNR-Division of Water and Land Development, the U.S. Navy, and the CZMP. The COE may provide support through the Planning Assistance to States program. Estimated cost of this Plan is $250,000 to $500,000.

F. References

Brasher, Anne M. and Stephen S. Anthony. 1998. Occurrence of Organochloride Pesticides in Stream Bed Sediment and Fish from Selected Streams on the Island of Oahu, Hawai'i, 1998. USGS Fact Sheet 140-00.

Department of Design and Construction. 2001. Kawa Ditch Improvements: Koolaupoko, Kaneohe, Oahu, Hawaii. State of Hawaii. DOH Water Quality Certification Application. Honolulu: Grey, Hong, Bills, Nojima and Assoc., Inc.

Department of Environmental Services. April 1999. Storm Drain and Street Cleaning Effectiveness Report. City and County of Honolulu Municipal Separate Storm Sewer System NPDES Permit No. HI0021229.

DLNR. 1980. Statewide Silt Basin Investigation. State of Hawaii. Prepared by: Fukunaga & Associates, Inc. Honolulu: DOWALD.

DLNR. 2001. Prefinal Sediment Sampling & Analysis Report: Moanalua and Kalihi Streams, Project #2EOOB051A & 2EOOB051B. Environet, Inc.

Shade, Patricia J. 1984. Hydrology & Sediment Transport, Moanalua Valley, Oahu, Hawaii. USGS Water Resources Investigations Report 84-4156.

Soil Conservation Service. 1981. Erosion and Sediment Control Guide for Hawaii. USDA.

Stream Dredging Program

◀ Sediment in Kapalama Canal.

Contaminated sediments have been detected in lower Moanalua Stream. ▶

Kalihi Watershed Erosion Prevention/Infiltration Enhancement Project (Page 1 of 2)

Project 13

Category	*Project Type*	*Participating Agencies*
Flood Control/Water Supply	PROJECT	BWS; DLNR-DOFAW, Engineering Div.; UH-WRRC; USFWS; NRCS

A. Problem Statement

Lands in the upper conservation areas of Hawai‘i were extensively planted with non-native tree species in the past century. Many of these tree species do not facilitate a multi-layered forest canopy and leave the forest floor exposed. A single-layered forest canopy renders the land susceptible to increased runoff and erosion. A project is needed to verify appropriate forest cover for the upper conservation areas that would contribute to reduced rainfall runoff and erosion and thereby increase groundwater infiltration.

B. Project Background

The conservation areas of the Ko‘olau Mountains were planted in the early 20th Century with a variety of introduced tree species, such as ironwood, eucalyptus, albizia, rose apple and others, with the objective of reducing erosion and improving groundwater recharge. Prior to this effort, the upper Ko‘olau Mountains were relatively treeless, thus the watershed enhancement program was established to increase groundwater resources. Many of these trees have reached full maturity, and the forest is beginning to degrade as some older non-native species that do not reproduce themselves in the Hawaiian environment reach maturity and die off. Replacement of these tree species should be done with the objective of optimizing groundwater recharge and to reducing runoff and erosion. Emphasis could be placed on native species to promote Hawaiian ecosystems. There are no existing studies that address the issue of vegetation type compared with rates of rainfall infiltration or erosion control in Hawai‘i. Wadsworth (1997) of the USDA Forest Service states:

> “Forests have an intimate relationship to water supplies. The delayed releases of rainwater from forested soils of the uplands are vital to lowland water supplies. Understory that is established on the forest floor absorbs the physical impact of torrential downpours and releases the water gently to the mineral soil beneath. This cushioning action largely prevents the water from suspending large quantities of surface soil particles and thus clogging soil pores beneath. In addition, the decaying litter enriches the water entering the soil and supports organisms that produce porous upper soil layers.”

C. Project Objectives

The objective of this project is to determine the optimal forest cover for the upper conservation zone of the Kalihi Watershed. This objective is intended to enhance rainwater infiltration and the sustainable yield of the basal aquifer, and to reduce rainfall runoff that contributes to erosion and sediment buildup of drainage ways in the watershed. These objectives will be accomplished by the selection and planting of native plant and tree species in defined areas that would constitute a typical multi-layered canopy forest in the upper Kalihi sub-watershed. Related benefits include improvement of habitats for native species such as the O‘ahu ‘elepaio, for which the USFWS has designated critical habitat boundaries. This long-term project (20 to 50 years) will evaluate vegetation species and associations through data collection and analysis of rates and quantities of transpiration, infiltration, and surface runoff of precipitation. The ongoing information gathered from this project and its evaluation may be used as a general reference for other watersheds in Hawai‘i. Study questions for this project include:

- What are examples of native Hawaiian upland forests featuring established understory and over story?
- What can botanists and foresters specializing in native forests contribute to understanding multi-layered native forest canopies?
- What parts of the upper Kalihi watershed lack understory and require reforestation? What parts could be used as a control area?
- What should be the size of the test plots? One-acre? Less?
- How should the effect of replanting on infiltration, transpiration, surface runoff, and sediment be monitored?

Kalihi Watershed Erosion Prevention/Infiltration Enhancement Project (Page 2 of 2)

Project 13

D. Preliminary Scope

This long-term project may be included in the "Demonstration Watershed," a series of watersheds designated for the purposes of understanding watershed dynamics and testing of BMPs (Project 02). However, unless the Demonstration Watershed is established in the near term, the Kalihi Watershed Erosion Prevention/Infiltration Enhancement Project should be initiated so that results may be gathered and utilized toward the improvement of all watersheds in Hawai'i. The preliminary scope of this project should include:

- Select test and control sites to conduct infiltration and erosion monitoring based on forest cover.
- Develop components of the study to include incidence of allelopathy caused by alien species; measurement of groundwater infiltration, sediment runoff and transpiration; modeling of groundwater increases and sediment load reduction based on forest types.
- Determine optimal associations of tree and plant species that contribute to increased sustainable yield of aquifers.
- Plant preferred species in conservation and upper urban residential areas.
- Perform monitoring of infiltration, transpiration, surface runoff, and sediment loading.
- Conduct some of this research and testing in a laboratory setting.

E. Agencies Involved and Project Cost

The responsible agencies in this project could be DLNR-DOFAW and the BWS. DOFAW is involved based on their four objectives: 1) to help ensure water quality and quantity, 2) to prevent rapid runoff of storm flows and soil erosion, 3) to improve water infiltration into soil, and 4) to encourage forestry activities on private land. Increasing the sustainable yield of drinking water is a primary concern for the Honolulu BWS. Supporting agencies may include the DLNR-Engineering Division as the State agency on flood control. NRCS, the COE, USFWS, and the UH–WRRC, may also have roles in this project. Estimated cost of this project is in the range of $250,000 to $500,000 per year.

F. References

DLNR. 1980. Statewide Silt Basin Investigation. State of Hawaii. Prepared by: Fukunaga & Associates, Inc. Honolulu: DOWALD.

DLNR. 1983. Flood Control and Flood Water Conservation in Hawaii. Vol. I (revised). Flood and Flood Control. Circular C92 FEMA.

Loh, Rhonda K. and J. Timothy Tunison. 1999. Vegetation Recovery Following Pig Removal in Olaa-Koa Rainforest Unit, Hawai'i Volcanoes National Park, Division of Resource Management. Cooperative Agreement CA8000-2-9004. University of Hawai'i at Mānoa.

Shade, Patricia J. 1984. Hydrology and Sediment Transport, Moanalua Valley, Oahu, Hawaii. USGS Water Resources Investigations Report 84-4156.

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U.S. Army Corps of Engineers. 1992. Urban Flood Control Study. Honolulu Hawaii. Final Reconnaissance Report (Main). U.S. Army Engineering District. Fort Shafter, Hawai'i.

Wadsworth, Frank H. Forest Production for Tropical America. Agriculture Handbook 710. USDA Forest Service.

Wong, Michael F. 1994. Estimation of Magnitude and Frequency of Floods for Steams on the Island of Oahu, Hawaii. USGS: Water-Resources Investigation Report 94-4052.

Erosion Prevention/Infiltration Enhancement Project

◀ Upper Kalihi Stream, exhibiting minimal understory and tall upper canopy.

Native forest with canopy and understory acts as a sponge to absorb and filter moisture to provide drinking water. ▶

Kalihi Watershed Invasive Fauna Control Project (Page 1 of 2) Project 14

Category	*Project Type*	*Participating Agencies*
Water Quality, Water Supply	PROJECT	BWS; DLNR-DOFAW; USFWS

A. Problem Statement

Damage caused by invasive species, primarily feral pigs, has led to deterioration in the Kalihi watershed through increased runoff and erosion in the upper conservation zone, which in turn leads to reduced infiltration of groundwater. Introduced mammals contribute to the spread of cryptosporidiosis and leptospirosis (introduced water-borne diseases). Reduction or eradication of pig and other invasive animal populations may contribute to increased groundwater resources and water quality as well as reduced erosion and sedimentation.

B. Project Background

Control of feral ungulates in the WHW study area varies throughout the three watersheds. Nu‘uanu Valley contains public bow hunting areas. Portions of upper Kalihi Valley are being proposed as public hunting areas. Moanalua is a private valley that has conveyed hunting rights to one hunter. Currently, there are no other control measures for feral ungulates or other mammals in the upper watershed area, and impacts have not been estimated. Feral ungulates, specifically pigs, damage vegetation cover in the watershed areas, which leads to erosion and thus increased sediment loads in streams and drainageways of the WHW area. This in turn creates water quality problems in the lower drainage ways. Increased runoff equates to less infiltration of rainfall, which reduces the sustainable yield of the aquifer. Other species of mammals that may be impacting the watershed are rats and feral cats, and in the case of Kalihi valley, wallabies. These alien species affect the integrity of critical habitats of native species such as the ‘elepaio. Control of these introduced species will eventually lead to improved critical habitat. Kamehameha Schools is currently conducting an effort to reduce rat populations on the Island of Hawai‘i. Leptospirosis is a bacterial disease found in the watershed and elsewhere in Hawai‘i that affects humans and animals, and is usually caused by exposure to water, food, and soil contaminated with the urine of infected animals such as pigs, dogs, rodents, and other wild animals.

C. Project Objectives

The objective of this project would be to analyze and implement ways to control feral ungulates and other mammals that cause harm to the upper Kalihi conservation area and to species covered under the USFWS critical habitat designation. Strategies for animal control include but are not limited to: fencing, hunting, trapping, and eradication. The program will include methods for monitoring animal populations and cataloging damaged areas.

Some research questions to be addressed in the development of this project include:

- What mammals existing in upper Kalihi Valley are suspected of damaging the watershed?
- What are the populations of each suspect species?
- What is the type and extent of damage caused by these species?
- What are the current mammal control strategies employed in Hawai‘i and elsewhere?
- What are the most appropriate mammal control measures for the WHW area?
- How should the selected mammal control strategies be evaluated?

Kalihi Watershed Invasive Fauna Control Project (Page 2 of 2) Project 14

D. Preliminary Scope

The scope of the project will be to research and evaluate the various ways in which feral ungulates are controlled, determine preferred practices, and develop an animal control program with an evaluation component. Some strategies to be investigated as part of the scope include but are not limited to: fencing, hunting, trapping, and eradication.

Project elements should include:

- Conduct surveys of the various mammal species and their populations that exist in and around the WHW area.
- Conduct surveys of the types and extent of damage to the watershed caused by feral ungulates.
- Research into existing mammal control practices in Hawai‘i and elsewhere.
- Determine the most appropriate mammal control measures for the WHW area.
- Establish an evaluation process for mammal control strategies.
- Establish an animal population and damage monitoring system.
- Implement preferred animal control strategies.

E. Agencies Involved and Project Cost

A possible lead agency for this project is DLNR-DOFAW based on their jurisdiction of the upper watershed area and their recreational hunting objectives that include: 1) develop access for more hunting opportunities; 2) research native and non-native animal interactions; 3) promote awareness of hunting's benefit to habitat; and 4) establish more dedicated game management areas. Other DOFAW objectives include helping to ensure water quality and quantity and prevention of rapid runoff of storm flows and soil erosion. The USFWS and BWS may also have a role in this effort. Estimated cost of the project is $250,000 to $500,000.

F. References

Koolau Mountains Watershed Partnership. 2002. Koolau Mountains Watershed Partnership Management Plan. Final Draft.

Loh, Rhonda K. and J. Timothy Tunison. 1999. Vegetation Recovery Following Pig Removal in Olaa-Koa Rainforest Unit, Hawaii Volcanoes National Park, Division of Resource Management. Cooperative Agreement CA8000-2-9004. University of Hawaii at Manoa.

Polhemus, John T. 2002 Pig Hunter Statistics –-1994- 2001. DLNR, DOFAW.

Pratt, Linda W., Lyman L. Abbott and David K. Palumbo. 1999. Vegetation Above a Feral Pig Barrier Fence in Rainforest of Kilauea’s East Rift, Hawaii Volcanoes National Park. Cooperative National Park Resources Study Unit, Hawaii.. Technical Report No. 124.

Feral Ungulate Impacts

◀ Area near Kalihi Stream devegetated by pigs.

Pigs and other mammals spread leptospirosis through mud and streams. ▶

Moanalua Watershed Invasive Fauna Control Project (Page 1 of 2)		**Project 15**
Category	*Project Type*	*Supporting Agencies*
Water Quality, Water Supply	PROJECT	BWS; DLNR-DOFAW; USFWS

A. Problem Statement

Damage caused by invasive species, primarily feral pigs, has led to watershed deterioration in upper Moanalua Valley through increased runoff and erosion in the upper watershed, which in turn results in reduced infiltration of groundwater. Introduced mammals also spread cryptosporidiosis and leptospirosis. Reduction or eradication of pig and other animal populations will improve natural ecosystems and may lead to increased groundwater resources, improved surface water quality, and reduced sedimentation.

B. Project Background

Control of feral ungulates in the watershed area varies throughout the three watersheds. Nu‘uanu Valley contains public bow hunting areas. Portions of upper Kalihi Valley are being proposed as public hunting areas. Moanalua is a private valley that has conveyed hunting rights to one hunter. Currently, there are no other control measures for feral ungulates or other mammals in the upper watershed area, and impacts have not been estimated. Feral ungulates, specifically pigs, damage vegetation cover in the watershed areas, which leads to erosion and thus increased sediment loads in streams and drainageways of the WHW area. This in turn creates water quality problems in the lower reaches. Increased runoff equates to less infiltration of rainfall, which reduces the sustainable yield of the aquifer. Other species of mammals that may be impacting the watershed are rats and feral cats, and in the case of Moanalua valley, wallabies. These alien species affect the integrity of critical habitats of native species such as the ‘elepaio. Control of these introduced species will eventually lead to improved critical habitat. Kamehameha Schools is currently conducting an effort to eradicate feral pigs to improve ecosystems in Kawailoa on O‘ahu and another effort to reduce rat populations on the Island of Hawai‘i. Leptospirosis is a bacterial disease found in the watershed and elsewhere in Hawai‘i that affects humans and animals, and is usually caused by exposure to water, food, and soil contaminated with the urine of infected animals such as pigs, dogs, rodents, and wild animals.

C. Project Objectives

The objective of this project is to analyze and implement ways to control feral ungulates and other mammals that cause harm to the upper conservation area and to species protected under the USFWS critical habitat designation. Strategies for animal control include but are not limited to: fencing, hunting, trapping, and eradication. The project will include methods for monitoring animal populations and cataloging damaged areas.

Some research questions to be addressed in the development of this project include:

- What mammals existing in upper Moanalua Valley are suspected of damaging the watershed?
- What are the populations of each suspect species?
- What is the type and extent of damage caused by these species?
- What are the current mammal control strategies employed in Hawai‘i and elsewhere?
- What are the most appropriate mammal control measures for the WHW area?
- How should the selected mammal control strategies be evaluated?

Moanalua Watershed Invasive Fauna Control Project (Page 2 of 2) Project 15

D. Preliminary Scope

The scope of the project will be to research and evaluate the various ways in which feral ungulates are controlled, determine preferred practices, and develop an animal control project with an evaluation component. Some strategies to be investigated as part of the scope include but are not limited to: fencing, hunting, trapping, and eradication.

Project elements should include:

- Copnduct surveys of the various mammal species and their populations that exist in and around the WHW area.
- Conduct surveys of the types and extent of damage to the watershed caused by feral ungulates.
- Research into existing mammal control practices in Hawai‘i and elsewhere.
- Determine the most appropriate mammal control measures for the WHW area.
- Establish an evaluation process for mammal control strategies.
- Establish an animal population and damage monitoring system.
- Implement preferred animal control strategies.

E. Agencies Involved and Project Cost

Damon Estate, the owner of most of upper Moanalua Valley, should take the lead for this project. Contributions to this project may be from the BWS, DLNR-DOFAW, and USFWS. Estimated cost of the project is $250,000 to $500,000.

F. References

Koolau Mountains Watershed Partnership. 2002. Koolau Mountains Watershed Partnership Management Plan. Final Draft.

Loh, Rhonda K. and J. Timothy Tunison. 1999. Vegetation Recovery Following Pig Removal in Olaa-Koa Rainforest Unit, Hawaii Volcanoes National Park, Division of Resource Management. Cooperative Agreement CA8000-2-9004. University of Hawaii at Mānoa.

Polhemus, John T. 2002 Pig Hunter Statistics –-1994- 2001. DLNR, DOFAW.

Pratt, Linda W., Lyman L. Abbott and David K. Palumbo. 1999. Vegetation Above a Feral Pig Barrier Fence in Rainforest of Kilauea’s East Rift, Hawaii Volcanoes National Park. Cooperative National Park Resources Study Unit, Hawaii.. Technical Report No. 124.

Feral Ungulate Impacts

◀ Area near Kalihi Stream devegetated by pigs.

Pigs and other mammals spread leptospirosis through mud and streams. ▶

Kalihi Streambank Stabilization Project (Page 1 of 2) Project 16

Category	*Project Type*	*Participating Agencies*
Surface Water Quality	PROJECT	DFM; DLNR-Engineering Division, DAR; COE

A. Problem Statement

The stream banks along the lower reaches of Kalihi Stream have not been stabilized and are below capacity for the 100-year flood. Erosion of these unprotected banks contributes to sediment build-up near the mouth of Kalihi Stream. At the mouth of Kalihi stream, the banks are overgrown with mangrove, which reduces channel capacity and destroys the natural ecosystem.

B. Project Background

The lower reaches of Kalihi Stream are in the flood zone because of inadequate channel capacity to convey storm waters of the 100-year flood. This reach of the stream is also in an industrial section of the city, and visual surveys of the unstabilized section reveal a condition of neglect and misuse. Eroding banks of Kalihi Stream contribute to stream sedimentation near the mouth of the stream. Mangrove have established and overtaken the banks of Kalihi Stream near the mouth, which reduces channel capacity in the vicinity of the restrictive bridge openings, further increasing the flood hazard. A 1975 COE report recommended 8,400 feet of channel improvements to the lower reaches of Kalihi Stream at a cost of about $7 million, which consisted of a system of levees and concrete-lined rectangular and trapezoidal sections with rip-rap side slopes. The project was not implemented due to a low benefit-to-cost ratio.

C. Project Objectives

The objective of this project is to stabilize the banks of Kalihi Stream between the Bannister Street area and the receiving waters of Keʻehi Lagoon, a stretch of approximately 3/4 miles. The project will incorporate the findings and recommendations in the *West Honolulu Watershed Expanded Trails Study* (Project 03). Reasons for restoring Kalihi Stream include native aquatic species habitat enhancement, increased pedestrian and bicycle access, and overall beautification of Kalihi Stream.

Questions to be considered in this project include:

- What successful streambank stabilization projects could serve as a model for Kalihi Stream?
- What are the policy requirements to implement streambank stabilization?
- What water quality, native species habitat, and public access considerations are to be incorporated into streambank stabilization?
- How will flood control designs be incorporated into the streambank stabilization project?

Kalihi Streambank Stabilization Project (Page 2 of 2) Project 16

D. Project Scope

The scope of this project will encompass the lower reach of Kalihi Stream. Background research on existing stream bank stabilization techniques from Hawai'i and elsewhere will be the foundation for BMPs that address the multiple objectives of this project. Tasks to be conducted as part this project include but should not limited to:

- Assess streambank conditions.
- Review successful stream bank stabilization and other restoration case studies in Hawai'i and elsewhere, and applicability to Kalihi Stream.
- Design streambank stabilization project that incorporates the findings and recommendations of WHWS Project Nos. 03, 04 and 06.
- Identify, prepare, and submit all required permits required for stream bank stabilization.
- Construct stream bank stabilization measures.
- Eradicate mangrove and replace with native shoreline/riparian vegetation.

This project could be implemented as an outcome of Project No. 06, "Kalihi Stream Restoration and Flood Control Study."

E. Agencies Involved and Project Cost

A potential responsible agency for this project is the City and County of Honolulu-DFM. The COE could be the implementing agency for this project, with DLNR-Engineering Division and the DAR providing additional assistance. Estimated cost of the project is $1,000,000 to $3,000,000.

F. References

CWRM. 1990. Hawaii Stream Assessment: A Preliminary Appraisal of Hawaii's Stream Resources. Hawaii Coop. Park Service Unit.
DLNR. 1983. Flood Control and Flood Water Conservation in Hawaii. Vol. II (revised). General Flood Control Plan for Hawaii. Circular C93. Honolulu: DOWALD.
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DLNR. 1994. Statewide Capital Improvement Program Flood Control Projects Report R98. Honolulu: Fukunaga & Associates. DOWALD
DLNR. 1994. Flood Control and Flood Water Conservation in Hawaii. Vol. III: Agencies and Legislation. Circular C94 (Revised).
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Wong, Michael F. 1994. Estimation of Magnitude and Frequency of Floods for Steams on the Island of Oahu, Hawaii. USGS: WaterResources Investigation Report 94-4052.
Riley, Ann L. 1998. Restoring Streams in Cities: A Guide for Planners, Policymakers, and Citizens. Washington, D.C.: Island Press.
Santa Clara Valley Water District. 1994. Lower Silver Creek Watershed Plan Update. USDA: NRCS.
Troutwine, Jack. 1972. Kalihi Stream Environmental Survey. U.S. Army Corps of Engineers, Environmental Section.

Kalihi Stream Stabilization

◀ Kalihi Stream has the potential for bank restoration.

Low, exposed banks along Kalihi Stream. ▶

Nu‘uanu Streambank Stabilization Project (Page 1 of 2)		**Project 17**
Category	*Project Type*	*Supporting Agencies*
Surface Water Quality	PROJECT	DFM; DLNR-DAR; COE

A. Problem Statement

Nu‘uanu Stream in the WHWS project area has a regulated flow yet is a generally unchannelized stream course above School Street. The reaches between School Street and Kapena Falls are strewn with litter and undeveloped as a pedestrian corridor. Neglect has reduced the integrity of native aquatic species habitats in this reach of the stream.

B. Project Background

A visual survey of Nu‘uanu Stream revealed a need to stabilize the banks in the relatively natural middle reaches of the Stream. Beginning with Lili‘uokalani Gardens above School Street to roughly Kapena Falls, the Stream is unchannelized and affords adequate space for landscaping and pedestrian trails. Some banks have exposed soils, which could be landscaped with plant varieties that would prevent erosion into the stream course. Stabilization should focus on permeable alternatives to concrete lining. The proposed outcome of the Nu‘uanu Stream Restoration and Flood Control Study (Project 08) will have a significant effect on the design of streambank stabilization, particularly if the recommended action of that study is to breach the dam.

C. Project Objectives

The objectives of this project are to determine the feasibility of restoring stream banks with native riparian vegetation, identify volunteer groups to perform stream clean-up and maintenance, determine required native aquatic species habitat improvements, and to create a trail along the middle reaches of Nu‘uanu Stream. Another objective of the project is to identify and implement strategies to reduce the input of contaminants into the Stream. The project will incorporate, as much as possible, considerations for pedestrian access, native species habitats, and flood control measures.

Questions to consider during project design include:

- What are examples of successful streambank stabilization projects in Hawai‘i and elsewhere that could serve as a model for Nu‘uanu Stream?
- What are the policy requirements for implementing streambank stabilization?
- How will water quality, native aquatic species habitats, riparian vegetation, and public access be considered in streambank stabilization of Nu‘uanu Stream?
- How will flood control designs be incorporated into streambank stabilization?
- Who are the stakeholders in the Nu‘uanu community (Kuakini Hospital, Hawai‘i Baptist Academy, etc.) that could form a task force to help maintain the Stream?

Nu‘uanu Streambank Stabilization Project (Page 2 of 2) Project 17

D. Project Scope

The scope of this project will encompass the channelized reach of the Nu‘uanu Stream between the H-1 Freeway to Kapena Falls. The background information for the project will consist of research focusing on existing techniques from Hawai‘i and elsewhere where stream restoration efforts have been successful and may apply to the streams in the project area. Actions to be conducted as part this project include but should not be limited to:

- Review successful streambank stabilization projects in Hawai‘i and elsewhere, and their applicability to Nu‘uanu Stream.
- Design streambank stabilization to incorporate the findings and recommendations of WHWS Project No.’s 03, 04, and 08.
- Identify, prepare, and submit all required permits required for streambank stabilization.
- Construct stream bank stabilization measures.

E. Agencies Involved and Project Cost

The local sponsor for this project could be the City and County of Honolulu-DFM. This project may present a partnership opportunity among government agencies (City & County, State DLNR-DAR, COE), landowners (i.e., Kuakini Medical Center, Hawai‘i Baptist Academy), and community groups (Neighborhood Board, school groups) to conduct planting, trail building, habitat restoration, clean-up, and maintenance. The implementing agency for this project is the COE, with supporting technical assistance from DLNR-DAR. A major program area for DAR includes promoting projects that protect native and resident aquatic species and their habitats. Estimated cost of the project is $1,000,000 to $3,000,000.

F. References

Bay Pacific Consulting. 1996 . Riparian Nonpoint Pollution Control in Hawaii. Prepared for the Office of State Planning, State of Hawaii.
CWRM. 1990. Hawaii Stream Assessment: A Preliminary Appraisal of Hawaii’s Stream Resources. Hawaii Coop. Park Service Unit.
DLNR. 1983. Flood Control and Flood Water Conservation in Hawaii. Vol. I (revised). Flood and Flood Control. Circular C92. FEMA.
Riley, Ann L. 1998. Restoring Streams in Cities: A Guide for Planners, Policymakers, and Citizens. Washington, D.C.: Island Press.
Santa Clara Valley Water District. 1994. Lower Silver Creek Watershed Plan Update. USDA: NRCS.

Stream Restoration

◀ Exposed soils near Nu‘uanu Stream within Lili‘uokalani Gardens.

Opportunity for restoration near Nu‘uanu Avenue. ▶

West Honolulu Surface Water Quality Monitoring Program (Page 1 of 2) Project 18

Category	*Project Type*	*Participating Agencies*
Water Quality	PROGRAM	DOH-CWB; DLNR; CZMP; NRCS; EPA

A. Problem Statement

The streams in the WHW generally receive polluted runoff and contaminated sediments from urban areas within the watershed. Toxic metals (copper, chromium, lead, etc.), pesticides, and other man-made pollutants accumulate in stream sediment, making them unsuitable for ocean disposal. In addition, elevated levels of metals and pesticides have been found in fish tissue. Therefore, there is a need to identify major street runoff inputs and other polluted runoff sources and the means to reduce such runoff to improve stream water quality.

B. Project Background

There have been only a limited number of water quality studies in the WHWS project area and most are outdated. A baseline water quality report for Kalihi Stream was conducted in 1973; however, water quality data collection by USGS was discontinued in 1993. Environet, Inc., conducted a study on contaminated sediments in 2001, which tested sediment samples in the lower reaches of Moanalua and Kalihi Streams. Results of these tests indicated high levels of contaminants in these streams. No current data exists on water quality in Nu‘uanu Stream. A bioassay report was conducted for Ke‘ehi Lagoon in 1990, which also concluded that there were high levels of contamination present. The City and County of Honolulu conducted a study on particulate matter collected as part of routine street sweeping operations in 2001, which found heavy metals and other contaminants that eventually make their way into streams and stream sediments. However, a comprehensive study to include all watercourses within the project area and possible relationships with regard to their effect on the receiving water, as in the ahupua‘a concept, has not been conducted. The continued presence of contaminants in stream water and sediments indicates a need for regular monitoring and BMP trials. The EPA released its biannual update of the Impaired Water Bodies List, Section 303(d) of the Clean Water Act. The report listed all water courses in the WHWS project area as impaired. This EPA designation leads to the imposition of TMDLS, which in turn leads to increased enforcement. This research program will contribute to the enforcement of such standards, as well as to recommendations for contaminant reduction and remediation efforts.

C. Project Objectives

The overall objective of the program is to determine polluted discharge sources and types of contaminants present in stream water and sediments in the WHWS project area. Based on these determinations, strategies for the reduction of the identified contaminants will be recommended. Water bodies to be analyzed in this program include those designated by the EPA as “impaired,” specifically Ke‘ehi Lagoon, Moanalua Stream, Kalihi Stream, Kapālama Canal, and Nu‘uanu Stream. This research effort will identify baseline levels of contamination for the impaired water bodies in the project area, determine the location and cause of contamination, and therefore, contribute to the enforcement of TMDL standards triggered by the EPA impaired water bodies status.

Study questions that are to be addressed in this effort include:

- What are common BMPs that prevent contaminants from entering streams, especially from streets?
- How many and where are the discharge points that enter into the stream courses?
- What are the standard public outreach strategies for prevention of stream water contamination?
- What is the most practical and cost effective means of ongoing water quality monitoring?
- Which agencies are potential partners in ongoing stream water quality monitoring?
- Which community groups have interests in becoming involved in ongoing stream water quality monitoring or educational outreach projects?
- Given the limited land area around streams in the project area, what are the possible remediation alternatives to address contamination?

West Honolulu Surface Water Quality Monitoring Program (Page 2 of 2) Project 18

D. Preliminary Scope

Water bodies to be analyzed in this program include those designated by the EPA as "impaired," specifically the Salt Lake Basin, Keʻehi Lagoon, Moanalua Stream, Kalihi Stream, Kapālama Canal, and Nuʻuanu Stream. The preliminary scope of work for this program for each stream and water course will include, but not be limited to:

- Research of BMPs that reduce polluted discharges into streams.
- Survey and inventory discharges into each water course of the WHWS project area.
- Conduct sampling of discharge water and sediments at selected intervals along each stream course to locate where contaminants enter the stream.
- Analyze results of water quality sampling.
- Make recommendations of BMPs to address the type, source, and extent of storm water contamination.
- Recommend ongoing water and sediment quality-monitoring programs to evaluate BMP performance.
- Recommend outreach education to reduce polluted stream discharges into streams in the project area.

E. Agencies Involved and Project Cost

The lead agency for the project could be the State DOH-CWB. The CWB protects the public health of residents and tourists, who recreate in Hawaii's coastal and inland water resources, and also protects and restores inland and coastal waters for marine life and wildlife. This is accomplished through statewide coastal water surveillance and watershed-based environmental management through a combination of permit issuance, monitoring, enforcement, sponsorship of polluted runoff control projects, and public education. DOH fosters partnerships with other agencies involved in non-point source pollution control. Assistance on this project may come from DLNR-Engineering Division, based on their interest in reducing contaminated stream sediments; and the CZMP due to their role in water quality in the State of Hawaiʻi. NRCS and EPA may also have a role in this project. Estimated cost is $250,000 to $500,000 per year.

F. References

Anthony, Stephen S . 1997 . Evaluation of the USGS Ground Water Data Collection Program in Hawaii. USGS Water Res. Invest. Rpt. 97-4232.

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Brock, James A. 1999. Necropsy & Liver Histopathy for Fish Sampled in the Vicinity of the Sand Island Ocean Outfall and Maunalua Bay. C&C DES.

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Johnson, J.M., et al. 1974. Bacterial Indicators in Kapalama Canal, Oʻahu: Tech. Memo. Rpt No. 37. In: Pollution in Hawaiian Watersheds.

Nakamura, M. N. and Reginald H. K. Young. 1974. Estimation of Storm Water Quality in Kalihi Stream Drainage Basin. Tech Memo 45.

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Noda, Edward K. & Associates. 1989. Keehi Lagoon Recreation Plan Final EIS. State of Hawaii Department of Transportation.

Shade, Patricia J. 1984. Hydrology and Sediment Transport, Moanalua Valley, Oahu, Hawaii. USGS Water Resources Investigations Report 84-4156.

Young, Reginald H.K. and Gordon Matsushita. 1973. Baseline Quality Data for Kalihi Stream. Technical Report No. 71. WRRC: UH Manoa.

Surface Water Quality Monitoring Program

◀ Discarded automobile battery in upper Kalihi Stream.

Street runoff collects oil & grease, and lead from brake pads, deposits into streams. ▶

Ke‘ehi Lagoon Estuary & Honolulu Harbor Monitoring Program (Page 1 of 2)		**Project 19**
Category	*Project Type*	*Participating Agencies*
Water Quality	Program	DLNR; DOH-CWB; DOT-Harbors; CZMP; EPA

A. Problem Statement

As the receiving waters of most of the WHWS area, the “impaired” condition of Ke‘ehi Lagoon waters is an indication of the quality of stream water in the watershed. Analyzing the condition of Ke‘ehi Lagoon and Honolulu Harbor as habitats is one way to measure the success of BMPs employed in the upper and lower watershed areas.

B. Project Background

Ke‘ehi Lagoon and Honolulu Harbor are the receiving waters for the WHW region. The coastal areas have undergone substantial change in the past century, and Ke‘ehi Lagoon and Honolulu Harbor are now the receptors of polluted runoff from the impaired streams in the project area. Despite this long-term damage to the area, the Lagoon continues to serve as an estuary for aquatic and marine species requiring conditions that are a part of their lifecycles. Ke‘ehi Lagoon is located between Honolulu Harbor and the Honolulu International Airport reef runway. It is also a recreational center, with well-attended canoe regattas hosted at Ke‘ehi Lagoon Park. With these conflicting activities, the water quality in the estuary is of critical importance, and this study will serve to address issues related to polluted runoff, pollution from harbor and airport activities, and the recreational needs of the public as well as the needs of native and other aquatic species.

C. Project Objectives

The objective of the study is to analyze the estuarine habitat and water quality of Ke‘ehi Lagoon and Honolulu Harbor as the receiving waters of the WHW region. Impacts related to Honolulu Harbor, Honolulu International Airport, and polluted runoff would be analyzed with respect to uses of the Ke‘ehi estuary and the Harbor in the lifecycles of ‘o‘opu and other native aquatic species, as well as the effect on human activities in and around Ke‘ehi Lagoon and Honolulu Harbor.

Study questions to be considered as part of this investigation include, but should not be limited to:

- What is the water quality in Ke‘ehi Lagoon and Honolulu Harbor? What are the major contaminants? What are the likely sources of these contaminants?
- What aquatic and marine species are present in Ke‘ehi Lagoon and the Harbor? For which of these species are there juveniles present? How many native species are there?
- What recommendations can be made to improve water quality and estuarine conditions present in Ke‘ehi Lagoon and Honolulu Harbor?
- What effect does water quality have on human recreational activities (water sports, fishing, etc.) in the Ke‘ehi Lagoon area?

Ke‘ehi Lagoon Estuary & Honolulu Harbor Monitoring Program (Page 2 of 2) Project 19

D. Preliminary Scope

The scope of this program will be to examine the water quality and other conditions of Ke‘ehi Lagoon and Honolulu Harbor as they contribute to aquatic species and to human activities that take place in the Lagoon. Monitoring of the conditions in the Lagoon and Harbor will provide an indication of the health of the entire watershed:

Actions in this program should include but not be limited to:

- Test water quality.
- Survey aquatic species, including juveniles, present in the Ke‘ehi estuary and the Harbor.
- Survey habitat characteristics of the Ke‘ehi estuary and the Harbor.
- Recommend further water quality and habitat improvement strategies based on these findings.
- Recommend actions that would improve safety for human recreational activities that take place in the Ke‘ehi Lagoon area.

E. Agencies Involved and Project Cost

The potential lead agency for this program is DLNR due to their jurisdiction over Ke‘ehi Lagoon. Supporting agencies in this study could be the DOH-CWB, EPA, DOT-Harbors Division, and the CZMP. Estimated cost of the program is $250,000 to $500,000 per year.

F. References

AECOS. 1990. Keehi Lagoon Bioassay. Honolulu, Oahu. No. 599.

Brasher, Anne M. and Stephen S. Anthony . 1998. Occurrence of Organochloride Pesticides in Stream Bed Sediment and Fish from Selected Streams on the Island of Oahu, Hawaii, 1998. USGS Fact Sheet 140-00.Brock, James A. 1999. Necropsy & Liver Histopathy for Fish Sampled in the Vicinity of the Sand Island Ocean Outfall and Maunalua Bay. C&C DES.

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Noda, Edward K. & Associates. 1989. Keehi Lagoon Recreation Plan Final EIS. State of Hawaii Department of Transportation.

Shade, Patricia J. 1984. Hydrology and Sediment Transport, Moanalua Valley, Oahu, Hawaii. USGS Water Resources Investigations Report 84-4156.

Ke‘ehi Lagoon and Honolulu Harbor Estuary Study

◀ Ke‘ehi Lagoon is a popular recreational area.

Air photo of Ke‘ehi Lagoon. ▶

West Honolulu Watershed Source Water Protection Plan (Page 1 of 2) Project 20

Category	*Project Type*	*Participating Agencies*
Water Supply, Water Quality	PLAN	BWS; DOH; EPA

A. Problem Statement

With urbanization and the demand for drinking water increasing in the Primary Urban Center, there is an interest to not only seek additional water resources, but to protect existing supplies. There are urban land uses above the source wells of the WHWS area and on the fringes of the primary groundwater recharge zone. Long-range contamination prevention strategies are needed to protect those source waters.

B. Project Background

There are 13 wells in four locations in the WHW region, most of which are located in the urban area. Nearly 25 percent of the groundwater pumped from O‘ahu wells comes from the West Honolulu region. Contaminants such as dieldrin have been detected in wells located in the Kalihi area as well as in wells adjacent to the project area. In the interest of protecting vital source water from urban-based contaminants, a protection plan is needed to focus on restricting urban activities that are a detriment to source water. The Hawai‘i Source Water Assessment Program is setting parameters for source water influence zones based on time-distance modeling and is creating an inventory of possible contaminants within those zones. An area-specific plan is needed to utilize this information to regulate certain land use activities that may undermine the quality of source waters in the WHW region. The study will be completed in late 2003.

Reducing or preventing microbiological and chemical contamination of source waters allows public water systems to avoid costly treatment and minimize monitoring requirements. The 1996 reauthorization of the Federal Safe Drinking Water Act included an amendment requiring states to develop programs to assess sources of drinking water and encouraging the establishment of protection programs. This points to a new, more comprehensive, watershed-based prevention approach to be applied to improving both groundwater and surface water quality. A source water protection program is needed that envisions a partnership among local, State, and Federal agencies and the community to ensure that the quality of drinking water sources is maintained and protected.

C. Project Objectives

The objective of this study is to research the various source water protection strategies used in Hawai‘i or in environments similar to Hawai‘i and to select and implement one or more appropriate strategies to protect groundwater in the WHW region. The primary strategy may be to regulate land use activities that threaten the quality of source water in the project area and to offer alternatives to those land use practices. Questions to be considered in the formation of this plan include:

- What are the land uses within each source water protection area for wells in the WHW Study area?
- What are the possible contamination threats revealed in the Hawai‘i Source Water Assessment Program for each well in the WHWS area?
- Are there additional contaminant sources not listed in the Hawai‘i Source Water Assessment Program?
- How can the impacts of potential contaminant sources be abated for each well?
- How can land use restrictions for critical source waters be implemented & enforced?

West Honolulu Watershed Source Water Protection Plan (Page 2 of 2) Project 20

D. Preliminary Scope

The preliminary scope of work for this Plan will include:

- Acquire technical information and findings in the Hawai'i Source Water Assessment Program for use in a protection plan for the WHW region.
- Updatei the inventory of possible contaminants for each wellhead.
- Identify land use restrictions and enforcement actions that are required to assure source waters are protected.
- Identify other strategies to protect source waters for wells in the WHW region.

E. Lead Agency & Project Cost

A possible lead agency for this plan is the BWS based on their mission to provide the City and County of Honolulu with a safe drinking water supply. The DOH and EPA may provide planning support in this effort. Estimated cost of the plan is $100,000 to $250,000

F. References

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Source Water Protection

◀ Moanalua Well #2, located on Moanalua Freeway and below Tripler Army Medical Hospital and residential neighborhoods.

Upper residential neighborhoods above Kalihi Station wells. ▶

Ko‘olau Mountain Infiltration Well Pilot Study (Page 1 of 2) Project 21

Category	*Project Type*	*Participating Agencies*
Water Supply	STUDY	BWS; DOH; EPA

A. Problem Statement

With urbanization and the demand for potable water increasing in the Primary Urban Center, there is an interest to not only protect the existing groundwater supply but to also seek additional water resources. Much of the rainfall in the primary recharge zone, the conservation district, is lost to runoff, which in turn increases erosion and sedimentation.

B. Project Background

Paul Hummel, an agricultural engineer involved in water resources, originally presented this idea during the Ala Wai Canal Watershed Improvement Project. Existing infiltration well projects worldwide focus on storm water management and surface water storage. A proposal to construct wells or large, high infiltration areas or “spreading basins,” with the objective of groundwater recharge, as well as storm water and sediment management, raises some critical issues. For instance, maintaining water quality as percolation time is reduced. Also, the issue of how is the dry well maintained with regard to sediment build-up after prolonged collection of sediment must be resolved. The study will also include a cost comparison of infiltration wells versus desalinization and other water resource alternatives under consideration in Hawai‘i.

Infiltration wells also act as storm water detention devices and serve to reduce erosion from high volume flows as well as settle out sediments carried in those flows. This study could possibly be combined with Project No. 13, “Kalihi Watershed Erosion Prevention/Infiltration Enhancement Project.”

C. Project Objectives

The objective of this study is to research the existing technology with regard to infiltration or “dry” wells as a means for groundwater recharge, and to evaluate the practicality and feasibility to groundwater mechanics in Hawai‘i. The specific objectives of this study are to:

- Gain an understanding of infiltration well technologies throughout the world.
- Identify all potential contaminant sources, such as leptospirosis, and methods to reduce the risk from those sources.
- Estimate the cost of construction and maintenance of infiltration wells or areas and compare to costs of desalinization and other alternative methods of increasing water supply.
- Estimate the volume of storm water that may be effectively detained in an infiltration well.
- Research ways in which sediment build-up in infiltration wells can be prevented or abated.

Ko'olau Mountain Infiltration Well Pilot Study (Page 2 of 2) Project 21

D. Preliminary Scope

The preliminary scope of work for this project will thus include:

- Research existing infiltration well technologies in Hawai'i and elsewhere.
- Identify impacts of infiltration wells on groundwater mechanics.
- Identify all possible vectors of contaminant entry to an infiltration well system
- Investigate means for maintaining wells with regard to sediment buildup
- Perform a feasibility analysis and compare projected costs for construction and maintenance of infiltration wells to alternative sources of potable water such as desalinization.

E. Lead Agency & Project Cost

The lead agency for this project will probably be the BWS based on their mission to provide the City and County of Honolulu with a safe drinking water supply. Support for this study may come from the DOH-Safe Drinking Water Branch, and the EPA. Estimated cost of the study is $100,000 to $250,000.

F. References

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Infiltration Wells

◀ Infiltration wells capture runoff that would otherwise go to streams and the ocean.

Diagram of infiltration well. ▶