DAVID Y. IGE
GOVERNOR OF HAWAII

FILE COPY

JUL 23 2019

SUZANNE D. CASE
CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES
COMMISSION ON WATER RESOURCE MANAGEMENT

ROBERT K. MASUDA
FIRST DEPUTY

M. KALEO MANUEL
DEPUTY DIRECTOR - WATER

AQUATIC RESOURCES
BOATING AND OCEAN RECREATION
BUREAU OF CONVEYANCES
COMMISSION ON WATER RESOURCE MANAGEMENT
CONSERVATION AND COASTAL LANDS
CONSERVATION AND RESOURCES ENFORCEMENT
ENGINEERING
FORESTRY AND WILDLIFE
HISTORIC PRESERVATION
KAHOOLAWE ISLAND RESERVE COMMISSION
LAND
STATE PARKS

RECEIVED

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
POST OFFICE BOX 621
HONOLULU, HAWAII 96809

'19 JUL 15 P4:08

OFC. OF ENVIRONMENTAL
QUALITY CONTROL

July 15, 2019

Ref: 12OD-084

Mr. Scott Glenn
Office of Environmental Quality Control
Department of Health, State of Hawai'i
235 S. Beretania Street, Room 702
Honolulu, Hawai'i 96813

Dear Mr. Glenn:

With this letter, the Department of Land and Natural Resources hereby transmits the draft environmental assessment and anticipated finding of no significant impact (DEA-AFONSI) for the Management Plan for Kalauha'iha'i Fishpond, situated at TMK (1) 3-7-002:018 and (1) 3-7-002:077), in the Honolulu District on the island of O'ahu for publication in the next available edition of the Environmental Notice.

Enclosed is a completed OEQC Publication Form, four digital CD copies and one paper copy of the DEA-AFONSI; and an electronic copy of the publication form in MS Word.

If there are any questions, please contact Barry Cheung of Land Division at 587-0430.

Sincerely,

Suzanne D. Case
Chairperson

Enclosures

cc: Maunalua Fishpond Heritage Center

20-020

APPLICANT
PUBLICATION FORM

Project Name:	Kalauha'iha'i Fishpond Management Plan
Project Short Name:	Kalauha'iha'i Fishpond Management Plan
HRS §343-5 Trigger(s):	Proposed Use of State Lands
Island(s):	O'ahu
Judicial District(s):	Honolulu
TMK(s):	(1) 3-7-002:018 and (1) 3-7-002:077
Permit(s)/Approval(s):	None
Approving Agency:	State of Hawai'i, Department of Land and Natural Resources
Contact Name, Email, Telephone, Address	Barry Cheung 1151 Punchbowl Street, Room 220 Honolulu, Hawai'i 96813 Telephone: (808) 587-0433 Email: barry.w.cheung@hawaii.gov
Applicant:	Maunalua Fishpond Heritage Center
Contact Name, Email, Telephone, Address	Chris Cramer, President, Board of Directors Maunalua Fishpond Heritage Center P.O. Box 240204 Honolulu, Hawai'i 96824 Telephone: (808) 382-0847 Email: Maunaluafishponds@gmail.com
Consultant:	n/a
Contact Name, Email, Telephone, Address	

Status (select one)	**Submittal Requirements**
_X_ DEA-AFNSI	Submit 1) the approving agency notice of determination/transmittal letter on agency letterhead, 2) this completed OEQC publication form as a Word file, 3) a hard copy of the DEA, and 4) a searchable PDF of the DEA; a 30-day comment period follows from the date of publication in the Notice.
____ FEA-FONSI	Submit 1) the approving agency notice of determination/transmittal letter on agency letterhead, 2) this completed OEQC publication form as a Word file, 3) a hard copy of the FEA, and 4) a searchable PDF of the FEA; no comment period follows from publication in the Notice.
____ FEA-EISPN	Submit 1) the approving agency notice of determination/transmittal letter on agency letterhead, 2) this completed OEQC publication form as a Word file, 3) a hard copy of the FEA, and 4) a searchable PDF of the FEA; a 30-day comment period follows from the date of publication in the Notice.
____ Act 172-12 EISPN ("Direct to EIS")	Submit 1) the approving agency notice of determination letter on agency letterhead and 2) this completed OEQC publication form as a Word file; no EA is required and a 30-day comment period follows from the date of publication in the Notice.
____ DEIS	Submit 1) a transmittal letter to the OEQC and to the approving agency, 2) this completed OEQC publication form as a Word file, 3) a hard copy of the DEIS, 4) a searchable PDF of the DEIS, and 5) a searchable PDF of the distribution list; a 45-day comment period follows from the date of publication in the Notice.
____ FEIS	Submit 1) a transmittal letter to the OEQC and to the approving agency, 2) this completed OEQC publication form as a Word file, 3) a hard copy of the FEIS, 4) a searchable PDF of the FEIS, and 5) a searchable PDF of the distribution list; no comment period follows from publication in the Notice.
___ FEIS Acceptance Determination	The approving agency simultaneously transmits to both the OEQC and the applicant a letter of its determination of acceptance or nonacceptance (pursuant to Section 11-200-23, HAR) of the FEIS; no comment period ensues upon publication in the Notice.
____ FEIS Statutory	The approving agency simultaneously transmits to both the OEQC and the applicant a notice that it

20-020

Acceptance	did not make a timely determination on the acceptance or nonacceptance of the applicant's FEIS under Section 343-5(c), HRS, and therefore the applicant's FEIS is deemed accepted as a matter of law.
____ Supplemental EIS Determination	The approving agency simultaneously transmits its notice to both the applicant and the OEQC that it has reviewed (pursuant to Section 11-200-27, HAR) the previously accepted FEIS and determines that a supplemental EIS is or is not required; no EA is required and no comment period ensues upon publication in the Notice.
____ Withdrawal	Identify the specific document(s) to withdraw and explain in the project summary section.
____ Other	Contact the OEQC if your action is not one of the above items.

Project Summary

Provide a description of the proposed action and purpose and need in 200 words or less.

The non-profit organization Maunalua Fishpond Heritage Center (MFHC) is applying for a long-term (30 year) lease of the Kalauha'iha'i Fishpond site at Niu, O'ahu. MFHC is a community-based organization committed to environmental conservation, and the historic and cultural revitalization of Maunalua's remaining fishponds. The Kalauha'iha'i Fishpond may be considered a historic property and cultural resource as it is the only intact shoreline fishpond in urban Honolulu besides nearby Kanewai Fishpond. While the pond is small, its potential to yield information important for research is high, and its accessible location in urban Honolulu makes it an especially valuable educational resource. The Kalauha'iha'i site will be managed as a Hawaiian fishpond and cultural learning site, using science and hands-on education to steward resources and restore traditional fishpond values. The proposed project will engage schools and the community in a suite of low intensity activities using hand tools and traditional methods and materials. Management objectives include eliminating invasive species and restoring natives; managing aquatic habitat and fish populations; and preserving and maintaining traditional fishpond infrastructure. These proposed management actions are essential for the continuing revitalization, preservation and long-term use of the fishpond.

20-020

Kalauha‘iha‘i Fishpond Management Plan

Niu Ahupua‘a, Kona District, Island of O‘ahu, Hawai‘i.

Draft Environmental Assessment

Anticipated Finding Of No Significant Impact
(HRS 343)

Prepared by
Maunalua Fishpond Heritage Center

July 2019

SUMMARY

Project Name: **Kalauhaʻihaʻi Fishpond Management Plan**
Location: Niu, Oʻahu
Judicial District: Honolulu
Tax Map Key (TMK): (1) 3-7-002:018 and (1) 3-7-002:077
Land Area Affected: Approximately 10,827 square feet
Applicant: Maunalua Fishpond Heritage Center
Accepting Authority: State of Hawaiʻi Department of Land and Natural Resources
Land Owner: State of Hawaiʻi Department of Land and Natural Resources
Existing Use: Vacant
Proposed Action: The proposed action entails a long-range management plan for the Kalauhaʻihaʻi Fishpond site, consisting of activities for conservation, biological and cultural revitalization, education, and scientific research at Kalauhaʻihaʻi. The Kalauhaʻihaʻi Fishpond Management Plan activities will be implemented by Maunalua Fishpond Heritage Center (MFHC) a 501(c)(3) nonprofit organization, through a community-based effort that involves schools, residents, Native Hawaiian cultural practitioners, scientists and others.

Current Land Use Designations:
State Land Use: Urban
City and County of Honolulu Development Plan Area: East Honolulu
City and County of Honolulu Zoning: R-10, Residential
Special Management Area: Within SMA boundary

Alternatives Considered:
No Action
Agency (DLNR) manages site as a passive State park
Proposed Management Plan for Kalauhaʻihaʻi - preferred alternative

Proposed Action:
The proposed action consists of a long-range management plan for Kalauhaʻihaʻi. Its goals are the revitalization and protection of the natural and cultural resources of the fishpond site, the provision of educational and scientific study opportunities, and the engagement of the community and residents of the State in employing cultural practices and traditional knowledge. The five focal areas for management that will be undertaken to meet these goals are described in detail in section 3, and are summarized as follows:

5 Areas of Management:

- Enhance and Maintain Aquatic Habitat of Kalauhaʻihaʻi Fishpond.
- Enhance and Maintain Terrestrial Habitat of Kalauhaʻihaʻi Fishpond.
- Manage Fish Populations.
- Maintain Traditional Fishpond Infrastructure.
- Build Community Awareness, Cultural Connections and Capacity for Sustained Stewardship of Kalauhaʻihaʻi Fishpond.

Anticipated Impacts:

Implementation of the proposed action is not expected to have a cumulative negative effect on the environment, instead it is expected to result in net beneficial outcomes for both the biological and social environments, including resources beyond the project area.

Some potential short term, temporary impacts have been identified. These are minimal and can be mitigated or avoided. Minor localized noise, dust, and erosion may occur as a result of invasive species removal. However noise levels will not exceed those normally encountered in an urban area (lawnmowing, hedge-trimming, etc.) and will not exceed allowable levels under County regulations. Similarly, dust levels will be comparable to those generated by everyday urban activities. Erosion is expected to be negligible as soil disturbance will be limited to small areas (less than 20 x 25) and overland flow at the site is almost non-existent. Additionally, once the site is completely cleared of invasive plants, noise, dust and erosion are expected to be negligible. MFHC will anticipate all potential and actual impacts and continue to employ best management practices to minimize them. MFHC values the opinions and interests of surrounding neighborhood residents and is committed to frequent communication and to working together to address potential community issues.

Long-term adverse impacts are not anticipated; instead it is expected that over the long run the proposed action will improve flora and fauna, ecosystems and habitats, water quality and social aspects including community involvement and education. The site is not located within agricultural lands. The project is located within the SMA and within flood and tsunami zones but is not expected to increase hazards or otherwise impact upon these zones.

Anticipated Determination: Finding of No Significant Impact

TABLE OF CONTENTS

Section **Page**

1. INTRODUCTION..... 1
1.1 Land Owner.....3
1.2 Applicant..... 3
1.3 Accepting Authority 4
1.4 Compliance with State of Hawaiʻi Environmental Laws 4
1.5 Studies Contributing to This Environmental Assessment 5

2. SITE DESCRIPTION 7
2.1 Location and Property Description 8
2.2 Existing Land Use Designations 10
2.3 Surrounding Land Uses 15
2.4 Regional Land Use History 15

3. SUMMARY OF PROPOSED ACTIONS.....17
3.1 Kalauhaʻihaʻi Management Plan 18
3.2 Project Vision, Objectives, and Management Targets..... 18
3.3 Proposed Management Actions 19
Strategy 1: Enhance and Maintain Aquatic Habitat. 19
Strategy 2: Enhance and Maintain Terrestrial Habitat..... 20
Strategy 3: Manage Fish Populations..... 21
Strategy 4: Maintain Traditional Fishpond Infrastructure..... 22
Strategy 5: Build Community Awareness, Cultural Connections, and Capacity for Sustained Stewardship.....23
3.4 Evaluation of Management 24
3.5 Schedule and Estimated Costs.....27

4. AFFECTED ENVIRONMENT, POTENTIAL IMPACTS, AND MITIGATION MEASURES..... 29
4.1 Physical Environment 30
4.1.1 Climate..... 30
4.1.2 Geology and Topography 30
4.1.3 Soils 32
4.1.3.1 Natural Resource Conservation Service Soil Survey 32
4.1.3.2 LSB Detailed Land Classification 34
4.1.3.3 ALISH 34
4.1.4 Hydrogeological Resources 36
4.1.4.1. Surface Water. 36
4.1.4.2 Groundwater 37
4.1.4.3 Coastal Waters.....42

4.1.5 Natural Hazards 43
4.1.5.1 Flood 43
4.1.5.2 Tsunami 45
4.1.5.3 Hurricane 45
4.1.5.4 Earthquake 47
4.1.6 Biological Environment 47
4.1.6.1 Groundwater Dependent Ecosystems 47
4.1.6.2 Flora 49
4.1.6.3 Fauna 52
4.1.7 Air Quality and Noise 53
4.1.7.1 Air Quality 53
4.1.6.2 Noise 54
4.2 Human Environment 55
4.2.1 Archaeological, Historic and Cultural Resources 55
4.2.2 Native Hawaiian Traditional Cultural Knowledge, Values and Practices 64
4.2.3 Infrastructure 68
4.2.3.1 Roadways, Traffic, Access, and Parking Facilities 68
4.2.3.2 Public Transportation 69
4.2.3.3 Water Supply and Wastewater 70
4.2.3.4 Solid Waste 70
4.2.3.5 Drainage System 71
4.2.3.6 Electrical and Communications 71
4.2.4 Visual Resources 72
4.2.5 Socio-Economic Characteristics 73
4.2.5.1 Population 73
4.2.5.2 Economy 73
4.2.6 Public Services and Facilities 74
4.2.6.1 Schools 74
4.2.6.2 Police, Fire, and Medical 75
4.2.6.3 Recreational Facilities 76
4.2.7 Hazardous Materials 77

5. LAND USE CONFORMANCE 79
5.1 State of Hawai‘i 80
5.1.1 State Land Use Law, Chapter 205, Hawai‘i Revised Statutes 80
5.1.2 Coastal Zone Management Act, Chapter 205A, Hawai‘i Revised Statutes 80
5.1.3 Hawai‘i State Plan 88
5.2 City and County of Honolulu 92
5.2.1 O‘ahu General Plan 92
5.2.2 East Honolulu Sustainable Community Plan 94
5.2.3 City and County of Honolulu Land Use Ordinance 95
5.3 Approvals and Permits 99

6. ALTERNATIVES TO THE PROPOSED ACTION 101
6.1 No Action Alternative 102
6.2 Active Agency Management (Passive Park) 103

7. FINDINGS AND ANTICIPATED DETERMINATION 107
7.1 Significance Criteria..... 108
7.2 Anticipated Determination 114

8. REFERENCES 115

9. APPENDICES (attached)
9.1 Aquatic Inventory by Keoki Stender
9.2 Archaeological Field Inspection by Cultural Surveys Hawai‘i
9.3 Botanical Inventory by Danielle Frohlich, M.S.
9.4 Hydrological Study by Joseph Kennedy

Section 1:
Introduction

Let us not allow the broken walls of the loko iʻa (fishponds) to separate us from what was known and practiced in the past. The foundations of the walls are still evident, as are the wisdom and knowledge of our kupuna. The reflections of sun, moon and stars upon our waters are as old as time. Let these be beacons to guide our haumana to these ponds of knowledge. Let us help them rebuild the walls of these living resources where they can gather as did the pua i'a (baby fish), to grow and be nurtured. With education and inspiration, the legacy of our ancestors can be preserved and passed on to future generations, a mau a mau (forever and ever).

-Christine Tamaru, Project Kahea Loko "The Call of the Pond".

Kalauhaʻihaʻi Fishpond Site Before and After Volunteer Cleanups

1. INTRODUCTION

The non-profit organization Maunalua Fishpond Heritage Center (MFHC) is applying for a long-term (30 year) lease of the Kalauhaʻihaʻi Fishpond site in the Maunalua region of southeast Oʻahu. Established in 2007, MFHC is a community-based organization committed to environmental conservation, and the historic and cultural revitalization of Maunalua's remaining fishponds. The Kalauhaʻihaʻi Fishpond may be considered a historic property and cultural resource as it is the only intact shoreline fishpond in urban Honolulu, besides nearby Kanewai Fishpond. The pond also is an important example of a Hawaiian groundwater dependent ecosystem. The potential for the fishpond to yield information important for research is high, and its accessible location in urban Honolulu makes it an especially valuable educational resource. The proposed management actions are essential for the continuing revitalization, preservation and long-term use of the fishpond. The Kalauhaʻihaʻi site will be managed as a Hawaiian fishpond and cultural learning site, using science and ʻāina-based hands-on education to steward resources and restore traditional fishpond values. MFHC previously obtained right-of-entry approval from the State of Hawaiʻi Department of Land and Natural Resources (DLNR) to conduct community-based stewardship of Kalauhaʻihaʻi Fishpond, and has developed a management plan for the Kalauhaʻihaʻi Fishpond site.

The Management Plan for Kalauhaʻihaʻi Fishpond consists of five long-term management strategies for conservation, biological and cultural revitalization, education and scientific research at Kalauhaʻihaʻi. Detailed descriptions of each proposed area of management, including need for actions, are found in Section 3 of this document. The plan will be implemented by Maunalua Fishpond Heritage Center (MFHC), a 501(c)(3) nonprofit organization, through a community-based effort that involves schools, residents, Native Hawaiian cultural practitioners, scientists and others. This Environmental Assessment (EA) is prepared in accordance with Chapter 343, Hawaiʻi Revised Statutes (HRS) for the proposed Kalauhaʻihaʻi Fishpond Management Plan and meets the DLNR lease application requirement.

Note on Spelling: Multiple name variants can found in the literature. These are Kalauhaʻihaʻi Fishpond, Kalauhaehae Pond or Kalauhaehae Fishpond, Lucas Spring, Lucas Pond and Lucas Fishpond. MFHC employs Kalauhaʻihaʻi, which is the oldest known name for the site.

1.1 Land Owner

The land owner is the State of Hawaiʻi, Department of Land and Natural Resources.

Contact:
State of Hawaiʻi, Department of Land and Natural Resources
Suzanne Case, Chairperson
1151 Punchbowl Street
Kalanimoku Building
Honolulu, Hawaiʻi 96813
Telephone: (808) 587-0400
Email: DLNR@hawaii.gov

1.2 Applicant

Maunalua Fishpond Heritage Center

Contact:
Chris Cramer, President, Board of Directors
Maunalua Fishpond Heritage Center
P.O. Box 240204
Honolulu, Hawaiʻi 96824
Telephone: (808) 382-0847
Email: Maunaluafishponds@gmail.com

1.3 Accepting Authority

The State of Hawaiʻi, Department of Land and Natural Resources is the designated accepting authority.

Contact:
State of Hawaiʻi, Department of Land and Natural Resources
Suzanne Case, Chairperson
1151 Punchbowl Street
Kalanimoku Building
Honolulu, Hawaiʻi 96813
Telephone: (808) 587-0400
Email: DLNR@hawaii.gov

1.4 Compliance with State of Hawaiʻi Environmental Laws

Preparation of this document is in accordance with the provisions of Chapter 343, HRS and Title 11, Chapter 200, Hawaiʻi Administrative Rules (HAR) pertaining to Environmental Impact Statements. Section 343-5, HRS established nine types of actions that "trigger" compliance. The use of State or County lands or funds is one of these "triggers." Because State lands will be managed by Maunalua Fishpond Heritage Center (MFHC) under the proposed management plan, compliance with the described HRS and HAR is required.

1.5 Studies Contributing to This Environmental Assessment

The information contained in this report has been developed from site visits, generally available information regarding the characteristics of the site and surrounding areas, and technical studies. Technical studies are provided as appendices to this EA. These studies are: Aquatic Inventory provided by Keoki Stender; Archaeological Field Inspection as documented by Cultural Surveys Hawaiʻi; Botanical Inventory provided by Danielle Frohlich, M.S.; and Hydrological Study provided by Joseph Kennedy.

Section 2:
Site Description

2. SITE DESCRIPTION

2.1 Location and Property Description

The Kalauhaʻihaʻi Fishpond is located along the Niu shoreline, Niu Ahupuaʻa, Kona District, City and County of Honolulu, Island of Oʻahu (Figure 1). The approximately 10,827 square feet site is made up of two parcels identified as TMK (1) 3-7-002:018 and TMK (1) 3-7-002:077 (Figure 2). The site is bounded to the south by Maunalua Bay, to the North by Kalanianaʻole Highway and to the east and west by residences. The site is a fenced vacant lot. When first accessed by Maunalua Fishpond Heritage Center, the Kalauhaʻihaʻi Fishpond and yard were overgrown with non-native, invasive vegetation. Most has been removed and native plants have begun to regenerate. Two dilapidated residences previously on the site were removed by DLNR in 2017. Current access to the property is from Kalanianaʻole Highway or (by foot or canoe) via a sandy beachfront along Maunalua Bay.

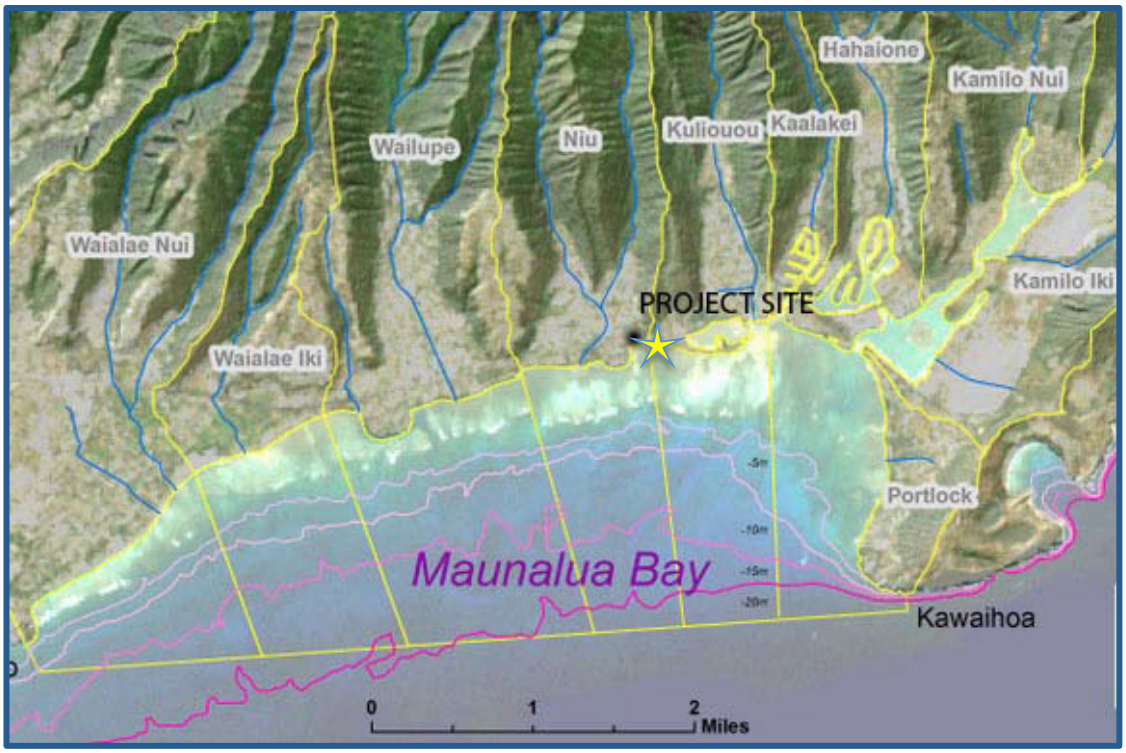


Figure 1. Location of Niu Ahupuaʻa and Kalauha'iha'i Fishpond

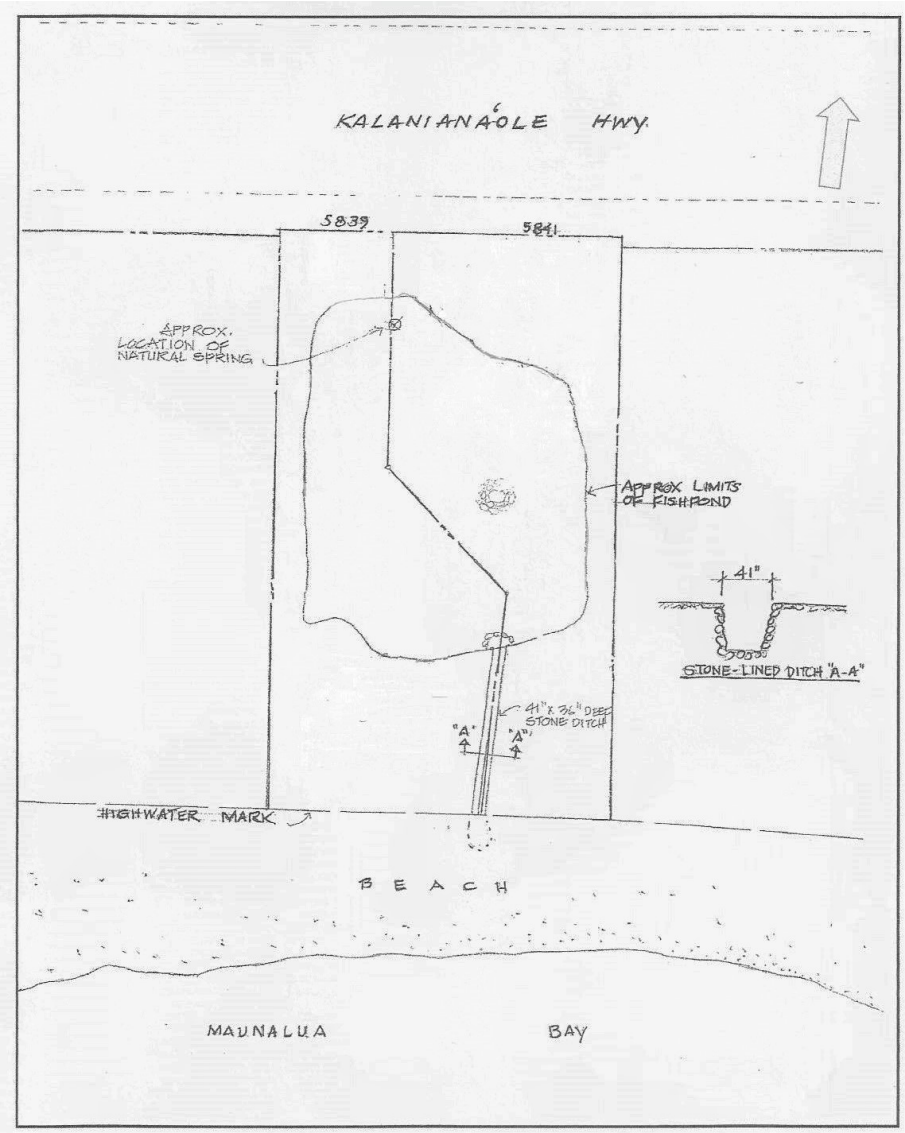


Figure 2. Kalauhaʻihaʻi Fishpond Site Diagram

Site Physical Description:

Kalauhaʻihaʻi Fishpond is a relatively flat coastal site located between Kalanianaʻole Highway and Maunalua Bay in the urbanized ahupuaʻa of Niu at approximately 21°16'56.9"N latitude, 157°43'52.5"W longitude. The site lies directly at the foot of the Kalapaomaua ridge which divides Niu Ahupuaʻa from Kuliʻouʻou Ahupuaʻa. The site diagram (Figure 2) shows the site layout with two irregular parcels comprising the fishpond and associated cultural features.

The two combined parcels form a rectangle bordered by Kalanianaʻole Hwy to the north, residences to the west and east, and approximately 75 feet of sandy shoreline to the south

The combined area of the two parcels is 10,827 square feet. The Kalauhaʻihaʻi Fishpond covers approximately 4,320 square feet or about 40% of the total site area. Associated fishpond structures consisting of an ʻauwai and remnants of a mākāhā together make up a small portion (well under one percent) of the site's area. The remaining 30% of the site is vegetated, with a mixture of native and non-native plant species. When MFHC first accessed the Kalauhaʻihaʻi Fishpond property, invasive non-native plants dominated the site. Today, most of the invasive vegetation has been uprooted and removed, and all will eventually be replaced with native or food-bearing plants. The fishpond area and the front entry from Kalanianaʻole Highway are fenced, with a gate that remains locked whenever MFHC personnel are off-site.

2.2 Existing Land Use Designations

Current land use designations for the site are:

Hawaiʻi State Land Use Zoning: Urban District (Figure 3)

City and County of Honolulu Zoning: R-10 -Residential (Figure 4)

East Honolulu Sustainable Communities Plan: Residential and Low Density Apartment (Figure 5)

Special Management Area: Within the SMA (Figure 6)

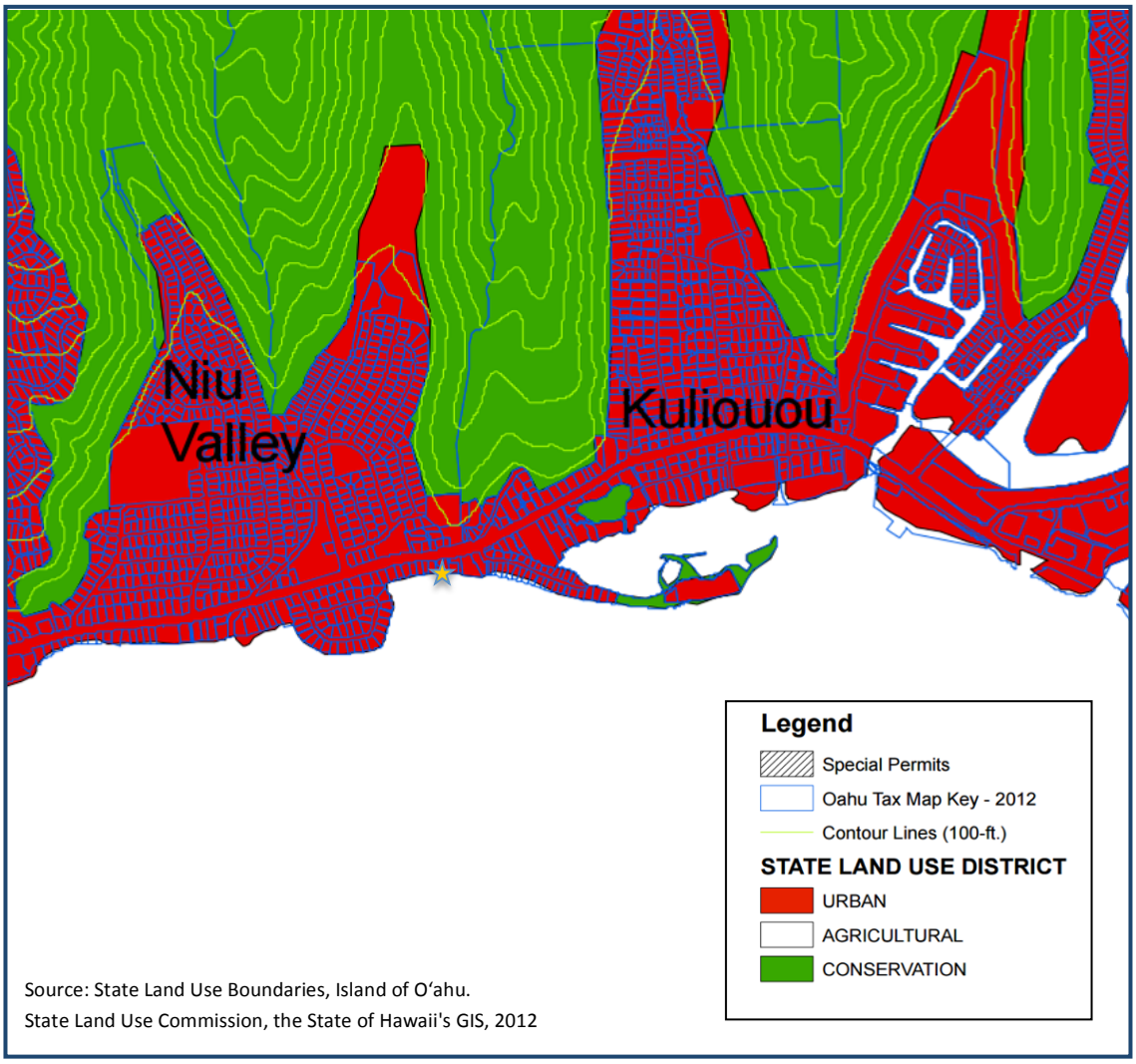


Figure 3. Hawai'i State Land Use Boundaries

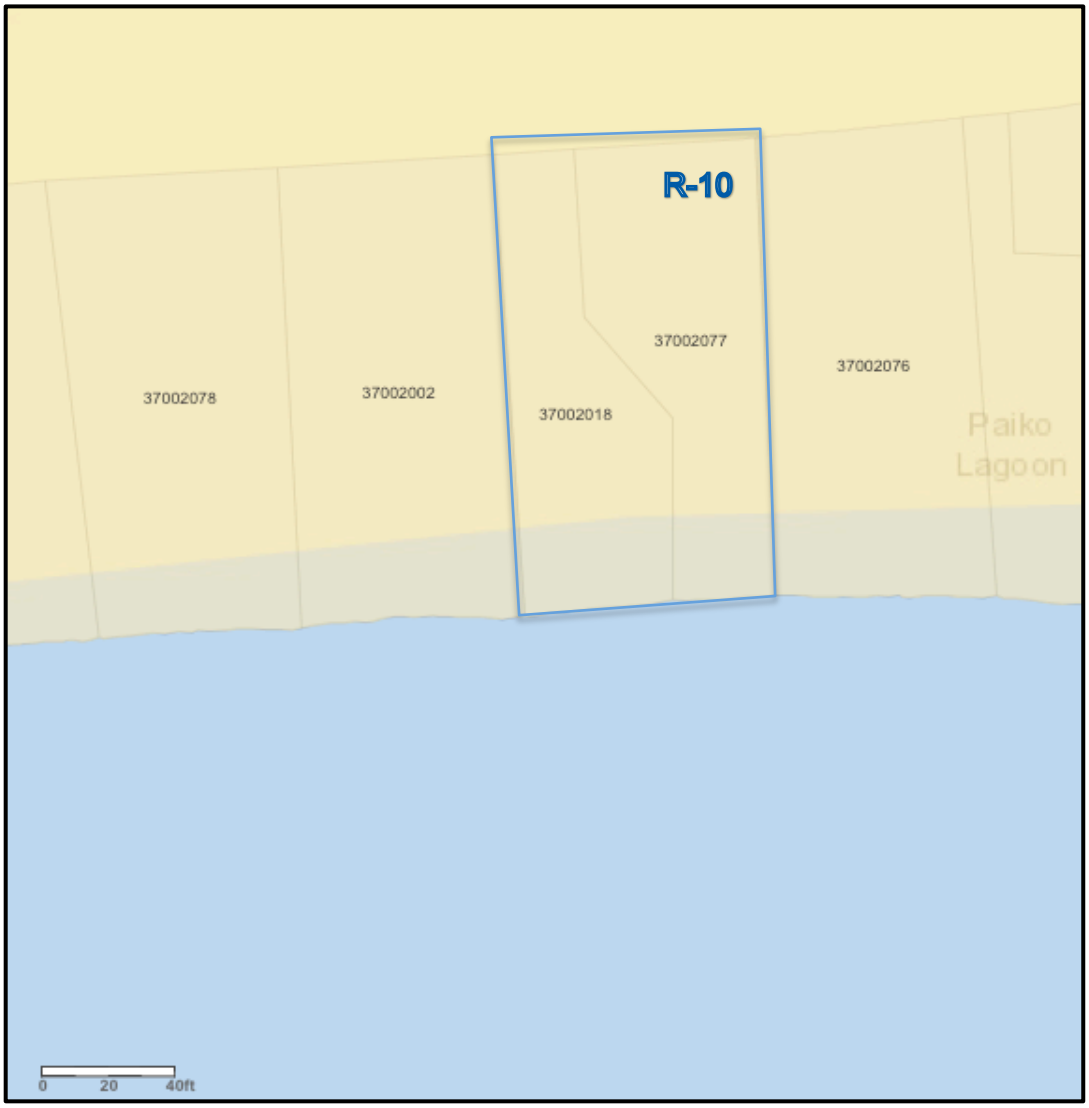


Figure 4. City and County of Honolulu Zoning
Parcel # 370020180000
Parcel # 370020770000

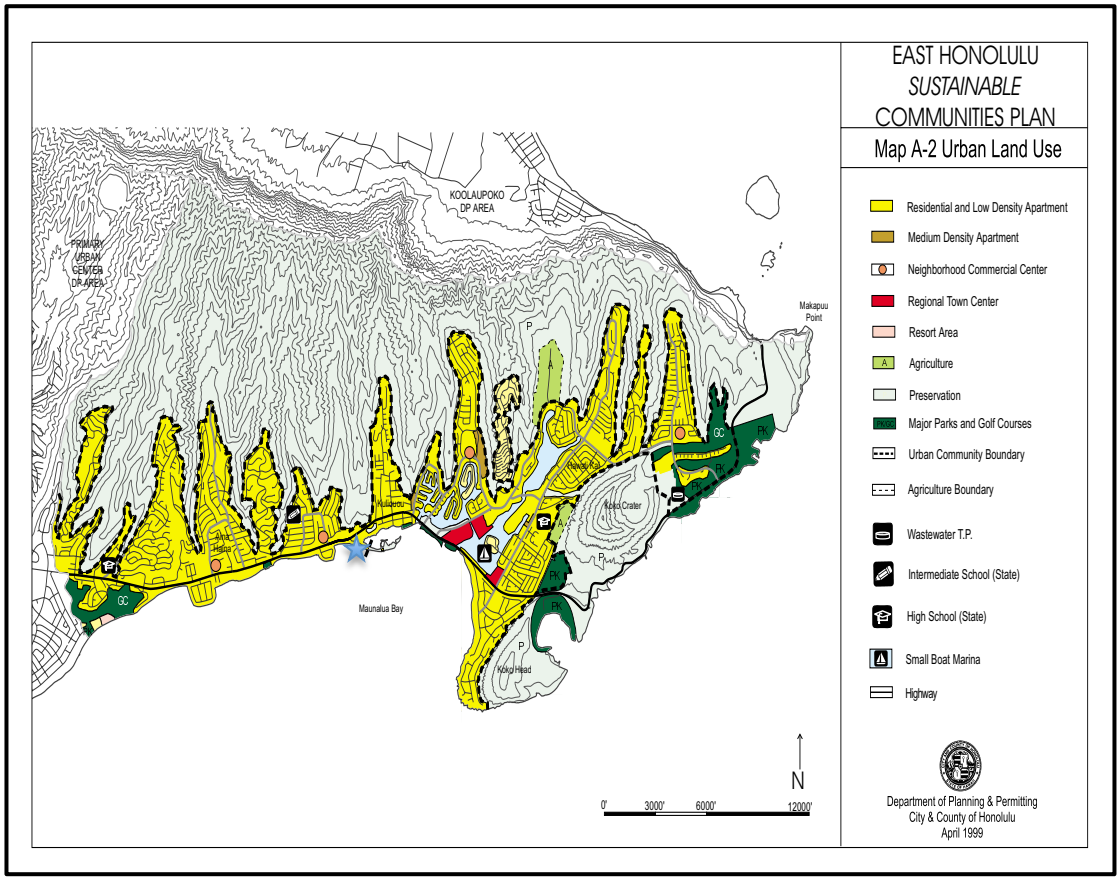


Figure 5. East Honolulu Sustainable Communities Plan Land Use

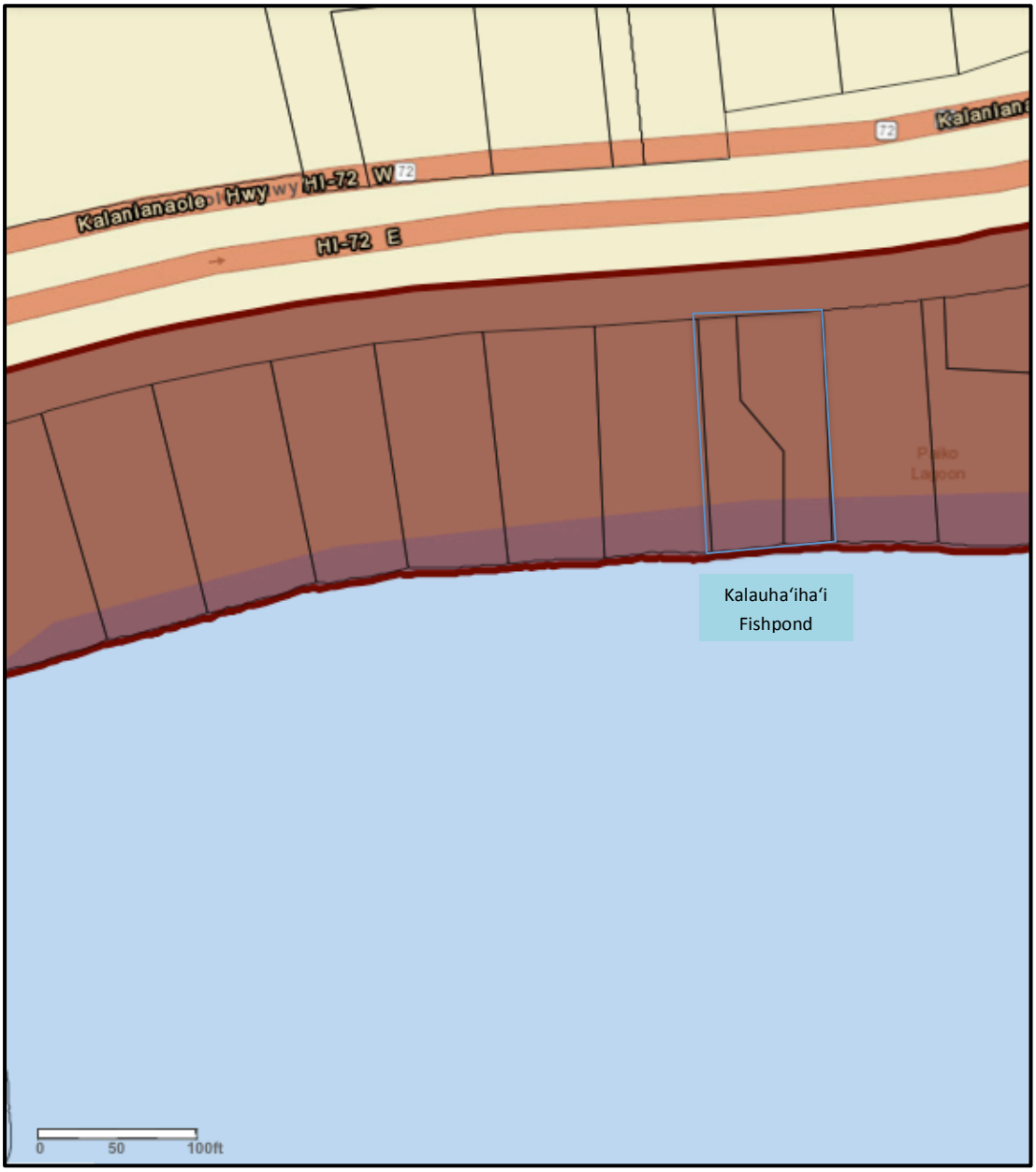


Figure 6. Special Management Area (shaded area)
TMK 37002018
TMK 37002077

2.3 Surrounding Land Uses

The Kalauhaʻihaʻi Fishpond site is bordered on two sides (east and west) by single-family residences, to the north by Kalanianaʻole Highway, and to the south by the sandy shoreline of Maunalua Bay.

2.4 Regional Land Use History

According to Cordy (2002) the Kona District lands of Oʻahu weren't permanently inhabited until around AD 1000-1300. This did not mean they weren't utilized, as they were rich in important resources such as timber, fishing grounds, bird nesting areas, and were visited and used intermittently by travelers from other areas. Dates in the range of AD 1200-1400 have been estimated for agricultural sites located in mid-valley areas of Kuliʻouʻou, indicating that settlements in the area were likely well-established by then.

Subsequent accounts by western voyagers to the southeast coast of Oʻahu suggest the area was well populated and that food resources were more than sufficient. Anchoring his ship, the *King George*, in Maunalua Bay in 1786, Captain Nathaniel Portlock reported: "Soon after our arrival, several canoes came off and brought a few cocoa-nuts and plantains, some sugar-cane and sweet root..." (Portlock 1789). During the early 19th century, accounts by missionary visitors, such as Gilbert F. Mathison, depicted what early southeast Oʻahu may have been like. While walking through the area in 1822, he noted a fishing village containing about 100 huts near Maunalua fishpond; he also reported "occasional huts, scattered here and there together with several fine groves of cocoa-nut trees" as he continued traveling westward along the coast (Mathison 1825). Missionary educator Levi Chamberlain reported a settlement of eighteen houses at Maunalua in 1826, with three additional settlements located between Maunalua and the schoolhouse in Waiʻalae (Hammatt & Chiogioji 2001).

In the early 1800's Kamehameha I used the Kalauhaʻihaʻi area with Queen Kaʻahumanu as the site of their favorite summer resort home. In 1820 Kamehameha conveyed the entire land area

of Niu to his sea captain Alexander Adams. The lands and fishponds of Niu were passed down to the descendants of Captain Adams, many of whom still retain homes in the area.

By 1900 the region was experiencing rapid change with the extension of Kalaniana‘ole Highway. By the middle of the 20th century, agriculture was gradually replaced by successive waves of urban development. The konohiki land owner for Niu (including its fishponds) was the Lucas Family. Mrs. Mary Lucas, through her fisheries manager Bob French managed the fishery carefully and continued the ancient kapu system traditions. There is also oral history that Kalauha‘iha‘i Fishpond was at one time used to raise mullet by Mr. Paiko, the konohiki of the Kuli‘ou‘ou area.

By the early 1960s, new land use changes such as the continued extension of Kalaniana‘ole Highway, military use, and urbanization had erased nearly all traces of the former cultural landscape. The Kupapa Fishpond at Niu and the Wailupe Fishpond at Wailupe had already been filled to make fast land for new housing. Similarly, the nearby great 523-acre fishpond Keahupua O Maunalua was dredged and filled for a planned urban development project called Hawai‘i Kai. The few surviving fishponds of the region, including Kalauha‘iha‘i Fishpond, became private fishponds or residential water features.

Section 3:
Summary of Proposed Actions

He ali`i ka `āina, he kaua ke kanaka (*The land is a chief, people are the stewards*)
-- Mary Kawena Pukui

3. SUMMARY OF PROPOSED ACTIONS

3.1 Kalauhaʻihaʻi Management Plan Development

A management vision, objectives and a set of priority management targets were developed through a strategic planning process by Maunalua Fishpond Heritage Center along with community partners and advisors. These elements were then used to develop specific management strategies and activities.

3.2 Project Vision, Objectives and Management Targets

The Vision for Kalauhaʻihaʻi

> *Kalauhaʻihaʻi Fishpond is thriving, traditions are honored and history is preserved, through a caring community.*

Management Objectives for Kalauhaʻihaʻi
The Maunalua Fishpond Heritage Center aspires to achieve the following objectives to achieve the vision:

- **Restore and sustain the biological health of Kalauhaʻihaʻi Fishpond**
- **Restore community uses and value of fishponds, including cultural & socio-economic values, education and outreach, and scientific study.**

Priority Management Targets are resources or values to be maintained or enhanced.
The priority management targets for Kalauhaʻihaʻi are:

- **Fishpond habitats (aquatic and terrestrial)**
- **Fish**
- **Fishpond infrastructure**
- **Community involvement, kuleana, cultural preservation and stewardship**

3.3 Proposed Management Actions

Five priority strategies were developed to achieve the vision and management objectives for Kalauhaʻihaʻi. Each priority strategy is presented below and has three components: 1) a description of need; 2) desired outcome; and 3) description of activities that will be carried out to achieve the strategy outcome

STRATEGY 1: ENHANCE AND MAINTAIN AQUATIC HABITAT

Description of Need: *Invasive aquatic species, diminished water quality and blockage of fish passage have negatively impacted fish habitat. Eroded sediment and debris cause mortality and loss of habitat for invertebrates and other life. Recovery of the fishpond also requires ongoing monitoring to assess effectiveness of projects to improve biotic and hydrological systems.*

Desired Outcome: Implement priority activities to improve and maintain the condition of fishpond aquatic habitat.

Activity 1.1: Regularly monitor existing populations of alien invasive fish, invertebrates and aquatic plants, and remove those which represent a threat to native fauna and flora. Alien fish and invertebrate species will be removed using hand nets and pole-and-line.

Activity 1.2: Conduct maintenance annually, or as needed to prevent pest species incursions and to maintain water volume. This includes patching leaks in fishpond walls by hand with stone, soil and plants, and eliminating mosquito breeding habitat. Note: links to Activity 4.1.

Activity 1.3: Remove leaf litter, debris, sediment and sand by hand annually or as needed. Recycle materials onsite as mulch or compost as much as possible. No large scale mechanized equipment will be used in or around the pond.

Activity 1.4: Conduct periodic monitoring of water quality and quantity in the pond. This includes measurements of temperature, nutrients, pH, turbidity, salinity, and volume.

Activity 1.5: Build partnerships between agencies and the scientific community for continued hydrological research and monitoring, and if possible, restoration of prior flow volumes.

Activity 1.6: Monitor populations of native aquatic flora and fauna to assess overall pond health. Conduct monthly visual monitoring of the site, and engage volunteers to provide 'citizen science' and learning opportunities.

STRATEGY 2: ENHANCE AND MAINTAIN TERRESTRIAL HABITAT

Description of Need: *Invasive species have displaced native terrestrial species and altered ecosystems. Removal and replanting with appropriate native vegetation is essential to restoring native ecosystems integrity. Rehabilitation will take time due to a persistent (weed) seed bank and slow growth rate of some native plants. Once back in balance, vegetative systems will need to be continuously monitored and maintained by the community.*

Desired Outcome: Rehabilitate and maintain terrestrial habitats at Kalauhaʻihaʻi.

Activity 2.1: Remove invasive, nonnative vegetation. Thus far the site has been cleared by periodically cutting back invasive vegetation and by uprooting smaller shrubs and trees (mostly koa haole saplings). A few medium-sized and larger trees may require removal using a saw.

Activity 2.2: Propagate and outplant species appropriate to Hawaiian fishponds and coastal environments. Plants may also be installed and maintained for educational purposes, scientific studies or erosion control (mulch, thatch/shade, food, habitat, etc.). One project already underway is the installation of 'puʻuohonua' floating plant islands which improve water quality and provide shelter for juvenile fish and invertebrates.

Activity 2.3: Control soil erosion around the fishpond. Although the soils are not highly erodible, best management practices will be employed to minimize erosion from foot traffic. These include establishing dedicated footpath areas around the fishpond, installing stepping stones and borders and barriers along any vulnerable areas, and by ensuring the site remains adequately vegetated.

Activity 2.4: Maintain landscaping through monthly weeding, mulching, watering, replacement of plants lost, and pruning. It will be many years until the seed bank of invasive vegetation is exhausted and native plants well-established, so diligence is required.

Activity 2.5: Monitor populations of native terrestrial flora and fauna to assess overall system health. Conduct monthly visual monitoring of the site, and develop a volunteer monitoring component to provide 'citizen science' and learning opportunities.

STRATEGY 3: MANAGE FISH POPULATIONS

Description of Need: *Recovery of fishponds requires active management of fish populations. Once habitats have been improved, the use of pono (responsible and appropriate) practice actions to stock, enhance and monitor the health of fish are needed to ensure healthy, productive fishponds.*

Desired Outcome: Implement management actions that ensure healthy fish resources.

Activity 3.1 Conduct regular monitoring of fish and invertebrate populations in the fishpond.

Activity 3.2 Develop site-specific management practices that integrate traditional Native Hawaiian and western scientific fishery knowledge and practice to ensure attainment of biological and cultural objectives, including maintaining sustainable yields of fish. Techniques developed at Kalauhaʻihaʻi may prove useful for other fishpond systems of this type. The pond is presently dominated by non-native fish, although there are a few individuals of native species such as ʻawa (milkfish), and āholehole (flagtail) present. Native species that traditionally were grown in fishponds will be added over time. These include oʻopu, (goby), 'ama'ama (striped mullet) and ʻopae (freshwater prawns and shrimp). Additional ʻawa (milkfish), and āholehole (flagtail) will also be added over time as water quality and quantity allow. Introduced species will not be intentionally propagated without securing appropriate review and permits

in advance. Practices will be developed in conjunction with the community and practitioners from other fishponds.

Activity 3.3 Continue to work with other fishpond managers, University of Hawaiʻi, government agencies and others to conduct research and share lessons learned for Kalauhaʻihaʻi. MFHC currently participates in the statewide Hui Mālama Loko Iʻa fishpond management group sponsored by the convening group Kuaʻāina Ulu ʻAuamo. The network offers opportunities for cross-site learning as well as partnering to leverage resources.

STRATEGY 4: MAINTAIN FISHPOND INFRASTRUCTURE

Description of Need: *Maintenance of the pond walls, ʻauwai and mākāhā are required to regulate fish passage and ensure appropriate circulation and tidal influence. Maintaining the existing hydrological connection with the ocean requires seasonal removal of debris and sand deposited by storm waves. Mākāhā will need to be installed or adjusted at appropriate times. Maintenance of fishpond infrastructure also includes erosion control, which is needed to prevent soil from entering the pond and ʻauwai.*

Desired Outcome: Implement a regular maintenance plan and schedule for fishpond structures.

Activity 4.1 Conduct regular monthly checks of fishpond walls, ʻauwai and mākāhā to ensure they are intact and working properly.

Activity 4.2 Clean, repair, replace and otherwise maintain infrastructure monthly or as needed to insure its integrity, control erosion, maintain water circulation, and otherwise ensure fishpond health and site safety. All repairs and maintenance by MFHC to the pond and ʻauwai will be conducted by hand, without the use of mechanized equipment.

Activity 4.3 Develop site best practices and rules of conduct for visitors to preserve traditional fishpond infrastructure.

STRATEGY 5: BUILD COMMUNITY AWARENESS, CULTURAL CONNECTIONS AND CAPACITY FOR SUSTAINED STEWARDSHIP

Description of Need: *Fishponds are best managed with community support and participation. Community management at a local scale is a proven effective strategy for socially-beneficial long-term sustainability of fishponds and is consistent with traditional Hawaiian management systems. When guided by community and supported by partnerships, management is resilient and effective in the long term.*

Desired Outcome: Community awareness is high and community is actively engaged and taking responsibility for stewarding Kalauhaʻihaʻi's natural and cultural resources and maintaining a safe, clean and healthy site.

Activity 5.1: Develop, consult, and periodically convene an advisory body made up of MFHC board members, community members, cultural practitioners, fishers, scientists and others; to provide guidance on best practices and program development.

Activity 5.2: Hold monthly workdays, workshops and other educational events to enable community to be involved in Hawaiian fishpond management and learning, and enhance opportunities for long term engagement. Activities to be conducted with volunteers include alien species removal, planting native plants, monitoring of aquatic and terrestrial habitats, and the management of fish populations. Activities will also include opportunities for learning about traditional Native Hawaiian management of fishponds, and local history such as moʻolelo and place names.

Activity 5.3: Develop and implement a communications and outreach strategy, based on an assessment of future needs to coordinate outreach and engage community.

Activity 5.4: Develop and implement a plan for operations safety and emergency evacuation. Although the activities conducted onsite are relatively low-risk, a safety plan will be developed to establish protocols for safe operations around the pond and shoreline; set requirements for site managers (e.g. first aid/CPR certification), safety briefings and checklists, signage, and safety equipment (e.g. first aid kits, barricades). The plan will also include emergency evacuation procedures.

Activity 5.5: Continue to conduct planning and fundraising as needed to ensure sustainable conservation and protection for Kalauhaʻihaʻi' Fishpond. Items likely to require funding in the future include outreach supplies, shade (e.g., tents), tools, tree-trimming, landscaping materials and fencing, porta-potties, monitoring equipment and solar lighting.

3.4 Evaluation of Management

Periodic evaluation of management will consist of two components: Annual tracking of plan implementation and strategy effectiveness, and a comprehensive review and needs assessment every 5 years or as needed. The components of the Kalauhaʻihaʻi' Fishpond management plan evaluation process are shown in Figure 7.

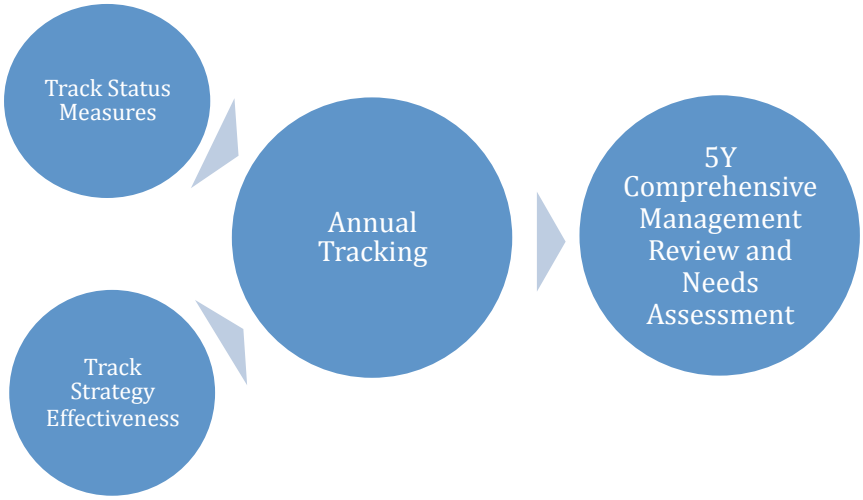


Figure 7. Components of Management Evaluation

Annual Evaluation

Two types of measures will be employed annually to track implementation and measure effectiveness:

1. **Status measures** to evaluate annual outcomes related to the health of the priority resources (Table 1). Measures will for the indicators will be refined as revitalization the fishpond progresses.

2. **Strategy effectiveness measures** to evaluate the impact of the activities on abating threats and achieving broader restoration outcomes (Table 2). Evaluative measures for education and outreach targets (e.g. community capacity and awareness) are included.

Table 1. Proposed Status Measures

Priority Target	Indicator
Fish & Aquatic Invertebrates	Biomass and health of target fish species: *Kuhlia sandvicensis, Mugil cephalus, Chanos chanos, Palaemon debilis*
Aquatic habitat	Structure and food availability
Groundwater	Quantity and quality
Terrestrial habitat	Percentage of target natives; degree of shading, soil stabilization (spatial extent)
Fishpond Structures (auwai, mākāhā, walls)	Condition and functionality

In addition to measuring the response of conservation targets to conservation actions, threat reduction can be evaluated through strategy effectiveness measures, which can also be used to track the progress of the plan overall.

Table 2. Proposed Strategy Effectiveness Measures

Type Measure	Indicator
Soil erosion	Soil loss (spatial extent or volume)
Invasive fish	Abundance & biomass relative to natives
Invasive plants	Abundance & biomass relative to natives
Land-based pollution	Measured levels of nutrients, sediment and detritis
Community awareness and capacity	# community engaged in management. # community participating in cultural/fishpond practices; # community participating in outreach/education activity; #community providing financial support for site management. Core community support for management.
Community partnerships	# of agencies, NGOs, schools and businesses engaged in partnerships

These measures will help to track, refine, and communicate strategic success more effectively from year-to-year.

5-Year Comprehensive Management Review and Assessment of Future Facilities Needs

Additionally, MFHC will periodically conduct a management review to evaluate overall progress, assess future operational needs, and adjust management activities accordingly. Every five years or as needed, MFHC will convene board members, partners and key subject matter experts to conduct a comprehensive management review and needs assessment. Major milestones and other accomplishments will be reviewed, as well as challenges and lessons learned in managing Kalauhaʻihaʻi Fishpond. The management plan will be updated to address gaps in strategies and activities, and incorporate new knowledge and opportunities. The five-year review will also include an assessment of future facilities needs for site operations and educational programming. Should a need for additional facilities, utilities or other development be identified at that time, MFHC will initiate planning and pursue all required Federal, State and County permits and approvals.

3.5 Schedule and Estimated Costs

MFHC is seeking a 30-year, renewable lease. Annual costs for MFHC operations currently are estimated at $60,000.00. This total includes insurance, maintenance, repairs, security, and ongoing education and outreach programming. Approximately 90 percent of annual costs presently are covered through in-kind volunteer labor and other in-kind donations. The remainder is funded through grants and cash contributions from the community.

Annual costs are expected to remain fairly constant, with potential for moderate budget increases in the future to cover site planning, expanded education and outreach efforts and new research projects.

Section 4:
Affected Environment, Potential Impacts, and Mitigation Measures

4. AFFECTED ENVIRONMENT, POTENTIAL IMPACTS AND MITIGATION MEASURES

4.1 Description of the Physical Environment, Potential Impacts, and Mitigation Measures

This section describes existing conditions of the natural environment, potential impacts of the proposed action, and mitigation measures to minimize impacts.

4.1.1 Climate

The climate of the region, similar to other parts of Hawaiʻi, can be characterized as mild, and subtropical. The climate of Niu Ahupuaʻa is consistent with windward portions of Oʻahu. According to the U.S. Climate Data website (2014), average annual temperatures in Honolulu range from 66-89 degrees Fahrenheit. Rainfall is relatively low. According to the NOAA Weather Service website, the Kupaua Valley side of Niu, upland from the project site, receives an average of 37.2 inches of rainfall per year (NOAA, 2015). According to *The Rainfall Atlas of Hawaiʻi* (Giambelluca et al., 2013), a rain gauge located somewhat shoreward of the site at nearby Paiko Drive records an average of just over 31 inches of precipitation per year. Thus it is reasonable to estimate annual rainfall at the Kalauhaʻihaʻi Fishpond site as somewhere between these two levels.

POTENTIAL IMPACTS AND MITIGATION MEASURES

The proposed action is not anticipated to have any negative impacts on regional climate. Micro-climatic effects at the site and vicinity, such as temperature, however, may occur. No mitigation measures are proposed.

4.1.2 Geology and Topography

The Island of Oʻahu was formed by two volcanoes; Koʻolau to the east and the older Waiʻanae, to the west. The volcanoes are believed to have formed during the late tertiary to early Pleistocene periods (MacDonald, Abbott, & Peterson, 1983).

The coastline of Maunalua Bay is chiefly the moderately dissected south slope of the eastern end of the old Koʻolau volcano, now the Koʻolau Range. The valleys generally are short, narrow and steep, widening somewhat at their lower ends, and containing small, steep intermittent streams. (Cox et al., 1963). The east side of Maunalua Bay borders the Koko Rift coastline. The cinder cones of the Koko Rift are among the most obvious row of vents of the Honolulu Volcanic Series (Fletcher, 2005). The coastal extent of this group: Koko Head, Hanauma Bay, and Koko Crater is approximately 6 miles and is essentially an undeveloped and natural shoreline. Ancient wave cut bluffs can be seen above the Niu shoreline, and road cuts along Kalanianaʻole Highway reveal layers of volcanic material mixed with ancient coral reef rubble.

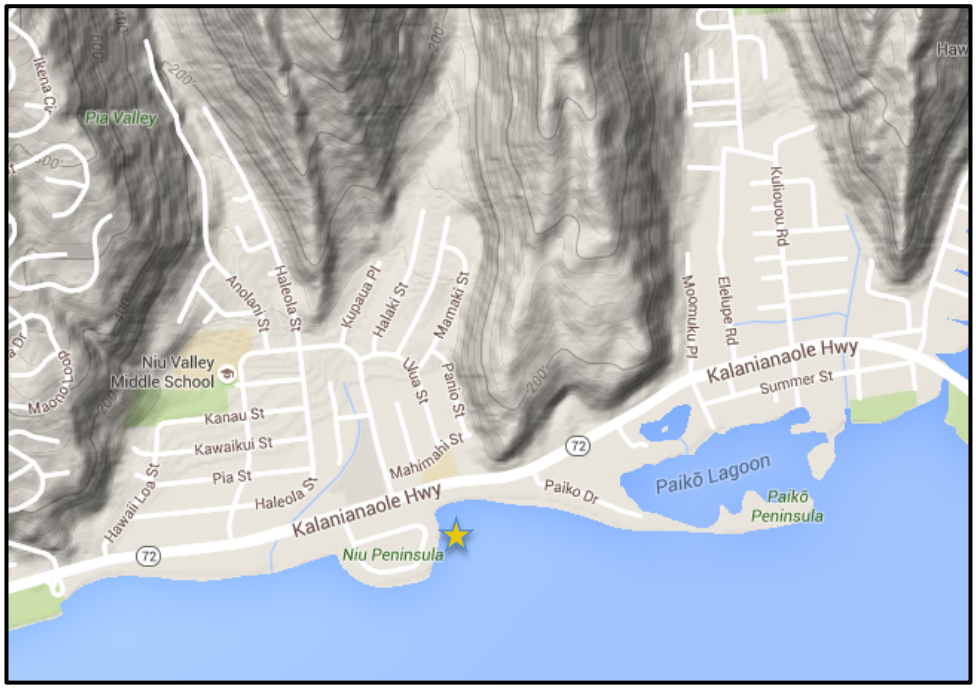
The area that includes Niu Ahupuaʻa is identified by Gill (1989) as a part of the Nuʻuanu Pali portion of the Koʻolau mountain range. The Niu Ahupuaʻa includes Pia, Kulepeamoa and Hawaiʻi Loa ridges to the west and Kalapaomaua and Kuliʻouʻou ridges to the east. Hawaiʻi Loa Ridge and Pia Ridge form Pia Valley, while Kulepeamoa Ridge and Kalapaomaua Ridge form Kupaua Valley. The Kalauhaʻihaʻi Fishpond is located at the foot of Kalapaomaua Ridge.

Topography

The Kalauhaʻihaʻi Fishpond site is nearly flat, sloping very slightly seaward from about a 4 foot elevation above mean sea level (AMSL) to roughly the 1 foot elevation AMSL. Figure 8 is a topographic map.

POTENTIAL IMPACTS AND MITIGATION MEASURES

The proposed action is not anticipated to have any negative effects on geology and topography. No mitigation measures are proposed.



Source: Google Maps

Figure 8. Topographic Map

4.1.3. Soils

There are three soil suitability studies prepared for lands in Hawai‘i whose principal focus has been to describe the physical attributes of land and the relative productivity of different land types for agricultural production; these are:

1) the U.S. Department of Agriculture Natural Resource Conservation Services (NRCS) Soil Survey;

2) the University of Hawai‘i Land Study Bureau (LSB) Detailed Land Classification; and

3) The Department of Agriculture’s Agricultural Lands of Importance to the State of Hawai‘i (ALISH) system.

4.1.3.1 Natural Resource Conservation Service Soil Survey

The NRCS Soil Survey for the Island of O‘ahu, classifies the soils of the site as: Keaau clay (KmA) 0-2%, and Jaucas sand (JaC) 0-15% (Figure 9).

Keaʻau Clay Series 0-2%. About half of the site is on soils identified as Keaʻau series 0-2%. The Keaʻau series are poorly-drained soils well-suited and used for agriculture and pasture, but which have mostly been converted to residential and commercial uses. This soil swells when wetted and shrinks when dried, which creates cracks and unstable conditions for construction over time, but is ideal for fishponds. Organic matter can improve soil tilth. Its sticky nature makes cultivation difficult. Coral bedrock is reached at 20 to 36 inch depth.

Jaucas Series 0-15% soils. About 20% of the site in the makai half of the site is on Jaucas Series 0-15% soils. This is very sandy soil with rapid permeability and very slow runoff. It is found along beaches on Kauaʻi, Oʻahu, Molokaʻi, Lanaʻi, and central Maui. This soils type is used for pasture, sugar cane, truck crops, alfalfa, recreation areas, wildlife habitat and urban development. It has weak physical structure and is generally unsuitable for engineering and construction.

Unclassified: The remaining makai portions of the site (approximately 30% of the site is unclassified and appears to be compacted beach sand.

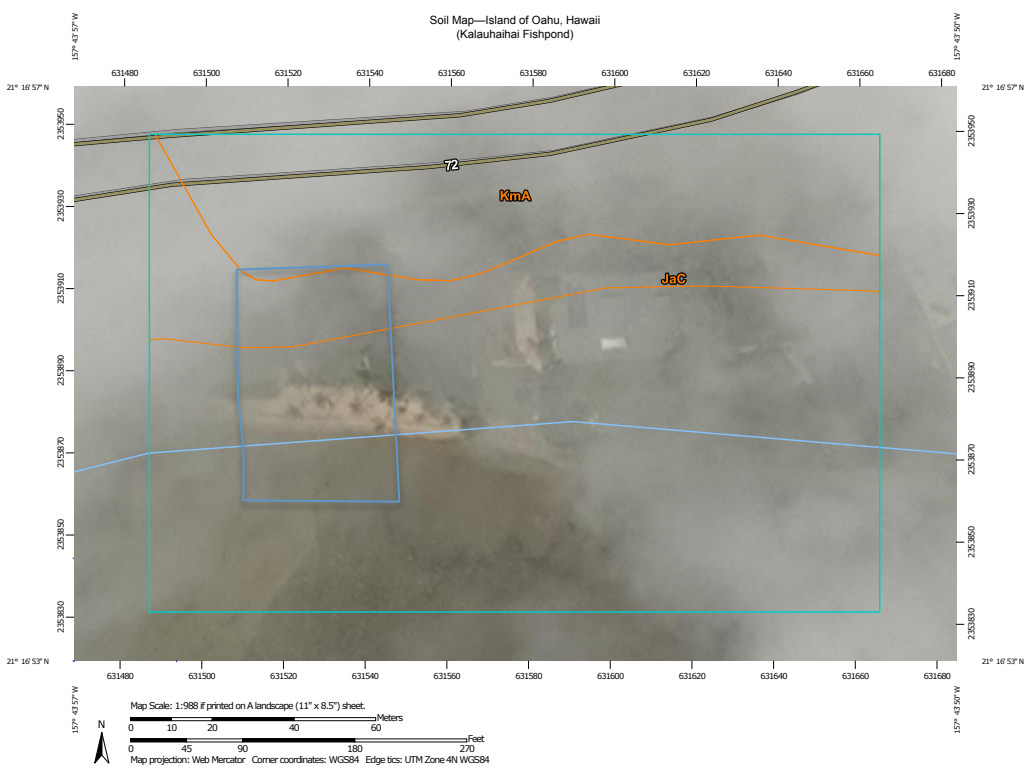


Figure 9. NRCS Soils Map

4.1.3.2 LSB Detailed Land Classification

The University of Hawaiʻi Land Study Bureau document, *Detailed Land Classification, Island of Oʻahu,* classifies soils based on a productivity rating. Letters indicate class of productivity with A representing the highest class and E the lowest. The site is designated as Urban and not classified under the University of Hawaiʻi LSB Detailed Land Classification system. This means that soils at the site are not considered to be suitable land for agriculture, or that the site was already designated within the State Land Use Urban District prior to the study.

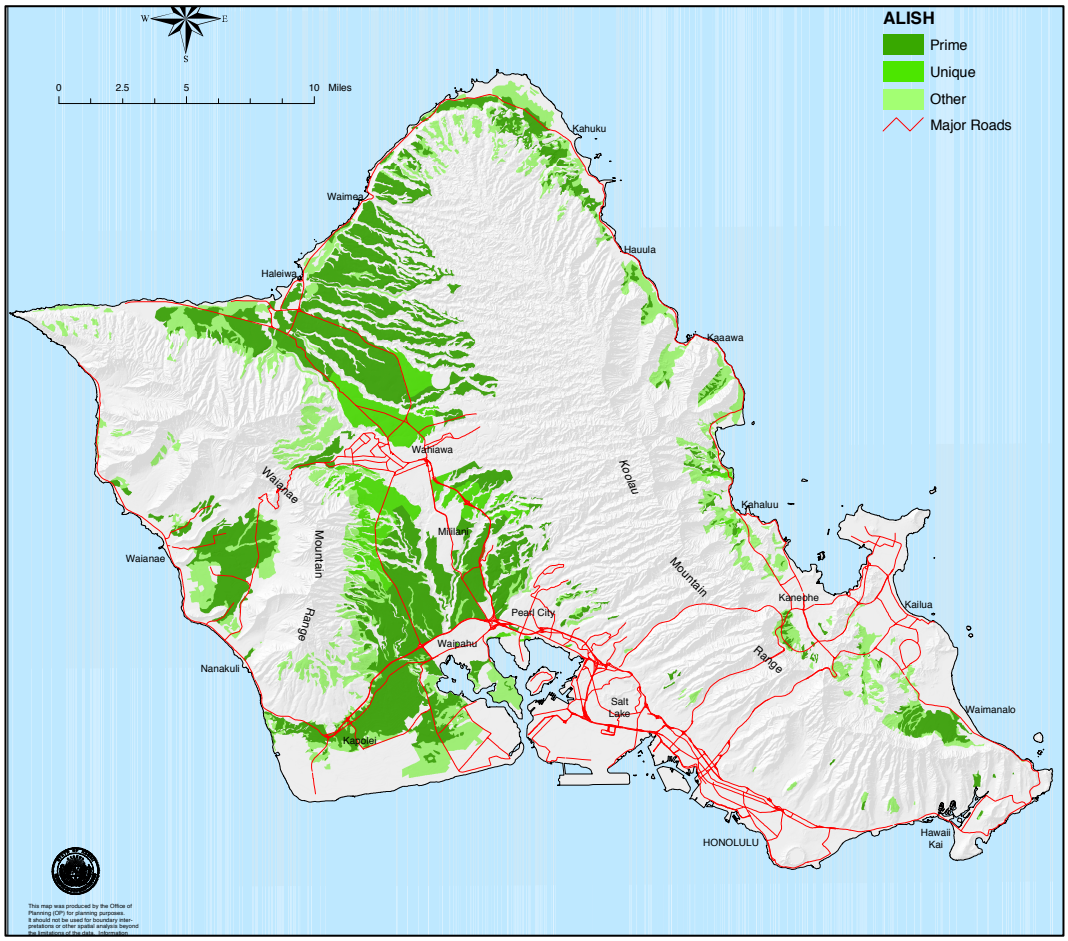
4.1.3.3 ALISH

The Agricultural Lands of Importance to the State of Hawaiʻi (ALISH) classification system is based primarily, but not exclusively, on the soil characteristics, the establishment of criteria for classification of lands, and the inventory system. The ALISH system identifies and maps three broad classes of agricultural land – Prime, Unique, and Other Important Agricultural Land, as well as Unclassified Land. The Site is not classified under the ALISH classification system (Figure 10).

POTENTIAL IMPACTS AND MITIGATION MEASURES

The proposed action will not reduce the inventory of agriculturally significant land. The site has a NRCS capability classification of IIIc, meaning it has severe agricultural limitations if irrigation water is not provided and that the climate is too cold or dry. In addition, the site is not classified under the LSB and ALISH classification system. Potential adverse impacts to the soils of the site include slight potential for soil erosion and the generation of dust during removal of invasive plants and planting of native species. Heavy rainfall could exacerbate erosion of soils in large disturbed areas. However, any affected areas will be very small (less than 25'x50') and best management practices will be incorporated to minimize impacts. BMPs utilized may include the following:

- Using vegetative ground-covers for control of erosion;
- Sprinkling disturbed areas when clearing or planting to prevent dust generation;
- Using stepping stones and weed barrier cloth in high-traffic areas.



Source: State of Hawaii, Office of Planning

Figure 10. ALISH Map of O‘ahu

4.1.4 Hydrogeological Resources

4.1.4.1 Surface Water

The Niu watershed is made up of two sub-basins and has an approximate total area of 2.7 square mi (6.9 square km), with a maximum elevation of 2,500 ft. (762 m).

As previously noted, Hawaiʻi Loa Ridge and Kulepeamoa Ridge form Pia Valley, while Kulepeamoa Ridge and Kalapaomaua Ridge form Kupaua Valley. The streams of both Pia and Kupaua are classified in the Hawaiʻi Watershed Atlas as perennial streams, although year-round subsurface flow commonly occurs. However the streams are hardened (lined with concrete and boulders) and channelized (straightened) in the urban areas, which generally blocks the formation of pools. The two streams join into one channel makai of Halemaumau Street. The consolidated, concrete-lined channel crosses under Kalaniana‘ole Highway and discharges into the ocean. The Kalauhaʻihaʻi Fishpond site is not located adjacent to any of these waterways.

Very little water transits through the property via overland sheet flow (runoff) from rainfall as soils are porous and most water percolates into the soil and sandy substrate, or enters the pond. As noted above, average annual rainfall is estimated to be between 31 and 37.2 inches.

POTENTIAL IMPACTS AND MITIGATION MEASURES

The proposed action will not significantly affect surface waters. No long-term uses that could contaminate surface water are expected to develop as part of the proposed action. The proposed activities will not entail any stream diversions and will not increase the amount of surface runoff. No mitigation measures are proposed.

4.1.4.2 Groundwater

Groundwater discharge has long been known to fringe O‘ahu’s south shores as springs and beach seeps, with many examples mapped and sporadically described since the early works of Stearns and Vaksvik (1935). Groundwater discharge occurs within Kalauha‘iha‘i Fishpond, as well as at its adjacent shoreline and at Kanewai Spring, Paiko Lagoon and from multiple shallow-water (submarine) springs within Maunalua Bay (Figure 11).

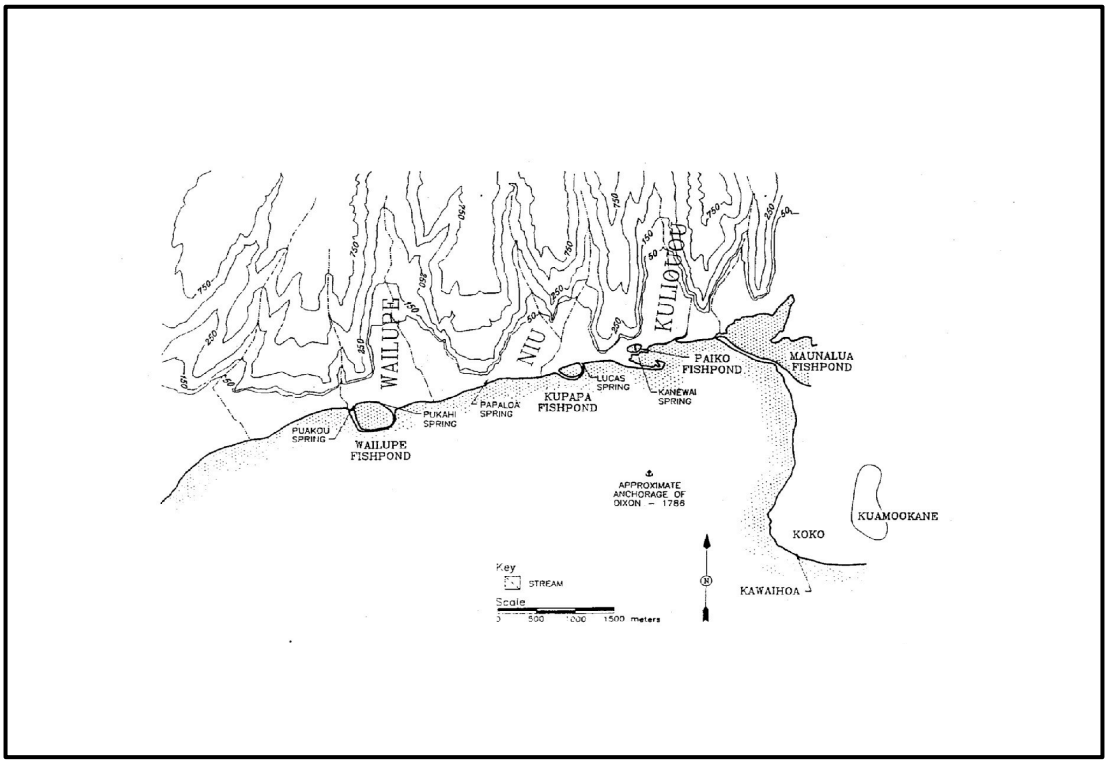


Figure 11. Major Ponds and Springs of the Region Prior to 1950. Corrected spring names from left to right are Punakou, Puhikani, Papa‘alaea
Source: Erkelens and Athens 1994

Groundwater within the general project area exists primarily as basal water floating on salt water (Figure 12). The close proximity of Kalauhaʻihaʻi Fishpond to the ocean results in groundwater levels that are generally controlled by ocean tidal conditions.

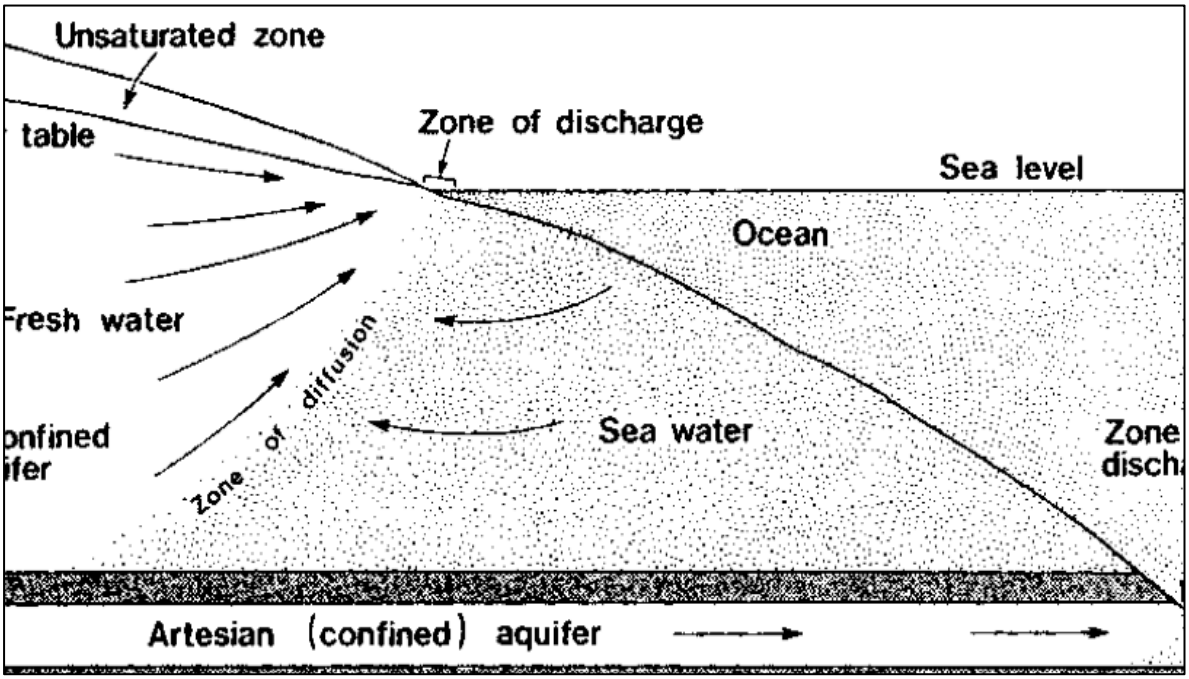


Figure 12. Idealized geologic representation of groundwater flow allowing for SGD
Source: Johannes, 1980

The precise groundwater levels at the project site are unknown, but are likely to vary between -2.0 and 0.0 feet at mean sea level (msl), based upon observed pond level fluctuations.

A road widening project of Kalanianaʻole Highway in 1993 effectively severed the flow of water from the freshwater conduit(s) that fed Kalauhaʻihaʻi Fishpond and allowed an estimated 1 million gallons of groundwater per day to infiltrate into an adjacent sewer line damaged during the construction (Fukunaga and Associates, 2005). The Hawaiʻi Department of Transportation installed several temporary monitor wells to assess declining water levels both mauka and makai during construction and also attempted gel injection to restore pre-widening project flow

but were unsuccessful (Hawaiʻi Commission on Water Resource Management 1995). A City and County of Honolulu rehabiltation project of the sewer line in 2010 improved conditions. University of Hawaiʻi scientist Joseph Kennedy (2011) monitored flows at Kalauhaʻihaʻi Fishpond before and after the sewer rehabilitation project (Appendix 9.4). Kennedy determined that groundwater flow into the impacted Kalauhaʻihaʻi Fishpond increased after the project by about two orders of magnitude. Although the increased spring discharge of 140 m^3 per day only represents about 20% of the historic flow measured at over 200,000 gallons or approximately 750 m^3 per day (Stearns and Vaksvik, 1935), it is still a significant improvement over the prior decades' average flow when the pond was almost completely dry.

POTENTIAL IMPACTS AND MITIGATION MEASURES

The proposed action will not negatively affect groundwater quantity or quality. No long-term uses that could contaminate groundwater are expected to occur as part of the proposed action. Water quality at Kalauhaʻihaʻi Fishpond is generally good and is expected to improve over the long-term as habitat enhancement activities are implemented. Freshwater flows from the fishpond will continue to be conveyed into Maunalua Bay at current levels. No mitigation measures are proposed.

Kalauhaʻihaʻi Fishpond Before (above) and After (below) Sewer Line Repairs
(Residence removed by DLNR in 2017)

Flow to ocean before highway widening

Flow before highway widening

Flow to ocean after sewer line repair restored partial flow

4.1.4.3 Coastal Waters

The adjacent waters of Maunalua Bay are designated as Class A (Hawaiʻi DOH). According to the State of Hawaiʻi, DOH, HAR 11-54, *Water Quality Standards*

> "It is the objective of class A waters that their use for recreational purposes and aesthetic enjoyment be protected... these waters shall not act as receiving waters for any discharge which has not received the best degree of treatment or control compatible with the criteria established for this class".

POTENTIAL IMPACTS AND MITIGATION MEASURES

The proposed action will not significantly affect coastal water quality. No long-term uses that could impair coastal waters are expected to occur as part of the proposed action. Although a long-term water quality data series has yet to be established for Kalauhaʻihaʻi Fishpond, short term monitoring data indicates temperature, dissolved oxygen, and nutrient parameters are adequate to support aquatic life. Freshwater flows from the fishpond will continue to be conveyed into Maunalua Bay at current levels, maintaining estuarine habitat. No discharges of sediment or pollutants to marine waters will occur. Occasional turbidity will occur within the pond during maintenance. However, turbidity will be minimized by employing best practices such as removing sediment and detritis by hand with dip nets and buckets, limiting efforts to a small portion of the pond at one time, and conducting maintenance during periods when surf is small. The pond is small (368 square meters) in area and has a hard limestone bottom, therefore resident volumes of detritus and sediment tend to be small. Because of these factors, the amount of turbidity typically generated during maintenance is very low. Additionally, the low velocity, low volume flow in the ʻauwai lacks sufficient energy to convey suspended materials, so as water moves from the pond through the ʻauwai during low tide, suspended solids settle in the ʻauwai channel and are easily removed.

4.1.5 Natural Hazards

O‘ahu is susceptible to potential natural hazards, such as flooding, tsunami inundation, hurricanes, earthquakes, and wildfires. This section provides an analysis of the site’s vulnerability to such hazards.

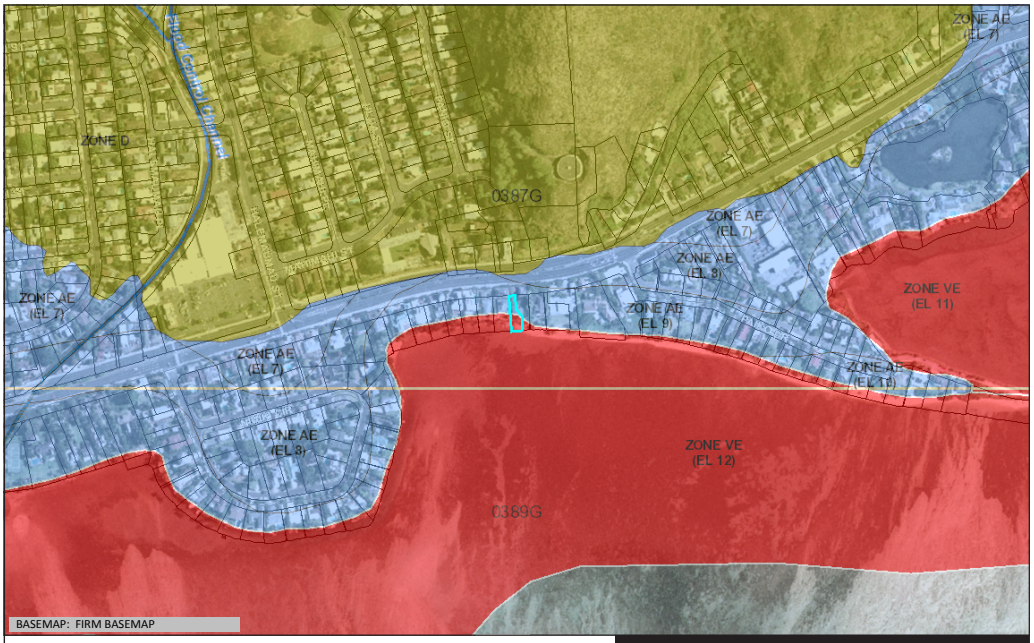
The State of Hawai‘i Department of Defense, Emergency Management Agency (formerly Office of Civil Defense) operates a system of civil defense sirens throughout the State to alert the public of emergencies and natural hazards, particularly tsunamis and hurricanes. The closest existing siren is OA104, at 6505 Kalaniana‘ole Highway, which is located approximately 0.5 miles (east) of the site. The nearest Public Emergency Shelter is Niu Valley Intermediate School, approximately 0.6 miles away. (http://www.scd.hawaii.gov/documents/2011%20Public%20Emergency%20Shelters.pdf). Potential impacts and mitigation measures for all natural hazards are considered below, following section 4.1.5.4.

4.1.5.1 Flood

Based on information provided by the State Department of Land and Natural Resources Flood Hazard Assessment Tool (http://gis.hawaiinfip.org/fhat/) according to the Flood Insurance Rate Map (FIRM) prepared by the Federal Emergency Management Agency (FEMA), National Flood Insurance Program, the site is located in Zone AE and VE, (Figure 13).

> **Zone AE** is the flood insurance rate zone corresponds to the 1-percent annual chance floodplains that are determined in the Flood Insurance Study by detailed methods of analysis. Base Flood Elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

> **Zone VE** is the flood insurance rate zone that corresponds to areas within the 1-percent annual chance coastal floodplain that have additional hazards associated with storm waves. Base Flood Elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone.



Flood Hazard Assessment Report

www.hawaiinfip.org

Flood map

Property Information

COUNTY:	HONOLULU
TMK NO:	(1) 3-7-002:018
WATERSHED:	NIU
PARCEL ADDRESS:	5839 KALANIANAOLE HWY HONOLULU, HI 96821

Notes:

Flood Hazard Information

FIRM INDEX DATE:	NOVEMBER 05, 2014
LETTER OF MAP CHANGE(S):	NONE
FEMA FIRM PANEL:	15003C0387G
PANEL EFFECTIVE DATE:	JANUARY 19, 2011

THIS PROPERTY IS WITHIN A TSUNAMI EVACUTION ZONE: YES
FOR MORE INFO, VISIT: http://www.scd.hawaii.gov/

THIS PROPERTY IS WITHIN A DAM EVACUATION ZONE: NO
FOR MORE INFO, VISIT: http://dlnreng.hawaii.gov/dam/

0 400 800 ft

Disclaimer: The Hawaii Department of Land and Natural Resources (DLNR) assumes no responsibility arising from the use, accuracy, completeness, and timeliness of any information contained in this report. Viewers/Users are responsible for verifying the accuracy of the information and agree to indemnify the DLNR, its officers, and employees from any liability which may arise from its use of its data or information.

If this map has been identified as 'PRELIMINARY', please note that it is being provided for informational purposes and is not to be used for flood insurance rating. Contact your county floodplain manager for flood zone determinations to be used for compliance with local floodplain management regulations.

FLOOD HAZARD ASSESSMENT TOOL LAYER LEGEND
(*Note: legend does not correspond with NFHL*)

SPECIAL FLOOD HAZARD AREAS (SFHAs) SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD - The 1% annual chance flood (100-year), also know as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. SFHAs include Zone A, AE, AH, AO, V, and VE. The Base Flood Elevation (BFE) is the water surface elevation of the 1% annual chance flood. Mandatory flood insurance purchase applies in these zones:

- **Zone A**: No BFE determined.
- **Zone AE**: BFE determined.
- **Zone AH**: Flood depths of 1 to 3 feet (usually areas of ponding); BFE determined.
- **Zone AO**: Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined.
- **Zone V**: Coastal flood zone with velocity hazard (wave action); no BFE determined.
- **Zone VE**: Coastal flood zone with velocity hazard (wave action); BFE determined.
- **Zone AEF**: Floodway areas in Zone AE. The floodway is the channel of stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without increasing the BFE.

NON-SPECIAL FLOOD HAZARD AREA - An area in a low-to-moderate risk flood zone. No mandatory flood insurance purchase requirements apply, but coverage is available in participating communities.

- **Zone XS (X shaded)**: Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.
- **Zone X**: Areas determined to be outside the 0.2% annual chance floodplain.

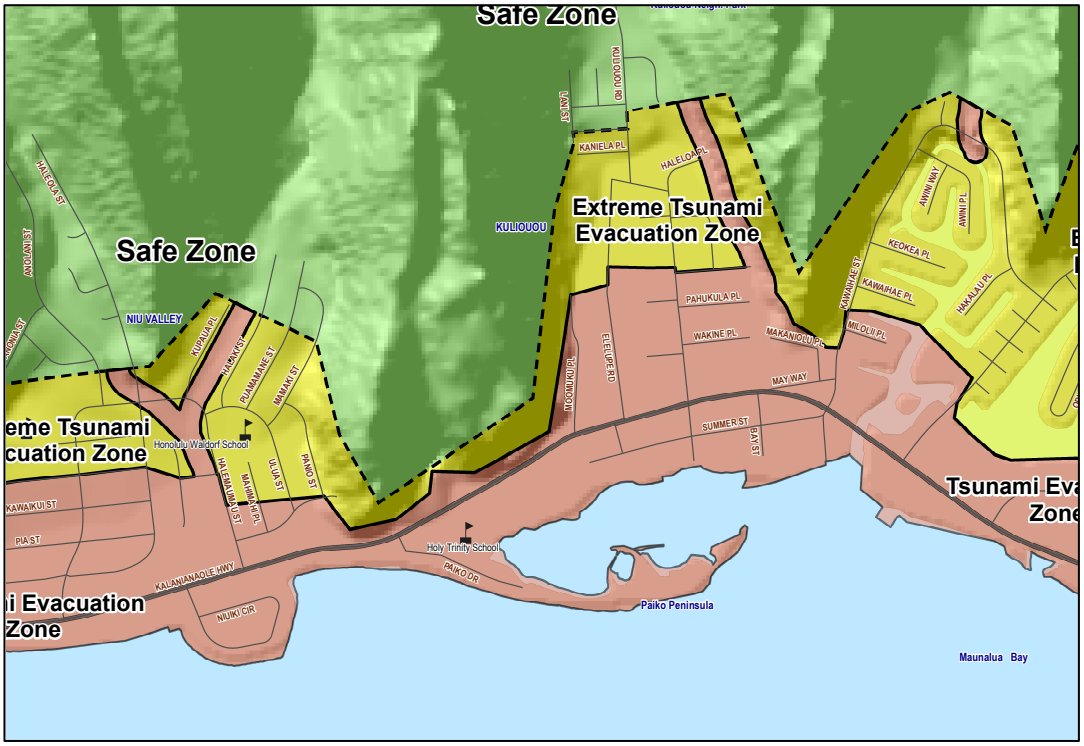
OTHER FLOOD AREAS

- **Zone D**: Unstudied areas where flood hazards are undetermined, but flooding is possible. No mandatory flood insurance purchase apply, but coverage is available in participating communities.

Figure 13. State Flood Hazard Map

4.1.5.2 Tsunami

Since the early 1800s, approximately 50 tsunami have inundated the State of Hawai‘i’s shores. Seven historical events have caused major damage in the State. According to the FEMA FIRM, the Site is in the tsunami zone. The City and County of Honolulu Department of Emergency Management (DEM) Tsunami Evacuation Map for the site and surrounding area is shown as Figure 14.



Source: City and County of Honolulu

Figure 14. DEM Evacuation Map

4.1.5.3 Hurricane

Hurricanes are classified into one of five categories according to the Saffir-Simpson Hurricane Scale. This scale provides some indication of the potential damage and flooding a hurricane will cause upon landfall. Since 1980, two hurricanes have had a devastating effect on Hawai‘i. They were Hurricane ‘Iwa in 1982 (Category 1- sustained winds between 75–95 mph) and Hurricane ‘Iniki in 1992 (Category 4 - sustained winds between 131–155 mph). In both instances, much of

the damage sustained on O‘ahu occurred along the Wai‘anae Coast as the hurricanes passed between the islands of Kaua‘i and O‘ahu. However as shown below, storm surge from Hurricane Iniki at Kalauha‘iha‘i resulted in wave runup as far as 25 ft. inshore. While it is difficult to predict such natural occurrences, it is reasonable to assume that future incidents are likely, given historical events.

Storm wave runup during Hurricane ‘Iniki in 1992.

4.1.5.4 Earthquake

In Hawaiʻi, most earthquakes are linked to volcanic activity, unlike other areas where a shift in tectonic plates is the cause of an earthquake. Each year, thousands of earthquakes occur in Hawaiʻi, the majority of which are detectable only with highly sensitive instruments. However, moderate and disastrous earthquakes have occurred in the islands in the past. The largest recorded earthquake in the state (magnitude 7.9) occurred in 1868 on Hawaiʻi Island. The largest earthquake within the past decade occurred on October 15, 2006 with a moment magnitude of 6.7 and a maximum Mercalli intensity of VIII (Severe). Major damages were reported from Hawaiʻi island, but damages on Oʻahu were minor and mainly confined to the western portion of the island.

POTENTIAL IMPACTS AND MITIGATION MEASURES

The proposed action will not increase the site's exposure to, or vulnerability to, any natural hazard. The site is located in the flood zone and in the designated tsunami evacuation zone and is at a low elevation. Therefore it is possible that the site will be affected should there be a tsunami or earthquake. Should there be a hurricane, the potential impact of destructive winds would likely be minimal as the site is vacant except for a storage shed near the highway. However soil erosion, and other damage from storm surge are possible. MFHC will retain the current vegetative buffer of native pōhuehue and naupauka on the seaward side of the property to protect against storm surge. As described in Section 3, Activity 5.4, MFHC also will develop site safety and emergency evacuation procedures to ensure readiness for disasters.

4.1.6 Biological Environment

4.1.6.1 Groundwater Dependent Ecosystems

Groundwater-dependent ecosystems and species (collectively termed GDEs) are defined by Murray et al. (2006) as ecosystems whose ecological structure and function depends on access

to groundwater. Groundwater provides a vital source of water and creates essential habitat conditions for a broad range of species and ecosystems in Hawaiʻi. Groundwater input into ponds and streams creates refuges of cool water that are critical during hot summer months. Some ecosystems, such as springs, receive no other water except groundwater. Good water quality, essential to the survival of fish, mollusks and other aquatic species, can be provided by groundwater. Unfortunately, no systematic inventory of GDEs in Hawaiʻi has occurred; meanwhile the pressures on groundwater are increasing as human activities alter its supply, flow pattern, and quality.

Multiple types of GDEs occur in the Maunalua region, including springs, wetlands, brackish and freshwater pools, and fishponds. Less than 1 km away from the Kalauhaʻihaʻi Fishpond are the Kanewai Spring (with an estimated flow of up to 840,000 gallons/day), the ancient Kanewai Fishpond, and the 33-acre coastal estuary and wetland of Paiko Lagoon Wildlife Sanctuary and associated Kuliʻouʻou Stream. These sites exhibit similar biological and hydrological attributes and connectivity. Understanding groundwater systems is critical to good management, although identifying and mapping groundwater-dependent ecosystems can be challenging. Groundwater flow paths are often complex; data and information are limited, difficult to collect, and highly technical; and in-depth study and analysis can be expensive. Nonetheless, developing partnerships with the scientific community to conduct geo-hydrological investigations will continue to be a priority for MFHC.

POTENTIAL IMPACTS AND MITIGATION MEASURES

Impacts to groundwater dependent ecosystems (springs and ponds) are expected to be positive. These include improvements to water quality, increased populations of native fish and plants. and improvements to terrestrial and aquatic habitat quality. No negative impacts are anticipated. No mitigation measures are proposed.

4.1.6.2 Flora

A botanical inventory of the Kalauhaʻihaʻi Fishpond site was conducted by Danielle Frohlich, M.S., in one day in February of 2016 during dry weather (Appendix 9.3). The survey included all terrestrial vegetated portions of the parcel, including the beach areas, and the visible areas of the fishpond.

At Kalauhaʻihaʻi Fishpond nearly all the plant species found by Dunn (2009) were observed, plus several additional native and non-native species. All species found are listed in Table 3.

Although Kalauhaʻihaʻi Fishpond hosts a few robust natives including naupaka kahakai (*Scaevola taccada*), and pōhuehue (*Ipomoea pes-caprae*), it clearly had been over-run with non-native species, in particular, koa haole (*Leucaena leucephala*).

A total of 6 native species and 35 non-native species were observed. The 6 native species that were encountered were aeʻae (*Bacopa monnieri*), niu (*Cocos nucifera*), pōhuehue (*Ipomoea pes-caprae*), moa (*Psilotum nudum*), naupaka kahakai (*Scaevola taccada*), and milo (*Thespesia populnea*). None of these species is threatened or endangered. No endemic species were found.

Table 3: Inventory of plant species found at Kalauhaʻihaʻi Fishpond

Scientific Name	Common Name	Status
Ageratum conyzoides	Chickweed, goat weed	N
Alysicarpus vaginalis	Alyce clover, white moneywort	N
Amaranthus spinosus	Amaranth, spiny	N
Amaranthus viridis	Amaranth, pigweed, `aheahea, pakai	N
Andropogon virginicus	Broomsedge bluestem	N
Artocarpus altilis	Breadfruit, ulu	C
Asystasia gangetica	Chinese violet	N
Bacopa monnieri	Aeʻae, dwarf bacopa, water hyssop	I
Bidens pilosa	Spanish needle	N
Brachiaria mutica	Para grass, buffalo grass	N
Cenchrus cilaris	Buffel grass	N
Citrus reticulate	Tangerine	C
Coccinia grandis	Ivy gourd	N
Cocos nucifera	Niu, coconut	I
Conyza bonariensis	Fleabane	N
Cordyline fruticosa	Ki, Ti	C
Cynodon dactylon	Bermuda grass	N
Cyperus rotundus	Purple nut sedge	N
Desmanthus pernambucanus	Slender or virgate mimosa	N
Desmodium incanum	Spanish clover, ka'imi	N
Euphorbia hirta	Athsma plant	N
Ficus microcarpa	Chinese banyan	N (invasive)
Ficus carica	Common fig	C
Hyptis suaveoleus	Pignut, chan	N
Ipomoea pes-caprae	Pohuehue	I
Jatropha integerrima	Jatropha	C
Leucaena leucocephala	Koa haole, leucaena	N (Invasive)
Oxalis corniculata	Creeping wood sorrel	N
Passiflora foetida	Passion flower	N
Pluchea indica	Indian pluchea, Indian fleabane	N
Portulaca oleracea	Common purslane	N
Psilotum nudum	Moa	I
Richardia scabra	Rough Mexican clover	N
Scaevola taccada	Naupaka kahakai, beach naupaka	I
Schefflera actinophylla	Octopus tree, schefflera	N
Solanum americanum	Glossy/American nightshade, popolo	N
Sphagneticola trilobata	Wedelia	C
Stenotaphrum secundatum	St. Augustine grass	C
Thespesia populnea	Milo, portia tree	I
Urochloa maxima	Guinea grass	N
Youngia japonica	Japanese hawkweed	N

I=indigenous (native); C=cultivated; N=naturalized

Of the non-native species, seven species that were encountered are Polynesian introductions or other cultivated species, and 28 species are non-native, non cultivated plants that are naturalized. Three of these latter, naturalized species tend to be more invasive than others, often altering the habitat and crowding out native plants and animals. They are:

- Koa haole (*Leucaena leucocephala*). This species has been identified by the IUCN as one of the 100 world's worst invasive alien species (Lowe et al., 2000)
- Chinese banyan (*Ficus microcarpa*)
- Ivy gourd (*Coccinia grandis*)

Some other aggressive and potentially invasive species found at Kalauhaʻihaʻi Fishpond were:

- Guinea grass (*Urochloa maxima*)
- Bermuda grass (*Cynodon dactylon*)
- Indian pluchea (*Pluchea indica*)
- Octopus tree (*Schefflera actinophylla*)
- Nut sedge (*Cyperus rotundus*)

POTENTIAL IMPACTS AND MITIGATION MEASURES

The proposed management activities will not affect any endangered or threatened plant species, as none are known to be present at the pond or surrounding area. Management efforts will be made to retain any native species found, and to incorporate additional traditional fishpond plants into the landscape.

4.1.6.3 Fauna

The terrestrial portions of the site are home to mostly non-native wildlife, such as introduced birds. The occasional red crested cardinal (*Paroaria coronata*), Northern red cardinal (*Cardinalis cardinalis*), common mynah (*Acridotheres tristis*), cattle egret (*Bubulcus ibis*), red-whiskered bulbul (*Pycnonotus jocosus*), and feral mallard ducks (*Anas platyrhynchos*) are seen for short periods at a time, and a ring-necked pheasant (*Phasianus colchicus*) began residing at the pond in February 2017. The native aukuʻu (*Nycticorax nycticorax*) is also an occasional visitor. No birds were recently observed along the shoreline, although the beach habitat could potentially support shorebirds such as sanderlings and ruddy turnstones. Introduced mammals such as cats, mongoose, rats and mice were not seen but are likely to exist in the area. MFHC scanned the U.S. Fish and Wildlife Service surveys of Critical Habitats using the State of Hawaiʻi GIS database (2015) and USFWS website (2015), and found no critical habitats appeared within the project site.

An inventory of the aquatic fauna of the pond was conducted by Keoki Stender (Appendix 9.1) in December 2013. He noted that non-native cichlid species including black-chin tilapia / salt-water tilapia (*Sarotherodon melanotheron*), and Mozambique tilapia (*Oreochromi mossambicus*), dominate the pond. Only a few individuals of two native fish species were found in the pond. These were āholehole (*Kuhlia sandvicensis*), and awa (*Chanos chanos*). The only invertebrate fauna seen were invasive introduced red-rim melania snails (*Melanoides tuberculata*).

POTENTIAL IMPACTS AND MITIGATION MEASURES

No negative impacts to native fauna are expected to result from the proposed action. There are no known native terrestrial vertebrates onsite other than the occasional aukuʻu (*Nycticorax nycticorax*). Non-native, invasive fish and invertebrates which now dominate the fishpond will be gradually removed. Native species that traditionally were grown in fishponds will then be added as conditions and availability allow. These include oʻopu (various goby species), ʻamaʻama (*Mugil cephalus*) and ʻopae huna (*Palaemon debilis*). Additional awa (*Chanos chanos*)

and āholehole (*Kuhlia sandvicensis*) may also be added as appropriate. Introduced species will not be intentionally propagated unless appropriate review and permits are secured in advance (Management Strategy 3).

4.1.7 Air Quality and Noise

4.1.7.1 Air Quality

Air quality in the vicinity of the site is generally good. The State of Hawaiʻi is in attainment with all National Ambient Air Quality Standards (NAAQS). The NAAQS have been established for man-made sources of pollution. At times air quality is reduced as a result of an increase in sulfur dioxide (SO_2) emissions from Kīlauea Volcano, located on the island of Hawaiʻi. Kīlauea Volcano is recognized as the largest point source of SO_2 gas in the United States. Seasonal winds carry emissions from Kīlauea in the direction of the site. The volcanic gases or "vog" can result in an increase in pollution, a decrease in visibility and can impair the health of sensitive individuals. Vog increased dramatically in 2018 when a new eruption began. Emission estimates increased to 5,000 – 14,000 tons per day (TPD) of SO_2, in contrast to previous average emission of 1,700 TPD.

POTENTIAL IMPACTS AND MITIGATION MEASURES

The proposed action is not expected to result in changes that exceed any State or Federal air quality standards in the long or short term. Long-term air quality impacts due to the proposed action are not expected. On a localized, very small scale, air quality in the area may be affected by dust. Some BMPs that can be utilized for dust control are:

- Using ground-covers and planting bare soil areas;
- Sprinkling disturbed areas with water when clearing, digging or planting to minimize airborne dust;
- Using stepping stones and weed barrier cloth in high-traffic areas.

A combination of these will be implemented as needed.

4.1.7.2 Noise

Community Noise Control regulations (HAR Title 11, Chapter 46) establish maximum permissible sound levels for construction activities occurring within three "acoustical" zoning districts. The site and surrounding areas are in the Class B acoustical zoning district, which limits maximum permissible daytime noise (7:00 AM-10:00 PM.), to 60 dB(A) and nighttime noise (10:00 PM-7:00 AM) to 50 dB(A). Any noise source that emits noise levels in excess of the maximum permissible sound levels cannot be operated without first obtaining a noise permit from the DOH. Although the permit does not attenuate noise, it regulates the hours during which excessive noise is allowed.

Current sources of noise in the vicinity of the site include vehicular traffic on Kalaniana'ole Highway, and typical everyday residential activities. Because the MFHC will be hosting work days and events for school groups and others at work days on a monthly basis, a slight increase in noise during these times is expected.

POTENTIAL IMPACTS AND MITIGATION MEASURES

The project is expected to produce short-term slight increases in noise levels during work days and events. MFHC holds an average of 2 workdays/events per month, with the greatest number occurring in the summer months. Events typically are from 2 to 4 hours in length and average group size is 20 or fewer. Noise generated will include that of people talking during orientations, educational events and work sessions, and occasional noise from power tools and a small generator used to run them. Exposure to noise is expected to vary by activity. However noise levels will not exceed those normally encountered in an urban area (lawnmowing, hedge-trimming, etc.) and will not exceed allowable levels under County regulations. It should also be noted that the 'ambient' noise level of vehicular traffic on Kalaniana'ole Highway is significantly

greater than noise generated by MFHC workdays. Maintenance work, educational events, scientific study activities, and 'open house' events will be scheduled during daytime hours (7:00 AM-10:00 PM), as described in HAR Title 11, Chapter 46. MFHC may additionally employ noise-blocking measures such as installing hedges to minimize noise impacts. To the extent possible, the noisiest activities will be scheduled during midday and/or on weekends to minimize nuisance to neighbors. MFHC also will work closely with the immediate neighbors to inform them if loud activity is anticipated, and obtain feedback.

4.2 Description of the Human Environment, Potential Impacts, and Mitigation Measures

This section describes the existing conditions of the human environment, potential impacts of the proposed actions, and preliminary mitigation measures to minimize any impacts.

4.2.1 Archaeological, Historic and Cultural Resources

A field inspection of the project area was conducted in spring of 2016 by Cultural Surveys Hawaiʻi (Appendix 9.2). One potential cultural resource was identified: Kalauhaʻihaʻi Fishpond and its associated fishpond features. Feature 1 consists of a basalt stone and mortar kuapā marking the limits of and partially enclosing the freshwater pond. Feature 2 consists of a basalt stone and mortar ʻauwai and the concrete remnants of a double mākāhā. Additionally, one subsurface cultural resource initially documented by Putzi et al. (1998) is located in the immediate vicinity of the project area.

Fieldwork was primarily focused on the inspection and documentation of the existing loko puʻuone (nearshore fishpond fed by both fresh and salt water) and associated features, including a basalt stone and mortar kuapā (wall), a basalt stone and mortar ʻauwai (channel or ditch), and concrete posts for a double mākāhā (sluice gate). Work also included a visual surface inspection of the adjacent SIHP # -5084.

Generally, fieldwork included a visual inspection of the entire project area in order to identify any previously undocumented cultural resources. The field inspection began at the northeast corner of the project area along Kalaniana‘ole Highway, immediately adjacent to SIHP # -5084. SIHP # -5084 consists of a subsurface human burial (MNI: 1) and associated burial pit (Putzi et al. 1996f in Putzi et al. 1998:55). The recovered human skeletal remains associated with SIHP # -5084 were “returned to representatives of the State Historic Preservation Division (SHPD) Burials Program of the Department of Land and Natural Resources.” These remains have since been relocated (Putzi et al. 1998:109). Visual surface inspection indicated SIHP # -5084 was located immediately northeast of the project area, within the makai sidewalk easement of Kalaniana‘ole Highway.

The northern boundary of the project area runs parallel to the southern (makai) edge of the sidewalk easement, and is slightly elevated from the adjacent Kalaniana‘ole Highway. The existing garage structure occupies the northwest corner of the project area. Extending south (makai) from the garage structure, a set of stairs leads into the interior portion of the project area. When viewed from the foot of these stairs, Kalaniana‘ole Highway and its sidewalk easement are elevated approximately 2.5 to 3 m above the interior portion of the project area, including Kalauha‘iha‘i Fishpond.

Kalauha‘iha‘i Fishpond consists of two features. Feature 1 is a basalt stone and mortar kuapā (wall) running the perimeter of the pond, and partially enclosing a surface area of 368 sq m. Basalt boulders and cobbles were utilized in the construction of the wall. The kuapā is four courses high and varies in height from 105 cm in its southwest (makai, ‘Ewa) section, 100 cm in its southeast (makai, Koko Head) section, 130 cm in its northwest (mauka, ‘Ewa) section, and 120 cm in its northeast (mauka, Koko Head) section (Figures 15-17). A portion of the northeast (mauka, Koko Head) section of the kuapā is capped with concrete material mixed with subangular aggregate; this concrete cap is approximately 4 cm thick. During the field inspection, two members of Maunalua Fishpond Heritage Center, Ms. Alyssa Miller and Mr. Chris Cramer, informed CSH that the fishpond wall had been constructed prior to the ownership of the property by Mr. Tad Hara in the early 1970s.

Figure 15. General view of Kalauhaʻihaʻi Fishpond wall, view to northeast

Figure 16. General view of ‘auwai, view to north.
Note: residential structure was removed by DLNR

A 104-cm wide gap was observed along the southern (makai) portion of the fishpond. This gap marks the northern limits of Feature 2, a basalt stone and mortar ʻauwai and concrete posts for a double mākāhā. This gap also marks the location of the northern (mauka) mākāhā. The northern mākāhā consists of two concrete posts constructed directly into the basalt stone and mortar kuapā, and located on both the eastern (Koko Head) and western (ʻEwa) sides of the gap (Figures 18 & 19). These posts are designed to secure a wooden vertical slide gate. The northern mākāhā measures approximately 82 cm high, with its concrete posts measuring approximately 30 cm wide and 8 cm deep. The northern mākāhā also marks the northern end of the basalt stone and mortar ʻauwai. This ʻauwai is approximately 12.35 m in total length. The ʻauwai walls are approximately 30 cm wide, with an approximately 4 cm thick concrete cap. The northern portion of the ʻauwai measures approximately 90 cm high and appears to have been built in two separate phases. The lower courses, measuring three courses high, appear to represent an older phase of ʻauwai construction. The upper courses, measuring two courses high, appear to have been a more recent addition. The interior width of the ʻauwai varies between 90-104 cm (Figure 16). The ʻauwai appears to represent an ʻauwai kai (sea gate) due to its sloping nature and decrease in height near its southern (makai) end. In its central portion, the ʻauwai walls measure approximately 65-68 cm high. At its southern (makai) end, the ʻauwai walls measure approximately 36 cm high. The southern end of the ʻauwai also marks the location of the southern (makai) mākāhā. The southern mākāhā consists of concrete post remnants. The extent (height) of these posts could not be determined due to sediment and overgrowth of naupaka, pōhuehue, and koa haole. These posts measure approximately 35 cm long and 20 cm wide, with a 3 cm deep groove designed to hold a wooden vertical slide gate. Loose basalt cobbles were also observed in the vicinity of the southern mākāhā. The two mākāhā and ʻauwai possibly represent "a more recent innovation (introduced by Chinese immigrants in the mid-1800s) . . . of a double mākāhā, two parallel grates set a few feet apart in a fishpond wall, which permitted the trapping of fish between the grates and allowed for easier harvesting by small hand nets" (Apple 1975 in Keala et al. 2007:11).

Ms. Miller and Mr. Cramer also informed CSH of the location of a spring known to feed freshwater into the walled pond. Upon examination of the northwest (mauka, ʻEwa) section of

the fishpond, CSH identified the partially infilled spring responsible for feeding freshwater into the pond (Figure 20). The inlet measures approximately 80 cm in diameter.

Figure 17. Southwest (makai, ‘Ewa) section of fishpond, view to southwest

Figure 18. Northern (*mauka*) *mākāhā*, view to northwest

Figure 19. Northern (*mauka*) *mākāhā*, view to northeast

Figure 20. Location of the spring (marked by photo scale) supplying freshwater to Kalauhaʻihaʻi Pond, view to north

Ms. Miller and Mr. Cramer also noted that Mr. Hara had previously identified the lava tube conduit that fed directly into the pond. According to Ms. Miller and Mr. Cramer, Mr. Hara had stated that the lava tube was large enough to fall into, and thus he was prompted to mark the circumference of the lava tube (or spring) with stones. During field inspection, CSH identified the location of the lava tube conduit damaged during Kalaniana‘ole Highway widening construction. The lava tube conduit responsible for feeding the Kalauha‘iha‘i Pond spring was observed on the north (mauka) side of Kalaniana‘ole Highway, approximately 40 m from the project area; a large bougainvillea tree and stand of koa haole (*Leucaena leucocephala*) currently marks the original location of the lava tube conduit.

Kalauha‘iha‘i Pond may be considered a historic property/cultural resource as it is the only intact shoreline fishpond in Honolulu, besides nearby Kanewai Fishpond. The potential for the fishpond to yield information important for research is high. Potentially, the fishpond and surrounding project area may yield information relating to pre-Contact and early post-Contact habitation and traditional land use patterns within Niu Ahupua‘a. Additionally, archival documents have indicated the project area was given to a Captain Adams “just before the coming of the first New England missionaries in 1820, as a reward for thwarting an attempted Russian invasion of the Island of Kauai in 1815.” The project area was also once the country home of Kamehameha the Great and Ka‘ahumanu and was also the site of the “great Kalauha‘iha‘i Assembly . . . [of] 1819, when the ancient tabu laws were broken on Oahu.” Thus, the fishpond and project area may possibly be associated with events that have made a significant contribution to broad patterns of Hawai‘i’s history, in addition to being associated with the lives of persons significant in Hawai‘i’s past.

4.2.2 Native Hawaiian Traditional Cultural Knowledge, Values and Practices

There are two stories regarding Hi‘iaka, the sister of the fire goddess Pele. Nathaniel B. Emerson places Hi‘iaka on the eastern coast of O‘ahu while she searches for food and encounters the residents of the area. Hi‘iaka begs some women who had caught small fish and crabs if she could have a portion of their catch. The women refused Hi‘iaka a portion and

suggested she would do much better catching her own fish. As the sister of the fire goddess, Hiʻiaka could not let their insults go unpunished and stated,

> He makani holo uha (a)
>
> Ko Ka-ele-kei a Pau-kua (b)
>
> Pau wale kea ho I ka noi ana,
>
> O ka loa hoʻi, e!
>
> Translation:
> Here's a blast shall posset the blood,
>
> As the chant of kahuna the back.
>
> Our patience exhausts with delay;
>
> We're famished from the length of the way. [Emerson 1915:187]

Hoʻoulumāhiehie gives a slightly different version from Emerson. Hiʻiaka is traveling from south to east on Oʻahu with her companions, Wahineʻōmaʻo and Lohiau. The trio had defeated several monsters in Palolo Valley and were headed toward the Maunalua to meet with chief Kaulanakalā who offered them a ride in his canoe to Molokaʻi (Hoʻoulumāhiehie 2008b:317).

Wahi Pana

Niu, literally translates to "coconut" (Pukui et al. 1974:166). The ahupuaʻa is divided into two valleys, separated by Kūlepeamoa ("flapping of chicken") Ridge. To the west is Pia ("arrowroot") Valley and to the east Kupaua ("upright clam") Valley. A heiau sits at the foot of Kūlepeamoa Ridge called Kūlepeamoa Heiau. Archaeologist J.Gilbert McAllister surveyed the entire island of Oʻahu in 1930. During his survey, he stated that portions of a terrace could still be observed measuring 120 ft wide, 5 ft high, and 40 to 100 ft in length (depending on the rise of the ridge). The heiau also faced the ocean.

In 2012, Laura Lucas Thompson, descendant of Alexander Adams who once owned the ahupuaʻa of Niu, attested to the cultural landscape of the area. In her affidavit, she recalls a well at the bottom of Kūlepeamoa Heiau. The water from the well was used for her father's dairy. She shared her memory of the well, "We were not allowed to go into the well but I remember watching two young guys from the dairy swimming and saying that two 'tunnels' (lava tubes) were the water source." At the border of Wailupe and Niu was a well called Wai Kuʻi a Kamehameha at a place called Papalea. The water originated from a large inland cave called Kaluapaniʻo. Near the border of Kuliʻouʻou and Niu was another spring called Ke Puhi o Kanau. A spring could also be found within the current project area. Although the traditional name is not known, it was frequently called Lucas Spring, named for the Lucas family who owned the land (Clark 1977:35). Lucas Spring is also known as Kalauhaʻihaʻi Pond, the current project area. Ms. Laura Lucas Thompson once resided at Kalauhaʻihaʻi and recalls the cold water and the abundance of aquaculture in the pond. In an article, former resident of Kalauhaʻihaʻi Tad Hara also shared his memories of the pond where he raised champion koi fish and also witnessed the variety of aquatic life. According to Mr. Hara, during the early 1990s the State of Hawaiʻi – DOT began widening Kalanianaʻole Highway. The four-lane highway was now being expanded to six lanes. To accommodate the extra two lanes, the DOT condemned 3 ft of Mr. Hara's property. During construction, contractors struck and severed the waterway that supplied fresh water to Kalauhaʻihaʻi Pond. DOT installed several temporary monitor wells to assess declining water levels both mauka and makai during construction and even attempted gel injection to restore pre-widening project flow but were unsuccessful. Mr. Hara came home to dead fish and a muddy pond. In addition to Kalauhaʻihaʻi Pond, there was also nearby Kūpapa Fishpond (also called Niu Pond). Kūpapa was once part of a large tract of land that Kamehameha I used as a summer home. Kūpapa Fishpond has since been covered and is now a residential area called Niu Peninsula.

Settlement Patterns and Cultivation

Previous archaeological research and findings indicate Niu Ahupuaʻa was a once flourishing community during pre-Contact times. The presence of fishponds, terraces, springs, religious structures, burial caves, and midden suggest the ahupuaʻa was ideal and used for settlement. In her affidavit, Ms. Laura Lucas Thompson recalls the "cloud of opae" and "the pungent strings of limu eleele" at Kalauhaʻihaʻi Pond. Fish were also observed at the pond "but not the size of those raised in Kuapa Pond at Koko Head." Mr. Tad Hara later lived in a two-story home above Kalauhaʻihaʻi Pond. The home's living room floor was constructed with glass from the inside so the homeowners could enjoy the pond. This residence was removed by DLNR in 2017. Besides Mr. Hara's prize-winning koi fish, the pond also contained wild mullet, prawns, crabs, and other aquatic life. Mr. Hara would also often take his children a mile out into the ocean to catch dinner. They often caught octopus, crab, papio (juvenile crevalle), and other reef fish.

POTENTIAL IMPACTS AND MITIGATION MEASURES

One potential cultural resource was identified: Kalauhaʻihaʻi Fishpond and its associated fishpond features. Feature 1 consists of a basalt stone and mortar kuapā marking the limits of and partially enclosing the freshwater pond. Feature 2 consists of a basalt stone and mortar ʻauwai and a concrete double mākāhā.

The proposed action entails the continuing revitalization of the Kalauhaʻihaʻi Fishpond and its associated features, and as such includes the preservation of the fishpond wall and ʻauwai. Therefore, no adverse effects are anticipated and no mitigation is proposed. However, MFHC will consult with the DLNR-State Historic Preservation Division and other experts regarding best practices and other mechanisms for maximizing protections for Kalauhaʻihaʻi Fishpond while ensuring public benefit. Additionally, MFHC will comply with all State regulations pertaining to fishponds.

4.2.3 Infrastructure

4.2.3.1 Roadways, Access, and Parking Facilities

The Kalauhaʻihaʻi Fishpond site is located at Niu at 5839/5341 Kalanianaʻole Highway. According to 2012 traffic data, Kalanianaʻole Highway experiences approximately 30,000 vehicles daily (2,936 in the AM peak hour, and 1,562 in the PM peak hour) in the westbound direction, and approximately 33,640 vehicles (1,668 in the AM peak hour, and 3,031 in the PM peak hour) in the eastbound direction each day. Peak hours for school-related traffic are between 7:30 a.m. to 7:55 p.m. in the mornings, and between 2:20 p.m. to 2:45 p.m. in the afternoons.

No vehicular traffic is allowed into the Kalauhaʻihaʻi Fishpond site as there is no available onsite parking. All visitors must enter on foot via Kalanianaʻole Highway or via the sandy shoreline along Maunalua Bay. Offsite parking was obtained through a MOA forged with nearby Holy Trinity Church, (about two blocks east) which has approximately 50 stalls. The church parking has access from the highway and a one-way traffic flow with two separate (in-out) driveways. Carpooling to the Holy Trinity Church is encouraged. Public sidewalks are provided along Kalanianaʻole Highway and adjacent side streets.

MFHC holds an average of 2 workdays/events per month at Kalauhaʻihaʻi Fishpond, with the greatest number occurring in the summer months. MFHC utilizes a RSVP system where participants must sign up in advance and parking needs are identified. Events typically are from 2 to 4 hours in length and average group size is 20 or fewer. To maintain the current excellent relations with the immediate neighbors, volunteers are restricted from parking or accessing from neighboring driveways unless expressly invited, and Holy Trinity Church is also notified if parking is needed.

Currently vehicular traffic generated by a workday is low, averaging 10 passenger vehicles for a community volunteer event and 2 large vehicles (vans or buses) for a school event. Typically any effect on local traffic volume and flow is indiscernible. Some community volunteers walk from their homes, or carpool to the parking site, and some school groups walk from their

schools or take public transportation (TheBus).

Future increases in the number of vehicles per event are a possibility, as MFHC has established a maximum of 50 people for a workday. Should the number of vehicles for any given event exceed 25, special arrangements will be made for parking. These may include using multiple parking lots (Holy Trinity Church, other nearby churches and Niu Valley Shopping Center are potential options), obtaining street parking permits and incorporating parking control measures such as valet parking attendants and HPD traffic safety officers.

POTENTIAL IMPACTS AND MITIGATION MEASURES

The proposed action is not anticipated to have long-term impacts on traffic. The proposed action will generate some additional trips both inside and outside of school hours by school groups, community members and others traveling to and from the Kalauhaʻihaʻi Fishpond, however the long-term contribution to cumulative traffic impacts on State highways facilities in the area (Kalanianaʻole Highway) will be negligible.

Short term effects on traffic are minimal, as workdays are not scheduled during peak traffic hours nor during large race events (e.g. Honolulu Marathon), and the number of vehicles arriving to the area for a workday currently is low (averaging 10 vehicles for a volunteer work event and 2 vehicles for a school event). If the expected volume of traffic for a given workday or event expands to greater than 25 vehicles, special traffic management measures will be implemented as appropriate. These may include using multiple parking lots, obtaining permits for street parking, or using parking controls such as parking attendants and HPD traffic safety officers.

4.2.3.2 Public Transportation

TheBus is a public transportation service provided by the City and County of Honolulu. There are presently several bus routes along Kalanianaʻole Highway, including Bus Routes: 1, 22, 23, 80, and 82. The nearest bus stops are located at the intersection of Halemaʻumaʻu Street and

Kalaniana‘ole Highway, which is approximately two blocks from Kalauha‘iha‘i Fishpond.

POTENTIAL IMPACTS AND MITIGATION MEASURES

The proposed action will generate some additional ridership both inside and outside of school hours by school groups, community members and others traveling to and from the Kalauha‘iha‘i Fishpond, however the contribution to ridership will be negligible. It is not anticipated that any of the public transportation routes or stops will be affected by the proposed action.

4.2.3.3 Water Supply and Wastewater

Water is supplied to the vicinity of Kalauha‘iha‘i Fishpond by the City and County of Honolulu 's Board of Water Supply via a water transmission line along Kalaniana‘ole Highway. The site is also connected to the City and County of Honolulu Department of Environmental Services wastewater system. Although there are existing water supply and sewer lines to the site, service has been shut off for over two decades. On event days, drinking water is transported to the site for volunteer workers. Facilities planning will not be conducted for the site until after a 5-year management review and facilities needs assessment are conducted (see section 3.4. Restroom facilities are available at nearby Holy Trinity Church and Kuli‘ou‘ou Beach Park on volunteer work days.

POTENTIAL IMPACTS AND MITIGATION MEASURES

The proposed action is not anticipated to have any negative impacts on the County's water supply or wastewater system. Both are presently disconnected. No mitigation measures are proposed.

4.2.3.4 Solid Waste

Curbside refuse collection and disposal for the area is currently conducted by the City and County of Honolulu's Department of Environmental Services Solid Waste Division. However, the

site is not serviced by the County. The City and County of Honolulu provides 10 public refuse drop-off locations: six (6) convenience centers, three (3) transfer stations and one (1) landfill around the island for residents to dispose of household rubbish and recycle green waste. The proposed action will include the ongoing removal of weeds, brush, trash and the occasional bulky item from the site. Currently, all waste from Kalauhaʻihaʻi is collected by MFHC and transported to the County convenience (transfer) station in Waimanalo.

POTENTIAL IMPACTS AND MITIGATION MEASURES

The amount of solid waste generated at the site is expected to increase in the short run due to invasive species removal, and to decrease in the long run with the transition to predominantly maintenance activities. The total amounts of green waste removed at one time, however, are not large (1-2 pickup truck loads). Additionally, the County transfer stations have been redesigned in an effort to divert materials that can be reused/recycled away from the landfill as well as minimize the amount of waste generated. This makes recycling materials such as green waste much easier. Every effort will be made to reduce overall waste generated, and to recycle the green waste that is generated. Moderate amounts of litter and bulky items originating from the adjacent Kalanianaʻole Highway will continue to be regularly removed by MFHC personnel and disposed of.

4.2.3.5 Drainage System

Niu Valley has an extensive municipal drainage system. Runoff throughout the built areas of Niu Valley is eventually captured by a combination of open and underground drainage features and eventually makes its way to the ocean. The site is not connected to this stormwater system, and does not collect stormwater from Kalanianaʻole Highway. Soils at the site are porus and fast-draining, and overland flow is almost nonexistant.

POTENTIAL IMPACTS AND MITIGATION MEASURES

The site is not connected to, and does not contribute runoff to, the County stormwater system. No mitigation measures are proposed.

4.2.3.6 Electrical and Communications System

Electrical, telephone, data and television services are provided to the area directly by the service providers Hawaiian Electric Company (electricity), Hawaiian Telcom (telephone) and Time Warner Cable/Oceanic (data and cable television service). All utility service to the Kalauhaʻihaʻi Fishpond site has been shut off for the past two decades.

At present, MFHC has a zero energy demand as the site is vacant and there are no lighting, electrical equipment or appliances onsite. Site maintenance is conducted during daylight hours primarily sing hand tools. Should any power tools be required, they will be powered by gasoline or a small portable generator. MFHC does not anticipate an immediate need for connections to electrical or communications networks, since onsite activities predominantly consist of short (2-4 hour duration) workdays conducted during daylight hours, and do not require classroom space or other indoor facilities. In the future, MFHC will investigate the feasibility of using small solar panels to power security lighting.

There is no internet or phone on site. Phone communications are conducted using personal cell phones.

POTENTIAL IMPACTS AND MITIGATION MEASURES

No adverse impacts to the local electrical and communications systems are anticipated. The site is very small and energy needs can be met with onsite power sources (e.g. generator or small-scale solar). As described in Section 3.4, MFHC will conduct a needs assessment for facilities as part of its 5-year periodic management review process. Should the need for facilities and associated utilities be identified at that time, MFHC will initiate planning and seek all required permits and approvals, including those pursuant to Chapter 343,HRS.

4.2.4 Visual Resources

Due to the flat topography of the site, and the surrounding residential developments, there are no significant view planes or view sheds on the site. While some of the hillside homes that are across the Kalanianaʻole Highway from the site have views of the ocean, the proposed action

will not affect these views.

POTENTIAL IMPACTS AND MITIGATION MEASURES

The site is bounded to the east and west by residential structures, to the North by Kalaniana‘ole Highway, and to the south by Maunalua Bay. Neither mauka (from the beach) nor makai (from the hillside) views will be affected as no structures or other development are proposed.

4.2.5 Socio-Economic Characteristics

4.2.5.1 Population

The U.S. Census reported that the population of O‘ahu was 953,207 in 2010 and 991,788 in 2014. The overall population increased by approximately 9% between 2000 and 2010 according to the U.S. Census 2010. The Kalauha‘iha‘i Fishpond is located within the U.S. Census Bureau’s East Honolulu Census Designated Place (CDP). In 2010, the population was 49,914 of which 10,530 were 19 years old or younger. The average household size was 2.81 people.

POTENTIAL IMPACTS AND MITIGATION MEASURES

The proposed action will not affect area population. The Management Plan activities will improve the Kalauha‘iha‘i Fishpond and its surrounding area, as well as address needs for access and learning about local fishponds and history.

4.2.5.2 Economy

The local economy within the East Honolulu CDP is primarily based on accommodation and food services, followed by retail trade (Town Charts 2015). Within the East Honolulu CDP, approximately 64% of the population is employed, 2% were unemployed and approximately 34% are not in the labor force.

POTENTIAL IMPACTS AND MITIGATION MEASURES

The proposed action will not substantially affect the economy within the East Honolulu CDP in either the short-term or the long-term. The activities in the Management Plan will improve the fishpond site and enrich community experience. No mitigation measures are proposed.

4.2.6 Public Services and Facilities

4.2.6.1 Schools

Niu Valley Middle School is the closest school. It is one of six public schools (four elementary, one middle, and one high school) within the DOE Kaiser Complex Area. There are no public charter schools in the Kaiser Complex Area. Table 4 presents estimated public school enrollment information for the Kaiser Complex Area.

Table 4. Enrollment for Kaiser Complex Public Schools

School	Enrollment 2014-2015
ʻĀina Haina Elementary School	505
Hahaʻione Elementary School	555
Kamiloiki Elementary School	418
Koko Head Elementary School	313
Niu Valley Middle School	887
Kaiser High School	1156

Source: (State of Hawaii Department of Education, 2015)

Private schools in the area include Honolulu Waldorf School (Pre-K-12), Kilohana Preschool (Pre-K-age 6), Holy Nativity School (Pre-K-6) and Calvary by the Sea Lutheran Church & Montessori School (Pre-K-age 6).

POTENTIAL IMPACTS AND MITIGATION MEASURES

No adverse impacts to schools are anticipated. Positive impacts are expected. MFHC and Kalauhaʻihaʻi Fishpond site will be adding value to schools by providing ʻāina based hands-on learning to steward native flora and fauna and restore traditional fishpond values. These activities are free and may also include classroom visits by MFHC personnel. Since July 2013, MFHC has engaged over 400 students from East Honolulu schools in fishpond science and stewardship projects at Kalauhaʻihaʻi. Students have ranged from middle school through secondary and college levels. No mitigation measures are proposed.

4.2.6.2 Police, Fire, and Medical

Police Protection

The Kalauha'iha'i Fishpond is located in Honolulu Police Department District 7. District 7 encompasses about 40 square miles in east Honolulu, from Punahou Street to Makapuʻu Point. With the exclusion of Waikiki, the area includes the neighborhoods of Mānoa, McCully, Moʻiliʻili, Kaimuki, Palolo, Diamond Head, Waiʻalae, Kahala, ʻĀina Haina, Niu, Kuliʻouʻou, Hawaiʻi Kai, Kalama, and Sandy Beach. East Honolulu has one Substation and a Burglary Theft Detail office located within the District. A walk-in / storefront Substation is located in the Hawaiʻi Kai Towne Center at 6600 Kalanianaʻole Highway. The Substation is around the Ewa corner of the Hawaiʻi Kai Satellite City Hall office. Hours of operation are between 9:00 a.m. to 9:00 p.m. The District's Burglary Theft Detail is located in the Diamond Head area, within the National Guard compound. This building was opened in early 2007 and is home to the East Honolulu & Waikiki Burglary Theft Details. The Burglary Theft Detail handles property crime investigations that occur within the District. The building is located at 4087 Diamond Head Road; access is from the 22nd Avenue roadway.

Fire Protection

The Kalauha'iha'i Fishpond is located between the following Honolulu Fire Department Stations: No. 23 Wailupe Station (located on Kalanianaʻole Highway near Kaai Street); and No. 34 Hawaiʻi Kai Station (located near Lunalilo Home Road and Kapaʻia Street).

Medical Services

There are numerous hospitals and medical centers with emergency rooms near Downtown Honolulu, with the closest being Kapiʻolani Medical Center (approximately 7 miles from Kalauhaʻihaʻi Fishpond and approximately 15 minutes by automobile). The nearest emergency medical service is stationed at Wailupe Fire Station Center, approximately 1.5 miles from Kalauhaʻihaʻi Fishpond and approximately 5 minutes by automobile. There are also Urgent Care clinics located at the Hawaiʻi Kai Towne Center Mall, and near Kahala Mall.

POTENTIAL IMPACTS AND MITIGATION MEASURES

Activities conducted onsite are low-risk and are therefore not expected to increase demand on the County's existing Police, Fire and Medical services. Further, an operations safety plan will be developed (see Section 3, Activity 5.4). The plan will address establish protocols for safe operations around the pond and shoreline, set requirements for site managers (e.g. first aid/CPR certification), signage, and equipment (e.g. first aid kits, backboards, barricades), and provide checklists for briefings. The plan will also include emergency evacuation procedures.

4.2.6.3 Recreational Facilities

The closest park is Niu Valley Neighborhood Park, which is approximately 0.7 miles distant. This park includes two tennis courts and new playground equipment. The adjacent Niu Valley Middle School currently has four hard courts (basketball), a playground, and a large lawn used for soccer, kite flying and frisbee-playing. Two other parks, Kuliʻouʻou Beach Park and Kawaikuʻi Beach Park, are also nearby (approximately 1 mile distant). These are popular parks for local surfers, stand-up paddlers, divers and beachgoers.

POTENTIAL IMPACTS AND MITIGATION MEASURES

Since the proposed action does not involve recreational uses and will not include use of local recreational facilities, no impacts to recreational facilities are anticipated. No mitigation measures are proposed.

4.2.7 Hazardous Materials

MFHC operations at Kalauhaʻihaʻi Fishpond will include the occasional use of small amounts of substances such as adhesives, paint, bleach for sanitizing equipment, and fuel for equipment.

POTENTIAL IMPACTS AND MITIGATION MEASURES

Accidental spills of the aforementioned materials are the most likely potential threat, although it is not expected that materials will be in sufficient quantity to pose a significant danger.

The MFHC will incorporate information on spill prevention and clean up into its briefings for docents and site managers. No mitigation measures are proposed.

Section 5:
Land Use Conformance

5. LAND USE CONFORMANCE

State of Hawaiʻi and City and County of Honolulu land use plans, policies, and ordinances relevant to the proposed action are described below.

5.1 State Of Hawaiʻi

5.1.1 State Land Use Law, Chapter 205, Hawaiʻi Revised Statutes

The State Land Use Law (Chapter 205, HRS), establishes the State Land Use Commission (LUC) and authorizes this body to designate all lands in the State into one of four Districts: Urban, Rural, Agricultural, or Conservation. The site is located within the State Land Use Urban District (Figure 3).

5.1.2 Coastal Zone Management Act, Chapter 205A, Hawaiʻi Revised Statutes

The U.S. Congress enacted the Coastal Management (CZM) Act to assist States in better managing coastal and estuarine environments. The act provides grants to States that develop and implement Federally-approved CZM plans. The State of Hawaiʻi's CZM Act Program was enacted pursuant to Chapter 205A, HRS. The program outlines management objectives centered around ten (10) areas: 1) Recreational Resources; 2) Historic Resources; 3) Scenic and Open Space Resources; 4) Coastal Ecosystems; 5) Economic Uses; 6) Coastal Hazards; 7) Managing Development; 8) Public Participation in Coastal Management; 9) Beach Protection; and 10) Marine Resources. All lands within the State of Hawaiʻi fall within the CZM area, including the Kalauhaʻihaʻi Fishpond site. The objectives and policies of the Hawaiʻi Coastal Zone Management (CZM) Program, along with a discussion of how the proposed action conforms to these objectives and policies, are discussed below.

The Office of Planning (OP) administers Hawaiʻi Revised Statutes (HRS) Chapter 205A, the Coastal Zone Management (CZM) law. The purpose of HRS Chapter 205A is to "provide for the effective management, beneficial use, protection, and development of the Coastal Zone." L.

1977, c188 §1. Special Management Area (SMA) permitting system is part of the CZM Program approved by Federal and State agencies.

Special Management Area

The site is located within the Special Management Area (Figure 6). No development is proposed. "Development" as defined by HRS 2015-A.22 means any of the following uses, activities or operations on land or under water within the SMA:

- grading, dredging, extraction, mining or removing of any materials
- construction, demolition
- change in intensity of use of land
- change in intensity of use of water, ecology related to or access related thereto
- construction, reconstruction, demolition or alteration of the size of any structure

Discussion**:** The site is located in the SMA therefore subject to requirements of the Special Management Area permitting system. However no development as defined under HRS 2015-A.22 is proposed. The pond is small and ongoing management will not alter the existing biological, hydrological or other systems in the SMA.

Recreational Resources

Objective: Provide coastal recreational opportunities accessible to the public.

> *Policy A: Improve coordination and funding of coastal recreational planning and management; and*
> *Policy B: Provide adequate, accessible, and diverse recreational opportunities in the coastal zone management area by:*
>> *(i) Protecting coastal resources uniquely suited for recreational activities that cannot be provided in other areas;*
>> *(ii) Requiring replacement of coastal resources having significant recreational value, including but not limited to surfing sites, fishponds, and sand beaches, when such resources will be unavoidably damaged by development; or requiring reasonable monetary compensation to the State for recreation when replacement is not feasible or desirable;*
>> *(iii) Providing and managing adequate public access, consistent with conservation of natural resources, to and along shorelines with recreational*

value;
(iv) Providing an adequate supply of shoreline parks and other recreational facilities suitable for public recreation;
(v) Ensuring public recreational uses of County, State, and Federally owned or controlled shoreline lands and waters having recreational value consistent with public safety standards and conservation of natural resources;
(vi) Adopting water quality standards and regulating point and nonpoint sources of pollution to protect, and where feasible, restore the recreational value of coastal waters;
(vii) Developing new shoreline recreational opportunities, where appropriate, such as artificial lagoons, artificial beaches, and artificial reefs for surfing and fishing; and
(viii) Encouraging reasonable dedication of shoreline areas with recreational value for public use as part of discretionary approvals or permits by the land use commission, board of land and natural resources, and County authorities; and crediting such dedication against the requirements of section 46-6.

Discussion**:** The site is located on the coastline, therefore policies regarding shoreline recreation resources are applicable. However no development is planned and the proposed actions are aligned with the objective.

Historic Resources

Objective: Protect, preserve and, where desirable, restore those natural and manmade historic and prehistoric resources in the coastal zone management area that are significant in Hawaiian and American history and culture.

Policy A: Identify and analyze significant archaeological resources;
Policy B: Maximize information retention through preservation of remains and artifacts or salvage operations; and
Policy C: Support State goals for protection, restoration, interpretation, and display of historic resources.

Discussion**:** The site contains cultural resources (fishpond infrastructure) that are significant in Hawaiian and American history and culture, therefore these policies apply. The revitalization and preservation of fishpond resources are central components of MFHC's management plan for Kalauhaʻihaʻi Fishpond. A cultural inventory was conducted by Cultural Surveys Hawaiʻi as part of this environmental assessment. Additionally, MFHC will consult with the State of

Hawai‘i DLNR State Historic Preservation Division to ensure State goals are supported.

Scenic and Open Space Resources

Objective: Protect, preserve and, where desirable, restore or improve the quality of coastal scenic and open space resources.

> *Policy A: Identify valued scenic resources in the coastal zone management area;*
> *Policy B: Ensure that new developments are compatible with their visual environment by designing and locating such developments to minimize the alteration of natural landforms and existing public views to and along the shoreline;*
> *Policy C: Preserve, maintain, and, where desirable, improve and restore shoreline open space and scenic resources; and*
> *Policy D: Encourage those developments which are not dependent to locate in inland areas.*

Discussion**:** No new developments are proposed for the site. Neighboring residences abut either side of the fishpond. Open space is primarily over the water of the fishpond. An existing cinder block wall and fencing provide a limited view of the fishpond. It is expected that the removal of alien invasive vegetation from around the fishpond will improve the overall site aesthetics as well as public views of the coastline.

Coastal Ecosystems

Objective: Protect valuable coastal ecosystems, including reefs, from disruption and minimize adverse impacts on all coastal ecosystems.

> *Policy A: Exercise an overall conservation ethic, and practice stewardship in the protection, use, and development of marine and coastal resources;*
> *Policy B: Improve the technical basis for natural resource management;*
> *Policy C: Preserve valuable coastal ecosystems, including reefs, of significant biological or economic importance;*
> *Policy D: Minimize disruption or degradation of coastal water ecosystems by effective regulation of stream diversions, channelization, and similar land and water uses, recognizing competing water needs; and*

Policy E: Promote water quantity and quality planning and management practices that reflect the tolerance of fresh water and marine ecosystems and maintain and enhance water quality through the development and implementation of point and nonpoint source water pollution control measures.

Discussion**:** No development is planned and the proposed actions are aligned with the objective. The site contains a fishpond which is a groundwater-dependent ecosystem. Kalauhaʻihaʻi Fishpond is integrated hydrologically with the local basal groundwater lens and biologically and hydrologically with nearby coastal resources (Maunalua Bay). The freshwater lens supplying the pond also supports other important nearby coastal ecosystems including the estuarine and wetland systems of Paiko Lagoon Wildlife Sanctuary. Coastal fishponds like Kalauhaʻihaʻi Fishpond are known for providing habitat for native aquatic organisms, among them species whose life history includes marine and freshwater phases, such as mullet, gobies, shrimp, and snails. The Kalauhaʻihaʻi Management Plan goals include improving habitat quality for these species. Additionally, the planned activities for invasive species control, erosion control and reduction of sediment and detritus, as described in Section 3, are likely to improve overall water quality at the site. It is anticipated that these management actions will also prove beneficial for the Maunalua Bay ecosystems.

Economic Uses

Objective: Provide public or private facilities and improvements important to the State's economy in suitable locations.

> *Policy A: Concentrate coastal dependent development in appropriate areas;*
> *Policy B: Ensure that coastal dependent development such as harbors and ports, and coastal related development such as visitor industry facilities and energy generating facilities, are located, designed, and constructed to minimize adverse social, visual, and environmental impacts in the coastal zone management area; and*
> *Policy C: Direct the location and expansion of coastal dependent developments to areas presently designated and used for such developments and permit reasonable long-term growth at such areas, and permit coastal dependent development outside of presently designated areas when:*
>
> > *(i) Use of presently designated locations is not feasible;*
> > *(ii) Adverse environmental effects are minimized; and*
> > *(iii) The development is important to the State's economy.*

Discussion**:** The proposed action will not directly impact the State's coastal-dependent economy.

Coastal Hazards

Objective: Reduce hazard to life and property from tsunami, storm waves, stream flooding, erosion, subsidence, and pollution.

> *Policy A: Develop and communicate adequate information about storm wave, tsunami, flood, erosion, subsidence, and point and non-point source pollution hazards;*
> *Policy B: Control development in areas subject to storm wave, tsunami, flood, erosion, hurricane, wind, subsidence, and point and non-point source pollution hazards;*
> *Policy C: Ensure that developments comply with requirements of the Federal Flood Insurance Program; and*
> *Policy D: Prevent coastal flooding from inland projects.*

Discussion**:** The site is located in the tsunami inundation zone, and storm wave runup

associated with hurricane conditions has been documented. However no development is proposed, there are no known erosion or subsidence problems in the area or pollution sources that would be significantly affected by the proposed management actions. Nor will there be increases in runoff from the site as a result of the proposed actions. As described in Section 3, Activity 5.4, MFHC will develop operational safety and emergency evacuation procedures, to ensure readiness for disasters.

Managing Development

Objective: Improve the development review process, communication, and public participation in the management of coastal resources and hazards.

> *Policy A: Use, implement, and enforce existing law effectively to the maximum extent possible in managing present and future coastal zone development;*
> *Policy B: Facilitate timely processing of applications for development permits and resolve overlapping or conflicting permit requirements; and*
> *Policy C: Communicate the potential short and long-term impacts of proposed significant coastal developments early in their life cycle and in terms understandable to the public to facilitate public participation in the planning and review process.*

Discussion**:** No development is proposed. However the Chapter 343, HRS, review process provides opportunity for public input on management activities at the site.

Public Participation

Objective: Stimulate public awareness, education, and participation in coastal management.

> *Policy A: Promote public involvement in coastal zone management processes;*
> *Policy B: Disseminate information on coastal management issues by means of educational materials, published reports, staff contact, and public workshops for persons and organizations concerned with coastal issues, developments, and government activities;*
> *Policy C: Organize workshops, policy dialogues, and site- specific mediations to respond to coastal issues and conflicts.*

Discussion**:** The proposed actions are aligned with the objective. The proposed management actions were developed in collaboration with community, agency and NGO partners, and the plan promotes the continuing involvement of community, scientists, Native Hawaiian practitioners, educators and others in Hawaiian fishpond management. In addition, this EA discusses potential impacts and mitigation measures of the proposed action and the Hawaiʻi EA review process provides an opportunity for public input.

Beach Protection

Objective: Protect beaches for public use and recreation.

> *Policy A: Locate new structures inland from the shoreline setback to conserve open space, minimize interference with natural shoreline processes, and minimize loss of improvements due to erosion;*
> *Policy B: Prohibit construction of private erosion-protection structures seaward of the shoreline, except when they result in improved aesthetic and engineering solutions to erosion at the sites and do not interfere with existing recreational and waterline activities; and*
> *Policy C: Minimize the construction of public erosion-protection structures seaward of the shoreline.*

Discussion**:** The site is located on the coastline, and abuts a public beach, therefore this objective and these policies apply. However, no shoreline development is proposed, and the proposed management activities will not cause beach erosion or otherwise alter shoreline processes. The beach is a highly dynamic environment, exhibiting seasonal variation in erosion and accretion. During times of high tides and high wave energy, ocean water may enter the pond and sediment (sand) deposits may occlude the pond and ʻauwai.

Marine Resources

Objective: Promote the protection, use, and development of marine and coastal resources to assure their sustainability.

> *Policy A: Ensure that the use and development of marine and coastal resources are*

ecologically and environmentally sound and economically beneficial;
Policy B: Coordinate the management of marine and coastal resources and activities to improve effectiveness and efficiency;
Policy C: Assert and articulate the interests of the State as a partner with Federal agencies in the sound management of ocean resources within the United States exclusive economic zone;
Policy D: Promote research, study, and understanding of ocean processes, marine life, and other ocean resources in order to acquire and inventory information necessary to understand how ocean development activities relate to and impact upon ocean and coastal resources; and
Policy E: Encourage research and development of new, innovative technologies for exploring, using, or protecting marine and coastal resources.

Discussion: The proposed actions are aligned with the objective and will not impact marine and coastal resources. Traditional Hawaiian fishponds were engineered to integrate into existing biological and hydrological systems. The proposed actions perpetuate traditional fishpond management practices, as well as foster research and study for improved understanding of biological and hydrological systems associated with fishponds (Strategy 3).

5.1.3 Hawaiʻi State Plan

The Hawaiʻi State Plan (Chapter 226, HRS), establishes a set of goals, objectives and policies that serve as long-range guidelines for the growth and development of the State. Objectives pertinent to the proposed action are as follows:

§226-25 Objective and policies for socio-cultural advancement--culture.

(a) Planning for the State's socio-cultural advancement with regard to culture shall be directed toward the achievement of the objective of enhancement of cultural identities, traditions, values, customs, and arts of Hawaiʻi's people.

(1) Foster increased knowledge and understanding of Hawaiʻi's ethnic and cultural heritages and the history of Hawaiʻi.

(2) Support activities and conditions that promote cultural values, customs, and arts that enrich the lifestyles of Hawaiʻi's people and which are sensitive and responsive to family and community needs.

Discussion**:** The proposed actions are aligned with this objective and its associated policies. As described in Section 3 of this document, MFHC envisions the revitalization and preservation of the fishpond to perpetuate traditional Native Hawaiian cultural practices and knowledge. Strategy 5 of the Kalauhaʻihaʻi Management Plan entails activities to restore community uses and value of fishponds. Hands-on mālama āina stewardship projects, fishpond heritage education and research are core components of MFHC's programs.

§226-11 Objectives and policies for the physical environment--land-based, shoreline, and marine resources.

(a) Planning for the State's physical environment with regard to land-based, shoreline, and marine resources shall be directed towards achievement of the following objectives:

(1) Prudent use of Hawaiiʻs land-based, shoreline, and marine resources.

(2) Effective protection of Hawaiiʻs unique and fragile environmental resources.

(b) To achieve the land-based, shoreline, and marine resources objectives, it shall be the policy of this State to:

(1) Exercise an overall conservation ethic in the use of Hawaiiʻs natural resources.

(9) Promote increased accessibility and prudent use of inland and shoreline areas for public recreational, educational, and scientific purposes. [L 1978, c 100, pt of §2; am L 1986, c 276, §10]

Discussion**:** The proposed actions are aligned with this objective and its associated policies. The goals of the Kalauhaʻihaʻi Management Plan are:

- **Restore and sustain the biological health of Kalauha‘iha‘i Fishpond; and**
- **Restore community uses and value of fishponds, including cultural & socio-economic values, education and outreach, and scientific study.**

The proposed use is prudent as it entails the revitalization of a Hawaiian fishpond and its associated systems, and the engagement of the community in stewarding and protecting unique and valuable resources. The proposed use has a strong conservation component as described in Section 3 of this document, particularly as related to the following strategies :

Strategy 1: Implement priority activities to improve and maintain the condition of fishpond aquatic habitat.

This strategy includes actions to remove invasive aquatic species, improve diminished water quality, remove sediment and debris and unblock fish passage to improve fish habitat at the site. Recovery actions also include ongoing monitoring to assess effectiveness of projects to improve biotic and hydrological systems

Strategy 2: Rehabilitate and maintain terrestrial habitats at Kalauha‘iha‘i.

This strategy entails removal of invasive species that have displaced native species and altered ecosystems. Removal and replanting with appropriate native vegetation is essential to restoring native ecosystems integrity. Rehabilitation will be lengthy due to a persistent (weed) seed bank and slow growth rate of some native plants. Once back in balance, vegetative systems will be continuously monitored and maintained by the community.

Strategy 3: Implement management actions that ensure healthy fish resources.

This strategy entails active management of fish populations. Once habitats have been improved, the use of pono (responsible and appropriate) practices to stock, enhance and monitor the health of fish are needed to ensure healthy, productive fishponds.

Strategy 4: Implement a regular maintenance plan and schedule for fishpond infrastructure.

This strategy entails maintenance of fishpond walls, ‘auwai and flow gates to regulate fish passage and ensure appropriate circulation and tidal influence. Maintenance of fishpond

infrastructure also includes associated erosion control, which is needed to prevent sediment from entering the pond and ʻauwai.

It is anticipated that the proposed management actions will also prove beneficial to the adjacent Maunalua Bay ecosystems.

State of Hawaiʻi Land Use District (Urban District):

The Urban District generally includes lands characterized by "city-like" concentrations of people, structures and services. This District also includes vacant areas for future development. Jurisdiction of this district lies primarily with the respective counties. Generally, lot sizes and uses permitted in the district area are established by the respective county through ordinances or rules."

In summary, no mitigation measures are proposed for the proposed action, as the activities in the Kalauhaʻihaʻi Fishpond Management Plan are aligned with the State designations, objectives and policies for the land

5.2 City And County Of Honolulu

County-specific land use plans and ordinances pertaining to the proposed action include the Oʻahu General Plan, East Honolulu Sustainable Community Plan and Land Use Ordinance.

5.2.1 Oʻahu General Plan

The Oʻahu General Plan (1992, amended most recently in 2003) is the policy document for the long-range development of the Island of Oʻahu. The Oʻahu General Plan is a statement of general conditions to be sought in the 20-year planning horizon and policies to help direct attainment of the plan's objectives.

There are two specific General Plan objectives that are applicable to the proposed action. The objectives and their associated policies are Section III(B) and Section X(B), as follows:

Section III: Natural Environment

Objective (B) To preserve and enhance natural landmarks and scenic views.

Policies:

> (1) Protect the Island's significant natural resources: its mountains and craters; forests and watershed areas; marshes, rivers, and streams; shorelines, fishponds, and bays; and reefs and offshore islands.
>
> (4) Promote public access to the natural environment for recreational, educational and cultural purposes and the maintenance thereof in a way that does not damage natural or cultural resources.

and

Section X: Culture and Recreation

Objective (B) To protect, preserve and enhance Oʻahu's cultural, historic, architectural, and archaeological resources.

Policies:

(1) Encourage the restoration and preservation of early Hawaiian structures, artifacts, and landmarks.

(2) Identify, and to the extent possible, preserve and restore buildings, sites, and areas of social, cultural, historic, architectural, and archaeological significance.

(4) Promote the interpretive and educational use of cultural, historic, architectural, and archaeological sites, buildings, and artifacts.

(7) Encourage the protection of areas that are historically important to Native Hawaiian and other cultural practices, in order to further preserve and continue these practices.

Discussion: The proposed action is consistent with the City and County of Honolulu General Plan Section III, Objective B and Section X, Objective B, and their associated policies. The goals of the Kalauhaʻihaʻi Management Plan are:

- **Restore and sustain the biological health of Kalauhaʻihaʻi Fishpond; and**
- **Restore community uses and value of fishponds, including cultural & socio-economic values, education and outreach, and scientific study.**

The proposed use entails the revitalization of a Hawaiian fishpond and its associated systems, and the engagement of the community in stewarding and protecting unique and valuable resources. The proposed actions have a strong conservation component as described in Strategies 1 – 4, Section 3 of this document. Strategy 1 entails priority activities to improve and maintain the condition of fishpond aquatic habitat. This strategy includes actions to remove invasive aquatic species, improve diminished water quality, remove eroded sediment and debris and unblock fish passage to improve fish habitat at the site. Recovery actions also include ongoing monitoring to assess effectiveness of projects to improve biotic and hydrological systems. Strategy 2 entails rehabilitating and maintaining terrestrial habitats at

Kalauhaʻihaʻi. This strategy entails removal of invasive species that have displaced native species and altered ecosystems. Removal and replanting with appropriate native vegetation is essential to restoring native ecosystems integrity. Rehabilitation will be lengthy due to a persistent (weed) seed bank and slow growth rate of some native plants. Once back in balance, vegetative systems will be continuously monitored and maintained by the community. Strategy 3 entails implementing management actions that ensure healthy fish resources. This strategy includes active management of fish populations. Once habitats have been improved, the use of pono (responsible and appropriate) practices to stock, enhance and monitor the health of fish are needed to ensure healthy, productive fishponds. Strategy 4 aims to implement a regular maintenance plan and schedule for fishpond infrastructure. This strategy includes activities to maintain fishpond walls, ʻauwai and flow gates to regulate fish passage and ensure appropriate circulation and tidal influence. Maintenance of fishpond infrastructure also includes associated erosion control, which is needed to prevent sediment from entering the pond and ʻauwai.

The proposed action also has a strong cultural heritage component as described in Strategy 5. This strategy is focused upon building community awareness, cultural connections, and capacity for sustained stewardship. It includes education, hands-on mālama ʻāina projects and other activities that maintain the integrity and value of an area that was historically important to Native Hawaiians, and that provide opportunities to further preserve and continue Native Hawaiian practices. Fishponds are best managed with community support and participation. Community management at a local scale is a proven effective strategy for socially-beneficial long-term sustainability of fishponds and is consistent with traditional Hawaiian management systems.

5.2.2 East Honolulu Sustainable Community Plan

The City and County of Honolulu has adopted the East Honolulu Sustainable Community Plan (EHSCP) as one of eight community-oriented plans to guide public policy, investment and decision making through the 2020 planning horizon (CCHDPP, 1999). The EHSCP was developed by the Department of Planning and Permitting (DPP) and its consulting team in partnership with

the community. The document contains policies specific to East Honolulu. These policies are then enacted through ordinances. The current EHSCP was published in 1999. In 2005, with community input, the City and County of Honolulu along with their consultants began revising the plan. A draft update is currently undergoing public review.

Section 3.4 of the EHSCP states:

> *The following general policies apply for historic and cultural uses*
>
> *- Emphasize physical references to East Honolulu's history and cultural roots.*
> *- Protect existing visual landmarks and support the creation of new, culturally appropriate landmarks.*
> *- Preserve significant historic features from earlier periods.*
> *- Retain, whenever possible, significant vistas associated with archaeological features.*

Discussion: The proposed action is consistent with the EHSCP concerning the preservation of historic and cultural uses. As previously described in Section 3 and Section 5.2.1, the purpose of the proposed management actions is to revitalize, conserve and protect the heritage of Kalauhaʻihaʻi Fishpond.

5.2.3 City and County of Honolulu Land Use Ordinance

The Land Use Ordinance (LUO) is located in Chapter 21 of the Revised Ordinances of Honolulu 1990. It implements the goals and objectives of the Oʻahu General Plan and the EHSCP. All lands within the City and County of Honolulu are zoned into specific districts. According to the DPP, the Kalauhaʻihaʻi Fishpond site is zoned R-10 "Residential District"(Figure 4).

> *"Sec. 21-3.70 Residential districts—Purpose and intent.*
> *(a) The purpose of the residential district is to allow for a range of residential densities. The primary use shall be detached residences. Other types of dwellings may also be allowed, including zero lot line, cluster and common wall housing arrangements. Non-dwelling uses which support and complement residential neighborhood activities shall also be permitted."*

Summary of City and County of Honolulu designations for Kalauhaʻihaʻi Fishpond

Council District:	4- Trevor Ozawa
Development Plan Area:	East Honolulu Sustainable Communities Plan
Flood Zones:	AE - 100 Year Flood, Base Flood Elevation Determined
Flood Zones:	*VE* - 100 Year Flood, Coastal Wave Action, Base Elevation Determined
Height Limit:	25' unless sloping
Neighborhood Board:	2 - Kuliouou-Kalani Iki
SMA:	In SMA
Shoreline:	Shoreline setback
Slide Area:	None
Lot Restriction:	None
Street setback:	None
State Zoning:	Urban District
City and County Zoning:	Residential, R-10 (presently vacant)

As previously described in Section 4.1.5.1, the Flood Insurance Rate Map (FIRM) contains data important for floodplain management, mitigation, and insurance activities for the National Flood Insurance Program (NFIP).

The National Flood Hazard Layer (NFHL) data present the flood risk information depicted on the FIRM. The 100-year flood is referred to as the 1% annual exceedance probability flood, since it is a flood that has a 1% chance of being equaled or exceeded in any single year. The primary risk classifications used are the 1-percent-annual-chance flood event, the 0.2-percent-annual-chance flood event, and areas of minimal flood risk. The 1% annual chance (base flood) is the flood that has a 1% chance of being equaled or exceeded in any year. The Special Flood Hazard area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, D, V, VE, and X

> **Zone AE** is the flood insurance rate zone corresponds to the 1-percent annual chance floodplains that are determined in the Flood Insurance Study by detailed methods of analysis. Base Flood Elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone. Mandatory flood insurance purchase requirements apply.

Zone VE is the flood insurance rate zone that corresponds to areas within the 1-percent annual chance coastal floodplain that have additional hazards associated with storm waves. Base Flood Elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone. Mandatory flood insurance purchase requirements apply.

Discussion: The proposed action is consistent with the LUO. According to the "Master Use Table" of the LUO, "Public uses and structures" are a permitted use in every zoning district regulated by the City and County of Honolulu.

Special Management Area

The site is located within the Special Management Area (Figure 6). The County authorities administer SMA permits and shoreline setback provisions. The SMA permit is a management tool to assure that uses, activities, or operations on land or in or under water within an SMA are designed and carried out with minimal adverse impacts to water resources and scenic and recreational amenities. The SMA rules and regulations are contained in Chapter 25, ROH.

Section 25-3.2, ROH, includes guidelines which are used by the City Council of the City and County of Honolulu to review developments proposed within the SMA. The relationship between the Proposed Action and the SMA review guidelines in Section 25-3.2 ROH are discussed below.

(a) All development in the special management area shall be subject to reasonable terms and conditions set by the City Council to ensure that:

(1) Adequate access, by dedication or other means, to publicly owned or used beaches, recreation areas and natural reserves is provided to the extent consistent with sound conservation principles;

(2) Adequate and properly located public recreation areas and wildlife preserves are reserved;

(3) Provisions are made for solid and liquid waste treatment, disposition and management which will minimize adverse effects upon special management area resources; and

(4) Alterations to existing land forms and vegetation, except crops, and construction of structures shall cause minimum adverse effect to water resources and scenic and recreational amenities and minimum danger of floods, landslides, erosion, siltation or failure in the event of earthquake

Discussion: No development is proposed and the proposed actions will not involve significant effects on environmental, ecological or recreational resources, nor exacerbate hazard risk in the SMA.

The Coastal Zone Management Act was previously discussed in Section 5.1.2.

5.3 Approvals And Permits

No permits are required for the proposed management actions. No development is proposed.

Approvals required for the proposed management plan actions are:

- Chapter 343, HRS Compliance, DOH-Office of Environmental Quality Control.

As described in Section 3.4, every 5 years MFHC will conduct a comprehensive review and assessment of facilities needs for site operations and educational purposes. Should a need for facilities, utilities or other development be identified, MFHC will initiate a planning process with partners, in which all applicable permits and approvals will be sought in accordance with Federal, State and County regulations, including Chapter 343, HRS.

Section 6:
Alternatives To The Proposed Action

6. ALTERNATIVES

Alternatives to the proposed action that were considered are:

(1) No Action; and

(2) Agency (DLNR) management of the site as a passive State Park.

6.1 No Action Alternative

Under this alternative, site management would consist of land owner DLNR maintaining a secure perimeter fence and signage, and having State of Hawaiʻi maintenance crews conduct periodic brush clearing and removal of dumped bulky items.

Under the No Action alternative, no additional traffic, air quality or noise impacts would be generated. This alternative would not affect the coastal resources or the site's geology, soils, climate, or vulnerability to natural hazards. However the long term revitalization and protection of Kalauhaʻihaʻi Fishpond would not occur. Moreover, this hands-off treatment of Kalauhaʻihaʻi Fishpond could reverse all gains in ecosystem health recently achieved by community stewardship. For example, spring flow would be blocked by sedimentation and debris in the pond and ʻauwai. Canopy regrowth of the nitrogen-fixing koa haole (*Leucaena leucocephala*) would reduce water quality in the pond, causing eutrophication and increased biological oxygen demand, which in turn would lead to die-offs of the pond's biota. Overgrowth of koa haole and Chinese banyan (*Ficus microcarp*a) would also crowd out native plants such as naupaka kahakai (*Scaevola taccada*) and milo (*Thespesia populnea*).

Additionally, beneficial social uses of the site for cultural revitalization, community-building, education and science would be curtailed as access would be prohibited. Traditional fishpond infrastructure (walls, ʻauwai) would gradually deteriorate. Adverse impacts to neighborhood security and sanitation could occur as a result of renewed incursions of homeless and transient

persons using the site as an encampment, drug den, or toilet. The No Action alternative was determined to be unacceptable for these reasons.

6.2 Active Agency Management (Passive State Park)

Under this alternative DLNR would manage and operate Kalauhaʻihaʻi Fishpond as a passive park or preserve. The Hawaiʻi Department of Land and Natural Resources, Division of State Parks presently administers several urban parks, including ʻIolani Palace, the Queen Emma Summer Palace, the Royal Mausoleum State Monument and Diamond Head State Monument, although none of these is described as a passive park. Passive or low intensity recreation is that which emphasizes the open-space aspect of a park and/or allows for the preservation of natural habitat. Common uses include nature observation, walking, and sitting. In the case of Kalauhaʻihaʻi, the site would also be considered a valuable access point for ocean recreational activities such as surfing, paddling, swimming and beach use, although it historically has not served as a public access way.

The Active Agency Management (Passive State Park) alternative would involve installing interpretive and other signage, landscaping and lighting; establishing hours of operation; and dedicating resources for regular maintenance. No supporting amenities such as parking or restrooms could be installed due to lack of space.

The Active Agency Management (Passive State Park) alternative would preserve some beneficial uses of the environment. It would enable management actions for maintaining habitats and native biota including removal of invasive species, installation of native landscaping, and maintenance of pond water quality. There would also be a degree of protection afforded to fishpond structures, the spring and groundwater flows to the ocean, although the level of resources that could potentially be afforded to manage these is unknown. Absent an active management presence, it is likely that theft of fish and degradation of the historic fishpond walls would occur, and that litter from Kalanianaʻole Highway would

accumulate. Opportunities for community and school use for educational purposes would be preserved, although a lack of control of the number of users may create a nuisance factor; and unsupervised access may not afford the same level of safety as managed access to the site.

Under this alternative, no air quality impacts would be generated with the possible exception of short-term, temporary dust generated by construction and landscaping. An increase in noise would be expected over the long term as a result of the removal of the hollow-tile wall and vegetation fronting Kalaniana‘ole Highway; and potentially over the short term due to conversations among park users.

This alternative would not affect the coastal resources or the site’s geology, soils, climate, or vulnerability to natural hazards. Likewise, effects on infrastructure and public services and facilities would be negligible, however potential security and safety issues might arise due to increased use of the area by ocean recreation users and homeless and transient persons. Traffic generated by a passive park would likely be minimal due to a lack of onsite parking, however it is reasonable to assume that up to 20 trips weekly might be generated by individuals parking in the nearby neighborhood in order to use the park.

Establishing a new park could serve to ease use pressures on other park sites in the region, which are presently overcrowded. However, the Kalauha‘iha‘i Fishpond site is very small and has not been identified as a priority site for the State to develop as a park. Budgetary constraints also could potentially present a barrier to transforming the site to a State park. According to a recent report, the DLNR Division of State Parks budget has been flat and declining for over 10 years. DLNR Parks Division currently operates on an $8 million budget, although it is estimated that the Division requires at least $13 million a year to keep up with increasing wear and tear at its parks. Thus, procuring sufficient resources to make improvements to and manage this site, while not impossible could be problematical. Additionally, although it is uncertain what uses might be allowed in a site containing a fishpond, traditional fishpond management presents a challenging and therefore unlikely prospect for a

passive park. Rather than managing the site as a fishpond, in an open access site it is more likely that the pond would be managed as a water feature. Under this scenario, restoration would likely not occur, and protections would be minimal. The benefits to community through engagement in conservation, cultural practices, education and scientific study would be relatively low.

Unsupervised access under the passive park alternative has the potential to invite liability to the State. Creating open unmanaged access invites beachgoers to stop or park on the highway. This presents a safety hazard as the fishpond is located behind a blind corner on Kalaniana‘ole Highway and there is no shoulder, safety lane or parking areas in the vicinity for vehicles to safely pull out of traffic.

For these reasons, the Active Agency Management (Passive State Park) alternative was therefore considered to be inferior to the proposed action.

Section 7:
Findings and Anticipated Determination

7. FINDINGS AND ANTICIPATED DETERMINATION

To determine whether the implementation of the proposed action may have a significant impact on the physical and human environment, all phases and expected consequences of the Management Plan activities have been evaluated, including potential primary, secondary, short-range, long-range, and cumulative impacts. Based on this evaluation, a Finding of No Significant Impact (FONSI) is anticipated. The supporting rationale for this finding is presented below.

7.1 Significance Criteria

The discussion below evaluates the significance of the proposed action's impacts based upon the Significance Criteria set forth in Hawaiʻi Administrative Rules Section 11-200-12.

(1) Involves an irrevocable commitment to loss or destruction of any natural or cultural resource;

Discussion: Under the proposed alternative, cultural resources will not be removed, damaged or otherwise significantly altered. The proposed management actions entail preservation and protection of the significant cultural and historical fishpond resources that are present on the site. The proposed actions also entail the conservation and revitalization of natural resources, including replacing non-native, invasive plants with natives, the enhancement of aquatic habitat and reintroduction of native fish and invertebrates. The proposed action will not affect coastal and marine resources. Environmental studies indicate that there are no threatened or endangered species of plants or wildlife present at the site.

By contrast, the No Action alternative, in allowing continued deterioration of the site, would likely involve an irrevocable commitment to damage to, or loss of, both cultural resources (fishpond and ʻauwai) and natural resources (namely groundwater, aquatic ecosystems and native plants). The Agency Management (Passive State Park) alternative would avoid total loss or destruction of either from occurring. However restoration of biological and hydrological

systems would be limited due to resource scarcity, and some loss of cultural resources would likely occur.

(2) Curtails the range of beneficial uses of the environment;

Discussion: The proposed action includes multiple management strategies to preserve and protect cultural and natural resources. Given that fishpond restoration and preservation is relatively new and that very few of the remaining fishponds statewide are in operational condition, the activities in this plan provide unique and valuable opportunities to expand knowledge about Hawaiian aquaculture and engage community in meaningful stewardship. The proposed action would ensure that the property will continue to be used for educational, scientific and stewardship activities; thereby expanding the range of beneficial uses while improving the health of the Kalauhaʻihaʻi Fishpond.

By comparison, the Agency Management (Passive State Park) alternative would preserve a range of beneficial uses, though a narrower range than that of the preferred alternative.
As previously discussed, the No Action alternative would severely curtail the range of beneficial uses of the site.

(3) Conflicts with the State's long term environmental policies or goals and guidelines as expressed in Chapter 344, HRS; and any revisions thereof and amendments thereto, court decisions, or executive orders;

Discussion: The Environmental policies enumerated in Chapter 344, HRS promote conservation of natural resources, and an enhanced quality of life for all citizens. It is anticipated that the proposed management actions will enhance ecosystems and engage, educate and empower the community.

The No Action alternative, as previously noted, is expected to negatively impact natural and cultural resources through neglect and exposure to elements and vandalism. The Agency Management (Passive State Park) alternative, would not negatively impact natural resources

but at the same time would not conserve natural resources or promote community values to the extent afforded by the preferred alternative.

(4) Substantially affects the economic or social welfare of the community or State;

Discussion: The proposed action is anticipated to provide social benefits in the form of increased opportunities for community engagement and place-based stewardship, the perpetuation of traditional Native Hawaiian practices and knowledge, and opportunities for scientific study and research. Otherwise no effects are anticipated. No commercial activities will take place on the property.

Neither the No Action alternative nor the Agency Management (Passive State Park) alternative would substantially affect the economic or social welfare of the community or State, but nor would they promote community values and education to the extent afforded by the preferred alternative.

(5) Substantially affects public health;

Discussion: The proposed actions would not substantially affect public health. There may be short-term minor impacts related to work days (e.g., noise, dust) but these would be temporary. The suite of proposed management actions are designed to adhere to environmental health laws and to avoid the potential degradation of noise, water and air quality of surrounding properties. No commercial or industrial activities will take place on the property. The proposed action would also maximize safety through managed access. Visitors are restricted from coming in vehicles. Visitor parking takes place off the highway away from the fishpond, and visitors walk several blocks on the sidewalk or along the beach

Neither the No Action alternative or Agency Management (Passive State Park) alternative would substantially affect public health, although both would likely attract homeless and transient people to the site, which may in turn raise health and safety considerations in the neighborhood. Both also would invite vehicles parking or stopping on Kalaniana‘ole Highway, a

potentially serious safety issue.

(6) Involves substantial secondary impacts, such as population changes or effects on public facilities;

Discussion: The proposed action will not result in an increase in usage of roads, parks or other area public facilities, or result in population changes. No foreseeable changes in land use or intensity of use, or visitation patterns are anticipated. Existing traffic patterns and volumes would be expected to continue as-is. Since the project site is in an urban area served by existing public utilities and infrastructure, no significant impacts to public facilities are expected

Likewise, neither the No Action alternative or Agency Management (Passive State Park) alternative would involve substantial secondary impacts to population or public facilities.

(7) Involves a substantial degradation of environmental quality;

Discussion: The proposed action would not substantially degrade environmental quality, mainly because the proposed management activities are occurring entirely within a previously disturbed area dominated by non-native plant and animal species. The goal of the proposed activities is the revitalization of existing habitats, biota, and fishpond resources; therefore over time an improvement in environmental quality is expected. It is anticipated that the proposed management actions will also prove beneficial to the adjacent Maunalua Bay ecosystems.

The No Action alternative, as previously noted, is expected to negatively affect environmental quality through neglect, theft and vandalism. The Agency Management (Passive State Park) alternative, would not negatively impact natural resources but at the same time would not actively conserve natural resources or promote restoration and community values to the extent afforded by the preferred alternative. The Agency Management (Passive State Park) alternative would also provide a lesser lesser degree of site safety and security than the preferred alternative.

(8) Is individually limited but cumulatively has considerable effect on the environment, or involves a commitment for larger actions;

Discussion**:** The proposed action is not part of a larger project, nor does it commit the State or County to any other larger actions, and will not generate any additional actions having a cumulative effect on the environment. As discussed, activities may generate minor, short-term temporary impacts (such as dust and noise) that can be addressed through BMPs.

The No Action alternative is expected to negatively affect environmental quality through neglect, theft and vandalism, although the scope of impact is small and the alternative will not generate additional actions that cumulatively have a substantial environmental impact. Similarly, the Agency Management (Passive State Park) alternative would not have far-reaching consequences or involve cumulative impacts.

(9) Substantially affects a rare, threatened or endangered species or its habitat;

Discussion: The proposed action would not substantially affect a rare, threatened or endangered species as there are no threatened, endangered or candidate listed animal or plant species, or habitats found on the project site that require protection under Federal or State regulations.

(10) Detrimentally affects air or water quality or ambient noise levels;

Discussion**:** No State or Federal air quality standards will be violated as a result of the proposed action. The only anticipated issue related to air quality is minor dust generated during initial removal of invasive plant species; however, activities would be short-term and temporary. Long-term negative impacts related to air quality are not expected. Likewise, no State or Federal water quality standards will be violated as a result of the proposed action. The quantity and quality of groundwater, surface waters or storm water runoff will not be impacted. Although activities will inevitably create noise, levels will not exceed those normally encountered in an urban area (lawnmowing, hedge-trimming, etc.) and will not exceed

allowable levels under County regulations. As described in Section 4, best management practices will be employed to minimize noise impacts.

The No Action alternative, as previously noted, is expected to negatively impact resources through neglect. In particular spring flow would be blocked by sedimentation and debris, and canopy regrowth of the nitrogen-fixing koa haole (*Leucaena leucocephala*) would reduce water quality in the pond, causing eutrophication and increased biological oxygen demand, which in turn would lead to die-offs of the pond's biota

The Agency Management (Passive State Park) alternative is not expected to negatively impact air or water quality. Minor increases in ambient noise would be expected over the long term as a result of the removal of the hollow-tile wall and vegetation fronting Kalaniana‘ole Highway.

(11) Affects or is likely to suffer damage by being located in an environmentally sensitive area, such as a flood plain, tsunami zone, beach, erosion-prone area, geologically hazardous land, estuary, fresh water, or coastal waters;

Discussion: The site is in the flood zone and the tsunami evacuation zone. However the site is vacant except for a storage shed. There are no known erosion or subsidence problems, or geological hazards in the area. The proposed action does not involve alterations to estuaries, water bodies or coastal waters.

For the reasons described above, none of the other alternatives considered is likely to affect or suffer damage from natural hazards or environmentally sensitive lands.

(12) Substantially affects scenic vistas and view planes identified in County or State plans or studies;

Discussion: No development is proposed and the proposed action would not obstruct or affect scenic vistas and viewplanes identified in County or State plans or studies. The site is located on the coastline, however it is located along a section of the coastline that is not clearly visible from the adjoining highway. Local views from the beach are expected to be improved by the

proposed actions, which include removing stands of koa haole and other invasive vegetation and planting native plants.

For the reasons described above, none of the other alternatives considered is likely to substantially affect scenic vistas and view planes.

(13) Requires substantial energy consumption.

Discussion**:** The proposed action will not result in substantial energy demand. Utilities at the site are presently shut off. Current operations have zero energy requirement and it is expected that future energy demands will be small and easily met using onsite solutions (e.g. solar powered lighting).

The No Action alternative would require no energy consumption. The Agency Management (Passive State Park) alternative would only require energy for lighting so consumption would be very low.

7.2 Anticipated Determination

A Finding of No Significant Impact (FONSI) for the preferred alternative is expected, based on this Environmental Assessment. This finding is based upon the basis of impacts and mitigation measures examined in this document, and analyses under the above criteria.

Section 8:
References

8. REFERENCES

Apple, R. and Kikuchi W. 1979. *Ancient Hawaii Shorezone fishponds: An Evaluation of Survivors for Historical Preservation.*

Barrera, W. 1979. *Kuliʻouʻou Valley Excavations*. Honolulu, Chiniago Inc.

CCHDPP (City and County of Honolulu Department of Planning and Permitting). 1999. *East Honolulu Sustainable Communities Plan*. (Currently undergoing review and update) Honolulu, HI: City and County of Honolulu.

CCHDPP (City and County of Honolulu Department of Planning and Permitting). Map of important agricultural lands. Accessed on February 2, 2016 at http://mapoahuagland.com/ial-maps/

Chamberlain, L., 1826. *Trip around Oʻahu, June 21, 1826 - July 11, 1826.*

Coles, S.L., DeFelice R.C., and L.G. Eldredge, 2002. *Nonindigenous Marine Species at Waikiki and Hawaiʻi Kai, Oʻahu, Hawaiʻi.*

Cordy, R., 2002. *The Rise and Fall of the Oʻahu Kingdom.* Honolulu, Mutual Publishing.

Cox, D.and J. F. Mink, 1963. The Tsunami of 23 May 1960 in the Hawaiian Islands, *Bulletin of the Seismological Society of America*, v. 53, no. 6, pp. 1191-1209.

Cultural Surveys Hawaiʻi, 2016. *Archaeological Literature Review and Field Inspection with Cultural Study for the Kalauhaʻihaʻi Fishpond Management Plan and Environmental Assessment, Niu Ahupuaʻa, Honolulu (Kona) District, Oʻahu*. *TMKs: [1] 3-7-002:018 and 077*. Honolulu.

Dieudonne, F.(ed) 2002. *The Pacific Islands and the Sea. 350 Years of Reporting on Royal Fishponds, Coral Reefs and Ancient Walled Fish Weir in Oceania*. Honolulu, Neptune House, Publications.

Erkelens, C. and J.S. Athens, 1994. *Burials, highways and history: archaeology along Kalanianaʻole Highway, East Honolulu, Oʻahu*. Report prepared for Hawaiʻi State Department of Transportation. Honolulu, International Archaeology Research Institute, Inc.

Farber, J. 1997. *Ancient Hawaiian Fishponds.* Honolulu, Neptune House Publications.

Fletcher, C., 2005. *Oʻahu.* Honolulu, HI: University of Hawai'i at Mānoa, Coastal Geology Group. http://www.soest.hawaii.edu/coasts/publications/hawaiiCoastline/ Oʻahu.html (last accessed 22 February 2007).

Frohlich, D. 2016. *Botanical Inventory: Kalauhaʻihaʻi Fishpond.* Honolulu.

Fukunaga and Associates, Inc., 2005. *Final Design Alternatives Report, Elelupe Road and Kalaniana'ole Highway Sewer Rehabilitation SMPR No. 36*. prepared for City & County of Honolulu, Department of Environmental Services, March 2005. Honolulu

Giambelluca, T.W., Q. Chen, A.G. Frazier, J.P. Price, Y.-L. Chen, P.-S. Chu, J.K. Eischeid, and D.M. Delparte, 2013. Online Rainfall Atlas of Hawaiʻi. *Bulletin of the American Meteorological Soc*iety 94, 313-316, doi: 10.1175/BAMS-D-11-00228.1. Accessed at http://rainfall.geography.hawaii.edu/interactivemap.html

Gill, L.T. 1989. *A Naturalist's View of Hawai'i Series: Hawai'i Kai View Plane Analysis*. Honolulu, Moanalua Gardens Foundation.

Hawaiʻi Commission on Water Resources Management 1995. Unpublished memoranda and reports for Kalanianaole Highway construction project. Document CDR.2937.3/CDR C94-05.

Hawaiʻi Department of Land and Natural Resources, Land Use Commission. Oʻahu Land Use Map 2012. Accessed at http://files.hawaii.gov/luc/maps/oahu_slud_2012.pdf.

Hawaiʻi Department of Land and Natural Resources and Bishop Museum. *Atlas of Hawaiian Watershed & Their Aquatic Resources*. Accessed November 8, 2015 at http://hawaiiwatershedatlas.com.

Johannes, R.E., 1980. The ecological significance of the submarine discharge of groundwater. *Marine Ecology*. Vol. 3, pp. 365-373.

Kawaharada, D., 2001. *Ancient Oʻahu: Stories of Fornander & Thrum*. Honolulu, Kalamakū Press.

Keala, G. 1992. *Loko I'a. A Manual on Hawaiian Fishpond Restoration and Management.*

Kelly, M. 199(?) *Ahupua'a, Fishponds and Lo'i*. Video series Title #295868 Format: DVD-R

Kennedy, J.J. 2011. *Evaluation of Anthropogenic Impacts on the Flow of Two Coastal Springs in Maunalua Bay, South Shore, Oʻahu*. Master's Thesis, University of Hawaiʻi at Mānoa.

Kikuchi, W. 1973. *Hawaiian Aquaculture Systems.* Doctoral dissertation. Tucson, University of Arizona.

Klasner, F.L and C.D., Mikami, 2003. *Land Use on the Island of O'ahu.* U.S. Geological Survey Water-Resources Investigations Report 02-4301

Lowe S., Browne M., Boudjelas S., De Poorter M., 2000. *100 of the World's Worst Invasive Alien Species, A selection from the Global Invasive Species Database*. Invasive Species Specialist Group (ISSG) a specialist group of the Species Survival Commission (SSC) of the World Conservation Union (IUCN), 12pp. Updated and reprinted version: November 2004.

MacDonald, G.A., Abbott, A.T., and F.L. Peterson. 1983. *Volcanoes in The Sea.* Honolulu, University of Hawai'i Press.

Maly, K. and H. Wong Smith. 1998. *Documentary Research: Koko Head Regional Park and Nature* Preserve. Hilo, Kumo Pono Associates.

Mathison, Gilbert. 1825. *Narrative of a visit to Brazil, Chile, Peru, and the Sandwich Islands, during the years 1821 and 1822*. 1825. London, Charles Knight.

Murray, B.R., G.C. Hose, D. Eamus, and D. Licari. 2006. Valuation of groundwater- dependent ecosystems: A functional methodology incorporating ecosystem services. *Australian Journal of Botany* 54(2): 221–229.

National Oceanic and Atmospheric Administration (NOAA) National Weather Service Forecast Office, 2015. Hydronet rain gauge data for NIUH1 rain gage. Accessed at http://www.prh.noaa.gov/hnl/hydro/pages/oahu_ytd_12.gif.

Moberly, R., Cox, D.C., Chamerlain, T., McCoy, F.W.and J.F. Campbell, 1963. *Coastal Geology of Hawaii*. Accessed at https://www.gpo.gov/fdsys/pkg/CZIC-qe500-h35-no-41/html/CZIC-qe500-h35-no-41.htm

Portlock, Nathaniel *A Voyage Round the World But more particularly to the North-West Coast of America: Performed in 1785, 1786, 1787 and 1788 in the King George and Queen Charlotte.* London

State of Hawai'i Critical Habitats - online database. Accessed March 5, 2015 at http://files.hawaii.gov/dbedt/op/gis/maps/all_crhb_map.pdf.

Stearns, H.T., and K.N. Vaksvik, 1935, *Geology and ground-water resources of the Island of O'ahu,* Hawai'i. Territory of Hawai'i, Division of Hydrography Bulletin 1 (Prepared in cooperation with the U.S. Geological survey). Maui Publishing Co.

Stender, K. 2015. *Aquatic Inventory, Kalauha'iha'i Fishpond.* Honolulu.

Storlazzi, C.D., Presto, M.K., Logan, J.B., and M.E. Field. 2010 *Coastal Circulation and Sediment Dynamics in Maunalua Bay, Oʻahu, Hawaiʻi. Measurements of Waves, Currents, Temperature, Salinity, and Turbidity: November 2008–February 2009.* U.S. Geological Survey Publication.

Summers, C. 1964. *Hawaiʻi Fishponds*. Honolulu, Bishop Museum Press.

Takemoto, A.H., Joerger, P. K., Mitchell, M. F., and C. E. Bareng. 1975. *Historical/Cultural Essay on the Kuapā Pond Area*. Honolulu, HI: U.S. Army Corps of Engineers.

Town Charts 2015. Census Bureau Statistics website. Accessed March 24, 2015 at http://www.towncharts.com/Hawaii/Economy/East-Honolulu-CDP-HI-Economy-data.html

U.S. Climate Data website 2015. Accessed at: http://www.usclimatedata.com/climate/honolulu/hawaii/unitedstates/ushi0026/2014/1.

U.S. Fish and Wildlife Service surveys of Critical Habitats - Accessed March 5, 2015 at http://ecos.fws.gov/ecp/report/table/critical-habitat.html.

U.S. Geological Survey. 1996. *Geohydrology of the Island of Oʻahu*, Professional Paper 1412B accessed at: http://pubs.usgs.gov/pp/1412b/report.pdf

Wyban, C.A., 1992. *Tide and Current: Fishponds of Hawai'i*. Honolulu, University of Hawaiʻi Press.

Appendices:

Kalauha‘iha‘i Fishpond Management Plan

Draft Environmental Assessment

MAUNALUA FISHPOND
HERITAGE
CENTER

Appendix 9.1:

Aquatic Inventory by Keoki Stender

Aquatic Survey of Kalauha'iha'i Fishpond

December 27, 2013

Keoki Stender

Marine Life Photography

www.marinelifephotography.com

Summary:

An evening snorkel survey of Kalauha'iha'i pond on December 12, 2013 resulted in no sightings of native animals except for a few awa (*Chanos chanos*) which were only seen from above the surface.

The pond bottom is silt over ancient reef and scattered basalt stones with no obvious freshwater input source. Several small tunnels under the mauka retaining wall also showed no signs of input.

The mud bottom was densely populated by invasive Red-rim Melanella snails (*Melanoides tuberculata)* that emerge after sunset to feed upon green algal clumps (Cladophora sp.) growing on rocks. The pond is also full of blackchin tilapia (*Sarotherodon melanotheron*), and presence of many 1 inch juveniles indicates there is a breeding population. Inspection of the retaining walls yielded no shrimp.

I would expect the health of Kalauha'iha'i to gradually improve if freshwater input and connection to the ocean are restored. It is possible that adjacent reef life would also benefit from restored freshwater flow cut off since highway expansion. Positive results observed at Kanewai could be realized here with time and effort. It is a shame to see this historic site in such a degraded state.

Red Rim Melania- (Invasive)
http://www.marinelifephotography.com/marine/mollusks/gastropods/freshwater/melanoides-tuberculata.htm

Black Chin Tilapia (Invasive)

http://www.marinelifephotography.com/fishes/damselfishes/sarotherodon-melanotheron.htm

Appendix 9.2:
Archaeological Field Inspection
by Cultural Surveys Hawai‘i

Draft
Archaeological Literature Review and Field Inspection with Cultural Study for the Kalauhaʻihaʻi Fishpond Management Plan and Environmental Assessment
Niu Ahupuaʻa, Honolulu (Kona) District, Oʻahu
TMKs: [1] 3-7-002:018 and 077

Prepared for
Maunalua Fishpond Heritage Center

Prepared by
Nicole Ishihara, B.A.,
Victoria Creed, Ph.D.,
Brittany Beauchan, M.A.,
Gina M. Farley, M.A.,
and
Hallett H. Hammatt, Ph.D.

Cultural Surveys Hawaiʻi, Inc.
Kailua, Hawaiʻi
(Job Code: NIU 2)

May 2016

Oʻahu Office
P.O. Box 1114
Kailua, Hawaiʻi 96734
Ph.: (808) 262-9972
Fax: (808) 262-4950

www.culturalsurveys.com

Maui Office
1860 Main St.
Wailuku, Hawaiʻi 96793
Ph.: (808) 242-9882
Fax: (808) 244-1994

Management Summary

Reference	Archaeological Literature Review and Field Inspection with Cultural Study for the Kalauha‘iha‘i Fishpond Management Plan and Environmental Assessment, Niu Ahupua‘a, Honolulu (Kona) District, O‘ahu, TMKs: [1] 3-7-002:018 and 077 (Ishihara et al. 2016)
Date	May 2016
Project Number(s)	Cultural Surveys Hawai‘i, Inc. (CSH) Job Code: NIU 2
Investigation Permit Number	CSH completed the fieldwork component of this study under archaeological fieldwork permit number 16-26, issued by the Hawai‘i State Historic Preservation Division (SHPD) per Hawai‘i Administrative Rules (HAR) §13-13-282.
Agencies	State of Hawai‘i Department of Land and Natural Resources/State Historic Preservation Division (SHPD); State of Hawai‘i Department of Health/Office of Environmental Quality Control (DOH/OEQC)
Land Jurisdiction	State of Hawai‘i Department of Land and Natural Resources
Project Proponent	Maunalua Fishpond Heritage Center
Project Location	The project area is located within Niu Ahupua‘a *makai* (toward the ocean) of Kalaniana‘ole Highway and consists of two private residences owned by the State of Hawai‘i – DLNR. The project area is depicted on a portion of the 1999 Koko Head U.S. Geological Survey (USGS) 7.5-minute topographic quandrangle.
Project Description	Kalauha‘iha‘i Fishpond is located along the Niu shoreline, bounded by Kalaniana‘ole Highway to the north and Maunalua Bay to the south. Private, single-family residences are to the east and west of the fishpond. The site is a residential lot with three dilapidated structures measuring approximately 10,827 square feet (sq ft). The residential structures are scheduled to be removed by the landowner in 2016. The project entails a long-range management plan for the Kalauha‘iha‘i Fishpond site consisting of activities for conservation, biological and cultural revitalization, education, and scientific research at Kalauha‘iha‘i. The management plan for Kalauha‘iha‘i will be implemented by the Maunalua Fishpond Heritage Center, a 501(c)3 non-profit organization, through a community-based effort that involves schools, residents, Native Hawaiian cultural practitioners, scientists, and others.
Project Acreage	The project area is approximately 10,827 sq ft (0.24 acres).
Area of Potential Effect (APE)	For the purposes of this archaeological reconnaissance, the APE for this project is defined as the entire 10,827 sq ft (0.24 acres).

Document Purpose	This investigation was designed—through detailed historical, cultural, and archaeological background research and a field inspection of the project area—to determine the likelihood that historic properties may be affected by the project, and, based on findings, consider cultural resource management recommendations. This document is intended to facilitate the project’s planning and support the project’s historic preservation and environmental review compliance. This investigation does not fulfill the requirements of an archaeological inventory survey investigation, per HAR §13-13-276. Consequently, this report cannot be used to make formal recommendations for SHPD review and acceptance. The cultural study was prepared to comply with the State of Hawai‘i’s environmental review process under Hawai‘i Revised Statutes (HRS) §343, which requires consideration of the proposed project’s potential effect on cultural beliefs, practices, and resources. Through document research, this report provides information compiled to date pertinent to the assessment of the proposed project’s potential impacts to cultural beliefs, practices, and resources (pursuant to the Office of Environmental Quality Control’s *Guidelines for Assessing Cultural Impacts*) which may include traditional cultural properties (TCPs). These TCPs may be significant historic properties under State of Hawai‘i significance criterion “e,” pursuant to HAR §13-275-6 and §13-284-6. Significance criterion “e” refers to historic properties that “have an important value to the native Hawaiian people or to another ethnic group of the state due to associations with cultural practices once carried out, or still carried out, at the property or due to associations with traditional beliefs, events or oral accounts—these associations being important to the group’s history and cultural identity” (HAR §13-275-6 and §13-284-6). The document will likely also support the project’s historic preservation review under HRS §6E and HAR §13-275 and §13-284. The document is intended to support the project’s environmental review and may also serve to support the project’s historic preservation review under HRS §6E-8 and HAR §13-284.
Fieldwork Effort	A field inspection of the project area was conducted on 20 May 2016 by Brittany Beauchan, M.A., and David Shideler, M.A., under the overall supervision of Hallett H. Hammatt, Ph.D. (principal investigator). Fieldwork consisted of documenting the current conditions of the project area with photographs and GPS location data. This fieldwork required 1 person-day to complete.
Results of Background Research	Background for this project yielded the following results (presented in approximate chronological order): 1. Niu literally means “coconut” (Pukui et al. 1974:166). Frank (1958:22) stated that the name was given to the *ahupua‘a* (land

	division usually extending from the uplands to the sea) after a women who husked coconuts. 2. Several springs are located in Niu Ahupua‘a including Papalea (located near the Wailupe Ahupua‘a border) and Lucas Spring, which is part of the current project area. The traditional name for Lucas Spring is unknown, however, it was named after the Lucas family who owned the land. 3. An ancient trail once led from the coast into Niu, towards the Ko‘olau Mountains, and down into the windward side of the island. The trail went through the valley of Kaiiliili-iki, possibly another name for Pia or Kupaua Valley, the two valleys that are separated by Kūlepeamoa Ridge (Sterling and Summers 1978:274). 4. Niu Ahupua‘a consisted of two fishponds: Kūpapa and Kalauha‘iha‘i. Kūpapa Fishpond (also known as Niu Pond) was later covered and became a roadway (Niuiki Circle) and residential area. 5. LCA documents indicate four claims were made for Niu Ahupua‘a, however, only one was awarded. LCA 802 was awarded to Captain Alexander Adams. The Niu lands awarded to Captain Adams consisted of 2,446 acres and were eventually passed down to his granddaughter, Mary Papapaupu Bannister Lucas. 6. Archival documents state that Niu lands were given to Captain Adams “just before the coming of the first New England missionaries in 1820, as a reward for thwarting an attempted Russian invasion of the Island of Kauai in 1815.” The property is very significant in that it was once the country home of Kamehameha the Great and Ka‘ahumanu and was also the site of the “great Kaluhaihai assembly was held in 1919, when the ancient tabu laws were broken on Oahu.” 7. Kalauha‘iha‘i later became the site of a dairy owned and operated by Charles Lucas and his son, Charles W. Lucas. 8. An affidavit submitted by Laura Lucas Thompson, a direct descendant of Alexander Adams and fifth generation resident of Niu, states that her father owned and operated Niu Dairy. The milk barn, cattle pens, and grass fields are now in the area known as Niu Estates. Water for the dairy was pumped out of a well located at the bottom of Kūlepeamoa. Although she was not allowed to swim in the well, she recalls two dairy workers swimming in the well and locating two “tunnels” (lava tubes) as the water source. 9. Tad Hara, a former resident who lived above Kalauha‘iha‘i, recalls raising prize winning koi in the pond. In addition to his

	koi, other aquatic life such as wild mullet, prawns, and crabs could be found in Kalauha‘iha‘i Pond. 10. State Inventory of Historic Places (SIHP) # 50-80-15-5084 consists of a subsurface human burial (Minimum Number of Individuals [MNI]: 1) and associated burial pit (Putzi et al. 1996f cited in Putzi et al. 1998:55). The recovered human skeletal remains associated with SIHP # -5084 were “returned to representatives of the State Historic Preservation Division (SHPD) Burials Program of the Department of Land and Natural Resources,” and relocated (Putzi et al. 1998:109). SIHP # -5084 was immediately northeast of the project area, within the *makai* (toward the ocean) sidewalk easement of Kalaniana‘ole Highway. 11. A field inspection of the project area was conducted and one potential cultural resource was identified: Kalauha‘iha‘i Pond consists of the fishpond and associated fishpond features. Feature 1 consists of a basalt stone and mortar *kuapā* (wall of fishpond) marking the limits of and partially enclosing the freshwater pond. Feature 2 consists of a basalt stone and mortar *‘auwai* (ditch or channel) and the concrete remnants of two *mākāhā* (sluice gates) located at the northern (*mauka*, toward the mountain) and southern (*makai*) end of the *‘auwai*. Kalauha‘iha‘i Pond is located within TMKs: [1] 3-7-002:018 and 077 and occupies approximately 368 sq m within the project area. Based on information provided by Maunalua Fishpond Heritage Center, Kalauha‘iha‘i Pond is one of only six remaining fishponds on O‘ahu, and is currently in the process of being revitalized and returned to a functional fishpond. Additionally, one subsurface cultural resource initially documented by Putzi et al. (1998) is located in the immediate vicinity of the project area.
Recommendations	Based on the information gathered from archival documents, previous archaeological reports, previous oral histories focusing on the project area, and field inspection, CSH recommends the following: 1. Consultation with the SHPD to request a State Inventory of Historic Properties (SIHP) number for Kalauha‘iha‘i Fishpond and the associated fishpond features. 2. The preservation of the Kalauha‘iha‘i Fishpond wall and *‘auwai*. 3. Consultation with the SHPD regarding a preservation plan in compliance to HAR 13-277-3. 4. Consultation with the SHPD regarding a monitoring program for the demolition of two house structures within the current project.

Table of Contents

Management Summary ii

Section 1 Introduction 1

1.1 Project Background 1
1.2 Document Purpose 1
1.3 Scope of Work 2
1.4 Environmental Setting 2
1.4.1 Natural Environment 2
1.4.2 Winds and Rains of Niu 6
1.4.3 Built Environment 8

Section 2 Methods 10

2.1 Field Methods 10
2.2 Archival Research 10

Section 3 *Ka‘ao* and *Mo‘olelo* (Legends and Stories) 11

3.1 *Ka‘ao* and *Mo‘olelo* of Niu 11
3.1.1 Hi‘iaka Travels through Southeastern O‘ahu 11
3.2 *Wahi Pana* (Storied Places) 12
3.3 *‘Ōlelo No‘eau* (Traditional Sayings) 14
3.3.1 *‘Ōlelo No‘eau* #1413 14

Section 4 Traditional and Historical Accounts 19

4.1 Traditional Accounts 19
4.2 Early Historic Period 20
4.3 The Māhele and the Kuleana Act 21
4.4 Late 1800s 26
4.5 1900s 28
4.6 Previous Oral Histories 34
4.6.1 Laura Lucas Thompson 34
4.6.2 Tad Hara 34
4.7 Previous Archaeological Research 37
4.7.1 McAllister 1933 42
4.7.2 Emory and Sinoto 1961 43
4.7.3 Soehren 1964 43
4.7.4 Dye 1977 43
4.7.5 McMahon 1988 43
4.7.6 Dixon 1993 43
4.7.7 Erkelens and Athens 1994 44
4.7.8 Putzi et al. 1998 44
4.7.9 Hazlett and Hammatt 2008 44

Section 5 Field Inspection Results 45

Section 6 Traditional Cultural Practices 69

6.1 *Ka‘ao* and *Mo‘olelo* 69
6.2 *Wahi Pana* 69

6.3 Burials 70
6.4 Settlement Patterns and Cultivation 70

Section 7 Summary and Recommendations 72

7.1 Results of Background Research 72
7.2 Recommendations 73

Section 8 References Cited 74

Appendix A LCA 802 79

Appendix B Affidavit from Laura Lucas Thompson 84

List of Figures

Figure 1. Portion of the 1999 Koko Head USGS 7.5-minute topographic quadrangle showing the location of the project area 3
Figure 2. Tax Map Key (TMK) [1] 3-7-002 showing the project area (Hawai‘i TMK 2014) 4
Figure 3. Aerial photograph showing the location of the project area (Google Earth 2013) 5
Figure 4. Overlay of *Soil Survey of the State of Hawaii* (Foote et al. 1972), indicating soil types within and surrounding the project area (U.S. Department of Agriculture Soils Survey Geographic Database [SSURGO] 2001) 7
Figure 5. Aerial photo of project area (center) facing *makai* (courtesy of client) 9
Figure 6. Aerial photo with Kalauha‘iha‘i Fishpond in the right foreground; note the former location of Kupapa Fishpond to the left background (courtesy of client) 9
Figure 7. Photo of remnants of Kūlepeamoa Heiau in Niu Ahupua‘a, n.d. 13
Figure 8. Painting by John B. Dale titled *Burial Cave Valley of Niu*, ca. 1845 (J. Welles Henderson Collection) 15
Figure 9. Photo of Kupapa Fishpond and the Niu Ahupua‘a coastline, ca. 1925 (Hawai‘i State Archives) 16
Figure 10. Photo of Kalauha‘iha‘i Pond, also known as Lucas Pond, n.d. (Historic Hawai‘i Foundation) 17
Figure 11. 2011 USGS Orthoimagery Aerial Photograph with hillshade depicting project area with place names and *wahi pana* 18
Figure 12. 1855 LaPasse map of the south coast of O‘ahu depicting project area and nearby fisheries 22
Figure 13. 1883 Jackson map of Waialae Coast, Diamond Head to Koko Head, with project area; note that nearby Kupapa Fishpond is no longer in use 23
Figure 14. 1913 Monsarrat Map of Oahu Fisheries, Waialae Section with project area; note that the Niu fishery is owned by the Lucas family as noted 25
Figure 15. 1919 U.S. Army War Department fire control map, Koko Head quadrangle; note the boundary walls for Niu Ahupua‘a that run *mauka* to *makai*; neighboring Kupapa Fishpond also has a wall that surrounds the *makai* perimeter 27
Figure 16. 1927 File Plan 279, Niu Beach Lots with project area shaded in red; a pond is noted within the property and includes an outlet to the south of the project area 29
Figure 17. 1934 U.S. Army War Department fire control map, Koko Head quadrangle with project area; a boundary wall marker for Niu Ahupua‘a can be found to the east bordering Kuli‘ou‘ou; Kupapa Fishpond has now been filled in 30
Figure 18. 1943 U.S. Army War Department terrain map, Diamond Head quadrangle with project area; portions of the wall that bordered Niu and Kuli‘ou‘ou Ahupua‘a are still intact; Kalaniana‘ole Highway is outlined in red and runs west to east 31
Figure 19. Portion of 1952 Koko Head USGS topographic quadrangle with project area; the boundary wall that bordered Niu and Kuli‘ou‘ou Ahupua‘a is no longer present on the map; private residences can be found along Kalaniana‘ole Highway and in both Niu and Kuli‘ou‘ou Valley 32
Figure 20. Portion of 1969 Koko Head USGS topographic quadrangle with project area in green; the former Kupapa Fishpond is now Niuiki Circle; both Niu and Kuli‘ou‘ou Valley now include a multitude of streets, businesses, and a school 33

Figure 21. Photo of Kalauha‘iha‘i and wall surrounding the pond, n.d. (courtesy of Laura Lucas Thompson).....35
Figure 22. Photo of cows drinking water in Niu Ahupua‘a, as described by Laura Lucas Thompson (courtesy of Laura Lucas Thompson).....36
Figure 23. Previous archaeological studies in the vicinity of the project area 38
Figure 24. Historic properties in the vicinity of the project area.....40
Figure 25. Aerial photograph depicting the locations of features associated with Kalauha‘iha‘i Fishpond (CSH 1) observed during the field inspection (Google Earth 2013).....46
Figure 26. Aerial photograph of Kalauha‘iha‘i Fishpond, Kalaniana‘ole Highway, and Koko Head Crater, view to east (courtesy Maunalua Fishpond Heritage Center) 47
Figure 27. General view of Kalauha‘iha‘i Fishpond, view to southwest.....48
Figure 28. General view of Kalauha‘iha‘i Fishpond wall, view to northeast.....48
Figure 29. General view of *‘auwai* and existing historic-era structure, view to north 49
Figure 30. General view of *makai mākāhā*, view to southwest.....50
Figure 31. General view of existing *mauka* structure; structure originally the private residence of Mr. Tad Hara, view to northeast.....51
Figure 32. General view of garage structure, view to northwest.....52
Figure 33. General view of existing *makai* structure, view to south 53
Figure 34. General view of the *makai* sidewalk easement of Kalaniana‘ole Highway and the general location of SIHP # -5084 (burial) documented by Putzi et al. (1998), view to west.....54
Figure 35. General view toward Kalaniana‘ole Highway and its sidewalk easement; elevated approximately 2.5 to 3 m above the interior portion of the project area, view to north.....55
Figure 36. Southwest (*makai*, ‘Ewa) section of fishpond, view to southwest.....57
Figure 37. Southeast (*makai*, Koko Head) section of fishpond, view to east.....58
Figure 38. Northwest (*mauka*, *‘Ewa*) section of fishpond, view to northwest 59
Figure 39. Northeast (*mauka*, Koko Head) section of fishpond, view to northeast.....60
Figure 40. Northern (*mauka*) *mākāhā*, view to northwest.....61
Figure 41. Northern (*mauka*) *mākāhā*, view to northeast.....62
Figure 42. Oblique view of northern (*mauka*) portion of *‘auwai* and cast iron utility, view to northwest.....63
Figure 43. Profile view of central portion of *‘auwai*, view to east.....63
Figure 44. Plan view of concrete posts for southern (*makai*) *mākāhā*, view to east 64
Figure 45. Close up of concrete posts for southern (*makai*) *mākāhā*, view to west.....65
Figure 46. Location of the spring (marked by photo scale) responsible for supplying freshwater to Kalauha‘iha‘i Pond, view to north.....66
Figure 47. General view of area *mauka* of Kalaniana‘ole Highway and the general location of the lava tube feeding Kalauha‘iha‘i Pond spring; note truncated lava tube in far right middle ground, view to northwest.....68

List of Tables

Table 1. Previous Archaeological Studies in the Vicinity of the Project Area.....39
Table 2. Historic Properties Identified in the Project Area Vicinity.....41

Section 1 Introduction

1.1 Project Background

At the request of Maunalua Fishpond Heritage Center, Cultural Surveys Hawai‘i, Inc. (CSH) has prepared this literature review and field inspection report (LRFI) with cultural study for the Kaluaha‘iha‘i Fishpond Management Plan and Environmental Assessment, Niu Ahupua‘a, Honolulu (Kona) District, O‘ahu Island, TMKs: [1] 3-7-002:018 and 077. The project area consists of two private residences owned by the State of Hawai‘i – Department of Land and Natural Resources (DLNR) and is *makai* (towards the ocean) of Kalaniana‘ole Highway. The project area is depicted on a portion of the year area U.S. Geological Survey (USGS) 7.5-minute topographic quadrangle (Figure 1), a tax map plat (Figure 2), and a year aerial photograph (Figure 3).

Kalauha‘iha‘i Fishpond is located along the Niu shoreline, bounded by Kalaniana‘ole Highway to the north and Maunalua Bay to the south. Private, single-family residences are to the east and west of the fishpond. The site is a residential lot with three dilapidated structures measuring approximately 10,827 square feet (sq ft). The residential structures are scheduled to be removed by the landowner in 2016.

The project entails a long-range management plan for the Kalauha‘iha‘i Fishpond site, consisting of activities for conservation, biological and cultural revitalization, education, and scientific research at Kalauha‘iha‘i. The management plan for Kalauha‘iha‘i will be implemented by the Maunalua Fishpond Heritage Center, a 501(c)3 nonprofit organization, through a community-based effort that involves schools, residents, Native Hawaiian cultural practitioners, scientists, and others.

1.2 Document Purpose

This investigation was designed—through detailed historical, cultural, and archaeological background research and a field inspection of the project area—to determine the likelihood that historic properties may be affected by the project and, based on findings, consider cultural resource management recommendations. This document is intended to facilitate the project’s planning and support the project’s historic preservation and environmental review compliance. This investigation does not fulfill the requirements of an archaeological inventory survey investigation, per HAR §13-13-276. Consequently, this report cannot be used to make formal recommendations for SHPD review and acceptance.

The cultural study was prepared to comply with the State of Hawai‘i’s environmental review process under Hawai‘i Revised Statutes (HRS) §343, which requires consideration of the proposed project’s potential effect on cultural beliefs, practices, and resources. Through document research, this report provides information compiled to date pertinent to the assessment of the proposed project’s potential impacts to cultural beliefs, practices, and resources (pursuant to the Office of Environmental Quality Control’s *Guidelines for Assessing Cultural Impacts*) which may include traditional cultural properties (TCPs). These TCPs may be significant historic properties under State of Hawai‘i significance criterion “e,” pursuant to Hawai‘i Administrative Rules (HAR) §13-275-6 and §13-284-6. Significance criterion “e” refers to historic properties that “have an important value to the native Hawaiian people or to another ethnic group of the state due to

associations with cultural practices once carried out, or still carried out, at the property or due to associations with traditional beliefs, events or oral accounts—these associations being important to the group’s history and cultural identity” (HAR §13-275-6 and §13-284-6). The document will likely also support the project’s historic preservation review under HRS §6E and HAR §13-275 and §13-284. The document is intended to support the project’s environmental review and may also serve to support the project’s historic preservation review under HRS §6E-8 and HAR §13-284.

1.3 Scope of Work

The scope of work for this LRFI with cultural study includes the following:

1. Examination of cultural and historical resources, including Land Commission documents, historic maps, and previous research reports with the specific purpose of identifying traditional Hawaiian activities including gathering of plant, animal, and other resources or agricultural pursuits as may be indicated in the historic record.
2. Review of previous archaeological work at and near the subject parcel that may be relevant to reconstructions of traditional land use activities; and to the identification and description of cultural resources, practices, and beliefs associated with the parcel.
3. Consultation and interviews with knowledgeable parties regarding cultural and natural resources and practices at or near the parcel; present and past uses of the parcel; and/or other practices, uses, or traditions associated with the parcel and environs.
4. Preparation of a report that summarizes the results of these research activities and provides recommendations based on findings.

1.4 Environmental Setting

1.4.1 Natural Environment

The project area is in the *ahupua‘a* (land division usually extending from the uplands to the sea) of Niu, bounded by the *ahupua‘a* of Wailupe to the west and Kuli‘ou‘ou Ahupua‘a to the east. On the north-south axis it extends from the coast to the base of the Ko‘olau Mountains. Niu Valley is a Y-shaped valley, bifurcated by Kūlepeamoa Ridge; the western valley is called Pia (“arrowroot”; *Tacca leontopetaloides*), while the eastern valley is called Kūpaua (“upright calm”); both are watered by branches of Kūpaua Stream. At the coast was a man-made shore pond, called Kūpapa Fishpond. This fishpond is now filled in, now covered by the Niuiki circle traffic turnaround. There were also two springs near the coast, Papalea Spring, near the boundary to the west with Wailupe, and Lucas Spring, at the boundary to the east with Kuli‘ou‘ou..

According to the U.S. Department of Agriculture (USDA) Soil Survey Geographic (SSURGO) database (2001) and soil survey data gathered by Foote et al. (1972), the project area’s soils consist of Jaucas sand, 0 to 15% slopes (JaC) and Keaau clay, 0 to 2% slopes (KmA) (Figure 4). Jaucas soils are described as follows:

> The slope range of this soil is 0 to 15 percent, but in most places the slope does not exceed 7 percent. Included in mapping were narrow strips of Beaches and areas of Pulehu, Mokuleia, and Keaau soils.

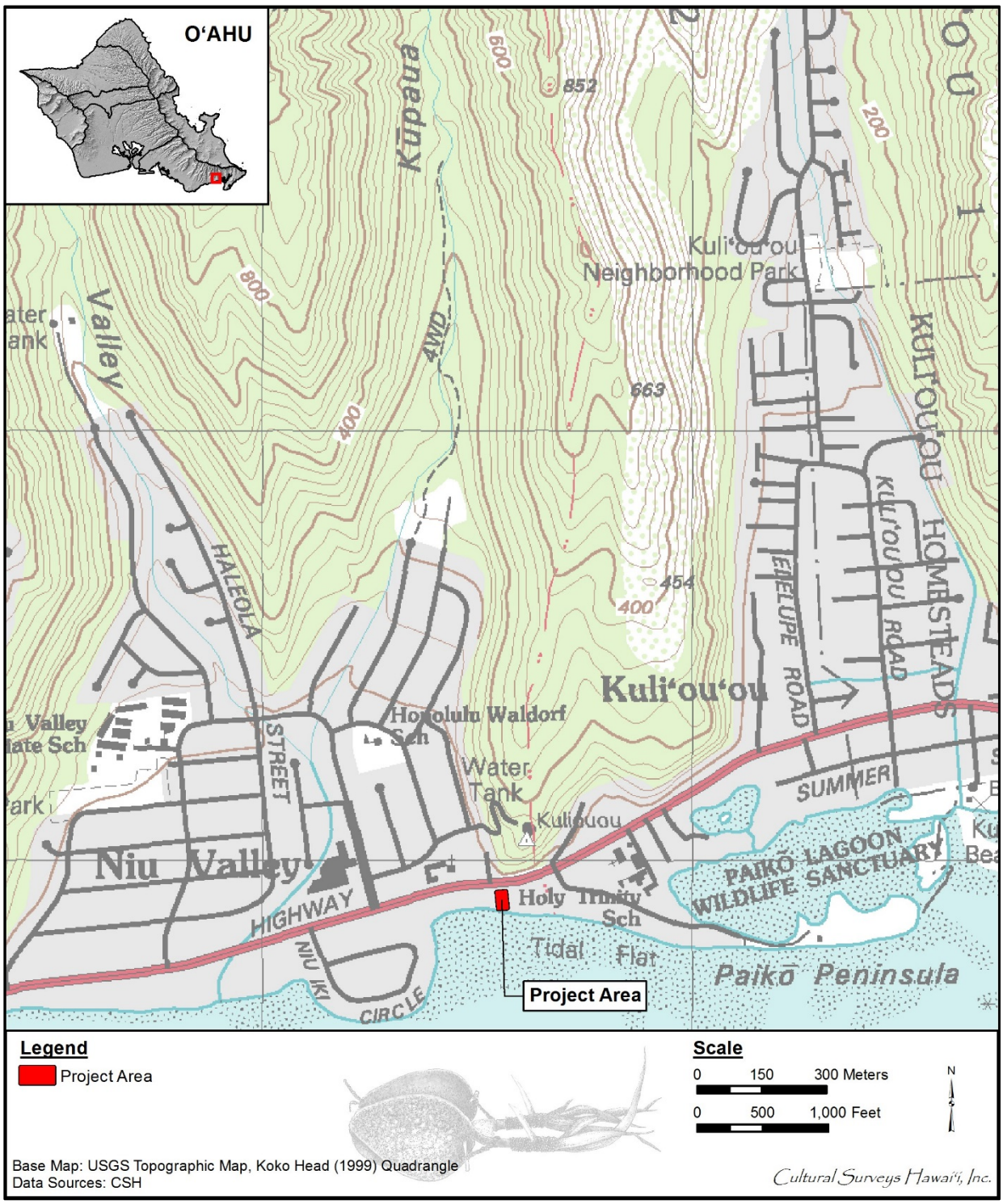


Figure 1. Portion of the 1999 Koko Head USGS 7.5-minute topographic quadrangle showing the location of the project area

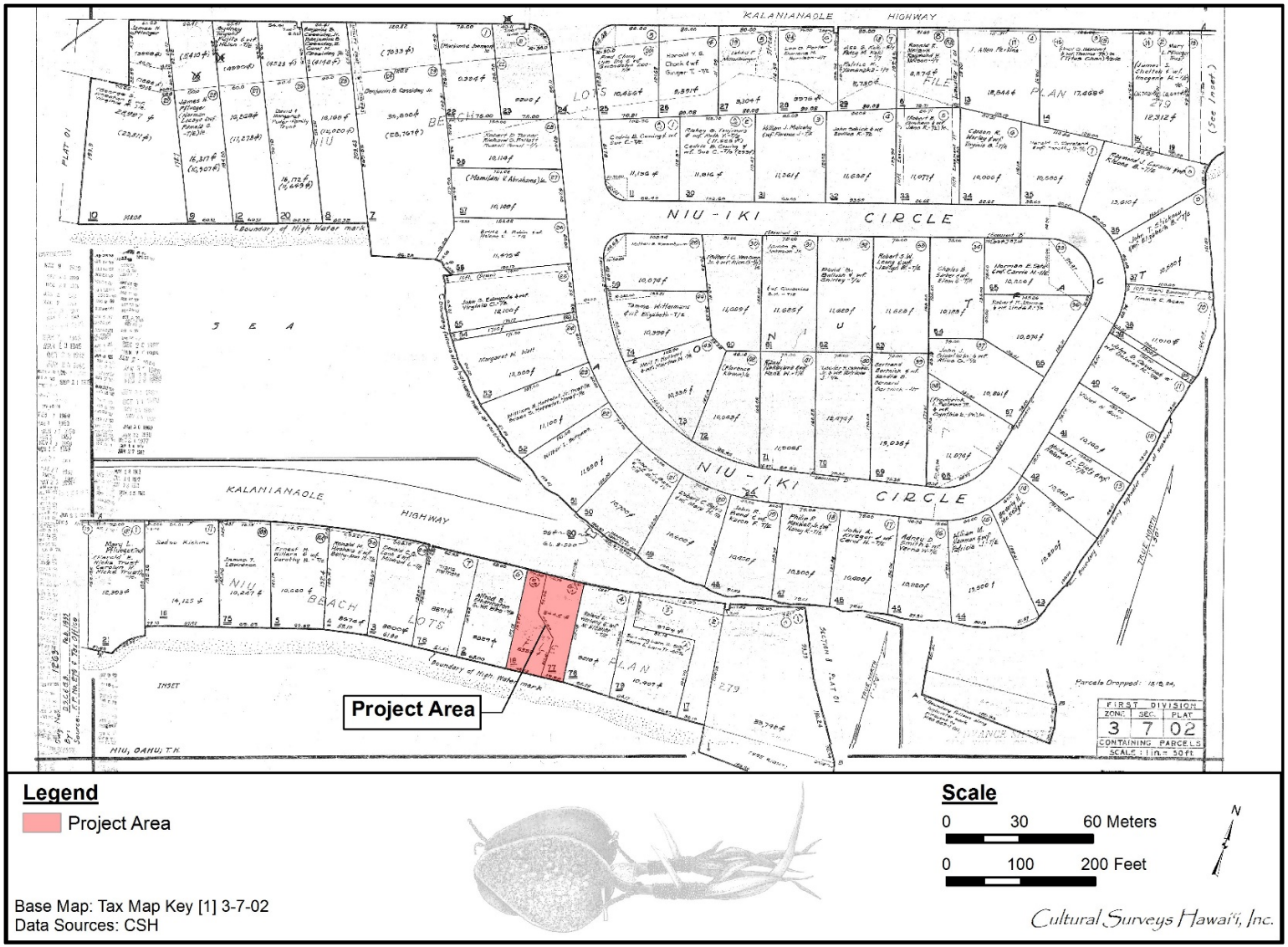


Figure 2. Tax Map Key (TMK) [1] 3-7-002 showing the project area (Hawai‘i TMK 2014)

Figure 3. Aerial photograph showing the location of the project area (Google Earth 2013)

> In a representative profile the soil is single grain, pale brown to very pale brown, sandy, and more than 60 inches deep. In many places the surface layer is dark brown as a result of accumulation of organic matter and alluvium. The soil is neutral to moderately alkaline throughout the profile.
>
> Permeability is rapid, and runoff is very slow to slow. The hazard of water erosion is slight, but wind erosion is a severe hazard where vegetation has been removed. The available water capacity is 0.5 to 1.0 inch per foot of soil. In places roots penetrate to a depth of 5 feet or more. Workability is slightly difficult because the soil is loose and lacks stability for use of equipment. [Foote 1972:48]

For archaeological purposes Jaucas sand is the sediment most likely to contain Native Hawaiian burials.

The Keaau Series of soils are described below:

> This series consists of poorly drained soils on coastal plains on the island of Oahu. These soils are developed in alluvium deposited over reef limestone or consolidated coral sand. They are nearly level and gently sloping. Elevations range from 5 to 40 feet. The annual rainfall amounts to 20 to 35 inches. Most of the rainfall occurs between November and April. The mean annual soil temperature is 73° F. Keaau soils are geographically associated with Kaloko, Mokuleia, and Pearl Harbor soils.
>
> These soils are used for sugarcane and pasture. The natural vegetation consists of kiawe, bermudagrass, bristly foxtail, and fingergrass. [Foote et al. 1972:65]

1.4.2 Winds and Rains of Niu

Each geographic area had a Hawaiian name for its own wind, rain, and seas. The name of the winds of O‘ahu are listed in a chant concerning a powerful gourd called *The Wind Gourd of La‘amaomao*. When the gourd was opened, a specific wind could be called. Below are the winds of the area:

> It’s the wind that blows inside Hanauma,
>
> A wind from the mountains that darkens the sea,
>
> It’s the wind that tosses the kapa of Paukua,
>
> Puuokona is of Kuli‘ou‘ou,
>
> Ma-ua is the wind of Niu,
>
> Holouhā is of Kekaha [Nakuina 1992:50]

In addition to winds having names, rains also did. Places could have several types of rain, all named differently and distinct from another. Rains also varied by duration, intensity, the way it traveled, and other characteristics.

> Aia ma Wailupe, he wahi e kapa ‘ia nei ka inoa ‘o Kauoha . . . ua kūkulu ‘ia kekahi mau hale nui no kekahi mau ali‘ino Kapueo a me Kepo‘onui, ua makemake loa kēia mau ali‘i i ia wahi, no ka ‘olu‘olu maika‘i o ka makani he Mālualua…kūkulu kala‘ihi a ka ua Hōli‘o i ua mau wahi ‘elemākule nei.

Figure 4. Overlay of *Soil Survey of the State of Hawaii* (Foote et al. 1972), indicating soil types within and surrounding the project area (U.S. Department of Agriculture Soils Survey Geographic Database [SSURGO] 2001)

> *At Wailupe is a place called Kauoha . . . several large houses were built for chiefs, for Kapueo and Kepo‘onui. These chiefs really liked this place because of the perfect coolness of the wind, a Mālualua . . . these old men were oppressed by the Hōli‘o rain.* [Akana and Gonzalez 2016:38–39]

1.4.3 Built Environment

The project area consists of two private residences owned by the State of Hawai‘i—Department of Land and Natural Resources (DLNR) and is bound by Kalaniana‘ole Highway to the north, Maunalua Bay to the south, and private residences to the east and west (Figure 5 and Figure 6).

Figure 5. Aerial photo of project area (center) facing *makai* (courtesy of client)

Figure 6. Aerial photo with Kalauha‘iha‘i Fishpond in the right foreground; note the former location of Kupapa Fishpond to the left background (courtesy of client)

Section 2 Methods

2.1 Field Methods

This LRFI was carried out under archaeological fieldwork permit number 16-26 issued to CSH by the SHPD per HAR §13-13-282.

A field inspection of the project area was conducted 20 May 2016 by Brittany Beauchan, M.A., and David Shideler, M.A., under the overall supervision of Hallett H. Hammatt, Ph.D. (principal investigator). This fieldwork required 1 person-day to complete.

In general, the purpose of the field inspection was to identify any surface archaeological features and to investigate and assess the potential for impact to such sites. Fieldwork consisted of a pedestrian reconnaissance of the project area, GPS data collection, and photographic documentation of the landscape.

2.2 Archival Research

Research centers on Hawaiian activities including *ka‘ao* (legends), *wahi pana* (storied places), *‘ōlelo no‘eau* (proverbs), *oli* (chants), *mele* (songs), traditional *mo‘olelo* (stories), traditional subsistence and gathering methods, ritual and ceremonial practices, and more. Background research focuses on land transformation, development, and population changes beginning with the early post-Contact era to the present day.

Cultural documents, primary and secondary cultural and historical sources, historic maps, and photographs were reviewed for information pertaining to the study area. Research was primarily conducted at the CSH library. Other archives and libraries including the Hawai‘i State Archives, the Bishop Museum Archives, the University of Hawai‘i at Mānoa’s Hamilton Library, Ulukau, The Hawaiian Electronic Library (Ulukau.org 2014), the State Historic Preservation Division (SHPD) Library, the State of Hawai‘i Land Survey Division, the Hawaiian Historical Society, and the Hawaiian Mission Houses Historic Site and Archives are also repositories where CSH cultural researchers gather information. Information on Land Commission Awards (LCAs) were accessed via Waihona ‘Aina Corporation’s Māhele database (Waihona ‘Aina 2000), the Office of Hawaiian Affairs (OHA) Papakilo Database (Office of Hawaiian Affairs 2015), and the Ava Konohiki Ancestral Visions of ‘Āina website (Ava Konohiki 2015).

Section 3 *Ka‘ao* and *Mo‘olelo* (Legends and Stories)

3.1 *Ka‘ao* and *Mo‘olelo* of Niu

3.1.1 Hi‘iaka Travels through Southeastern O‘ahu

In Nathaniel B. Emerson’s version of *Pele and Hi‘iaka—A Myth*, he places Hi‘iaka, the sister of the fire goddess Pele, on the eastern coast of O‘ahu where she searches for food and encounters those who live in the area:

> At Kuliouou, which they reached after passing through Waialae, Wai-lupe and Niu, they came upon some women who were catching small fish and crabs in the pools and shallow water along the shore and, to satisfy their hunger or, perhaps to test their disposition, Hiiaka begged the women to grant her a portion of their catch to satisfy their need. The answer was a surly refusal, coupled with the remark that Hiiaka would better do her own fishing. As the sister and representative of the proud god Pele, Hiiaka could not permit the insult to go unpunished. Her reply was the utterance of this fateful incantation:
>
> *He makani holo uha* (*a*)
>
> *Ko Ka-ele-kei a Pau-kua* (*b*)
>
> *Pau wale kea ho I ka noi ana*,
>
> *O ka loa ho‘i, e!*
>
> Translation:
>
> Here’s a blast shall posset the blood,
>
> As the chant of kahuna the back.
>
> Our patience exhausts with delay;
>
> We’re famished from the length of the way. [Emerson 1915:187]

The Ho‘oulumāhiehie version is slightly different than Emerson’s. Instead, Hi‘iaka is traveling with her companions Wahine‘ōma‘o and Lohiau. The trio had defeated several monsters in the *mauka* region of Kaimukī in Palolo Valley. As they descended to the coast to meet up with the chief Kaulanakalā, who agreed to carry them in his canoe to Moloka‘i.

> *. . . huli akula kēia i kai o Wai‘alae a ‘ike akula kēia i ka wa‘a o Kaulanaokalā e holo a‘e ana, a laila, ha‘alele lākou nei i Kaimukī a hele akula no lākou nei a hala ‘o Wai‘alae, a hala ‘o Wailupe, a hō‘ea lākou nei i Maunalua, a hala ia wahi i hope, hō‘ea lākou nei i Niu, i Kuli‘ou‘ou; i nānā aku ka hana o lākou nei, e lawai‘a mai ana kekahi mau wāhine, ‘o ka pāpa‘i me ka ‘ōhune kā lāua i‘e e ulawai‘a ana.*
>
> . . . [Hi‘iaka] turned to look seaward of Wai‘alae and saw Kaulanaokalā’s canoe sailing along. They departed Kaimuki and traveled past Wai‘alae, past Wailupe, and reached Maunalua. When that area had fallen behind them, they arrived in Niu, then Kuli‘ou‘ou. They looked about, and saw some women fishing for *‘ōhune* [goby] fish and crabs. [Ho‘oulumāhiehie 2008a:295; Ho‘oulumāhiehie 2008b:317]

3.2 *Wahi Pana* (Storied Places)

Wahi pana, storied or legendary places, can refer to natural geographic locations, such as streams, peaks, rock formations, ridges, landmarks, offshore islands and reefs, or they can refer to Hawaiian land divisions such as *ahupua‘a*, *‘ili* (land section), *mo‘o* (narrow strip of land, smaller than an *‘ili*), and man-made structures, such as fishponds. Professor and historian, Davianna Pōmaika‘i McGregor, describes sacred sites in her book *Na Kua‘āina*: *Living Hawaiian Culture*:

> Natural places have mana, and are sacred because of the presence of the gods, the akua, and the ancestral guardian spirits, the ‘aumakua. Human-made structures for the Hawaiian religion and family religious practices are also sacred. These structures and places include temples, and shrines, or heiau, for war, peace, agriculture, fishing, healing, and the like; pu‘uhonua, places of refuge and sanctuaries for healing and rebirth; agricultural sites and sites of food production as the lo‘i pond fields and terraces slopes, ‘auwai irrigation ditches, and the fishponds; and special function sites such as trails, salt pans, holua slides, quarries, petroglyphs, gaming sites, and canoe landings. [McGregor 1996:22]

Niu literally means “coconut” (Pukui et al. 1974:166). Frank (1958:22) stated it was named for a woman who husked coconuts (*He ‘o niu kana hana*). Niu is variously described as an *‘ili* in the *ahupua‘a* of Waikīkī or an *ahupua‘a* in the district of Kona. It extends from the border with Wailupe on the west to the border with Kuli‘ou‘ou on the east, and from the sea to the Ko‘olau Mountains. As noted previously, the ridges that separate Wailupe and Niu are labeled Papalea and Papu‘uloa on a ca. 1850-1860 map, but on all subsequent maps they are called Hawai‘ilea and Hawai‘iloa Ridges. Frank (1958:22) says the upper ridge between Wailupe and Niu was called Maunaloa. Niu is divided into two valleys, separated by Kūlepeamoa (“flapping of chicken”) Ridge. On the west is Pia (“arrowroot) Valley and on the east is Kupaua (“upright clam”) Valley. The two streams of these valleys merge into Niu Stream near the coast. There was also a temple, Kūlepeamoa Heiau, at the foot of Kūlepeamoa Ridge (Figure 7). Parts of it were still standing in the 1930s (McAllister 1933:70). An ancient trail once led from the coast in Niu inland up to the Ko‘olau Mountains, and then down again to the windward side of the island. According to the description (Sterling and Summers 1978:274), the trail went through the valley of Kailiili-iki. This is probably an alternate name for either Pia or Kupaua Valley. John ‘Ī‘ī, a member of Kamehameha’s court and historian, wrote about the many trails of O‘ahu that traveled along the coastline, on the plain, and towards the *ko‘olau* (windward side of the island). He describes the trails leading towards east O‘ahu:

> From Paliiki the trail ran up to Kalahu, above Leahi, and on to the place where the Waialae stream reached the sand. The trail that ran through Kaluahole went from Kaalawai, up, over, and down into Kahala, to meet the other trail at the place where the stream reached the sand. There they met the mauka trail that came from Ululani’s place in Pawaa to Kapaakea, then up to Moiliili, and to Kaphoakikeke, where it left the trail that went up to Palolo, and continued on to Mauumae, above Kaimuki where a pole later stood to serve as a mark for ships. From there it went down to, and along the upper side of, the taro patches and the pools of Waialae to join the other trails at the sand and go along Keahia and on to Maunalua, to the sea of Koko, to Makapuu, and so on. [‘Ī‘ī 1959:94]

Figure 7. Photo of remnants of Kūlepeamoa Heiau in Niu Ahupua‘a, n.d.

On the coast, at the dividing point between Wailupe and Niu, was a well called Wai Ku‘i a Kamehameha, which was dug through the *pāhoehoe* (smooth, unbroken type of lava) at a place called Papa‘alaea (also called Papalea), where fresh water gushed into the sea. The water originated from a large inland cave called Kaluaipani‘o, 100 feet inland near the *pali* (cliff) of Niu (Frank 1958:22-23). One such cave can be seen on an 1845 sketch of the Wai‘alae coast (Figure 8). At the eastern border of Niu was a place called Kanau, near the beginning of Paikō Peninsula. At this place was a *puhi* (possibly a spring) called Ke Puhi o Kanau (Aia ke puhi i Kanau) (Frank 1958:23). A large fishpond along the coast was called Kūpapa or Niu Pond. Kūpapa Pond was once part of a large tract of land that Kamehameha I used as a summer home (Figure 9 and Figure 10) (*Honolulu Advertiser* 22 March 1953 in Sterling and Summers 1978:275).

This probably explains the origin of the name Wai Ku‘i a Kamehameha for the nearby well. Adjacent to the east side of the pond was a spring. The traditional name of the spring is not known, but on 1930s maps it was called Lucas Spring, named for the Lucas family, who owned the land. Currently the coastal area west of Kūpapa pond is called Niu Beach. The area is generally a mudflat, but the residents have constructed a private pier to a sand pocket offshore to provide a protected swimming place (Clark 1977:35).

A composite of place names and *wahi pana* can be found in Figure 11.

3.3 *‘Ōlelo No‘eau* (Traditional Sayings)

Hawaiian knowledge was shared by way of oral histories. The following section draws from author and historian Mary Kawena Pukui and her knowledge of Hawaiian proverbs describing *‘āina* (land), weather, and places.

3.3.1 *‘Ōlelo No‘eau* #1413

The following proverb describes the ocean, Maunalua Bay, that fronts Niu Ahupua‘a.

> Kai pakī o Maunalua.
>
> *The spraying sea of Maunalua [O‘ahu]*. [Pukui 1983:153]

Figure 8. Painting by John B. Dale titled *Burial Cave Valley of Niu*, ca. 1845 (J. Welles Henderson Collection)

Figure 9. Photo of Kupapa Fishpond and the Niu Ahupua‘a coastline, ca. 1925 (Hawai‘i State Archives)

Figure 10. Photo of Kalauha‘iha‘i Pond, also known as Lucas Pond, n.d. (Historic Hawai‘i Foundation)

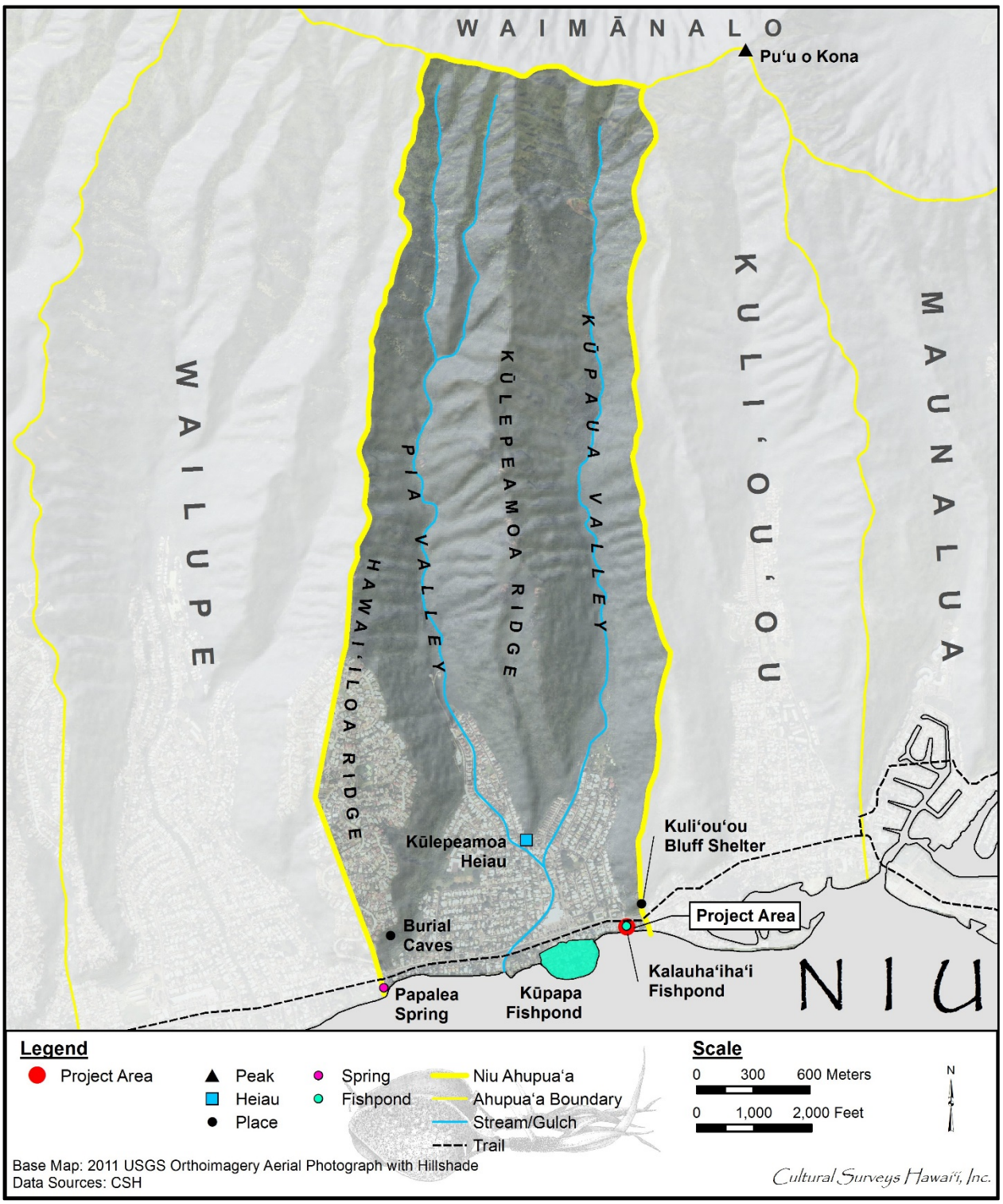


Figure 11. 2011 USGS Orthoimagery Aerial Photograph with hillshade depicting project area with place names and *wahi pana*

Section 4 Traditional and Historical Accounts

The project is located within the *ahupua‘a* of Niu in the *moku* of Kona, now called the District of Honolulu. The *ahupua‘a* of Wailupe is to the west and Kuli‘ou‘ou to the east.

4.1 Traditional Accounts

During the inter-island warfare that preceded Kamehameha’s unification of the Hawaiian archipelago, Maunalua’s natural harbors of Hanauma and Koko (Maunalua Bay) were considered vulnerable points in the defense of O‘ahu. Alapai, the eighteenth century *ali‘i nui* (high chief) of the island of Hawai‘i attempted an attack of O‘ahu. After his warriors were driven back first at Waikīkī, then at Wai‘alae, and then at Koko, Alapai’s troops were beaten a final time at Hanauma Bay (Kamakau 1992:71). Following this successful defense of O‘ahu, the rulers of O‘ahu maintained the island until 1783, when Kahekili, the *mō‘ī* (king, sovereign) of Maui, fought Kahahana, the *mō‘ī* of O‘ahu, for control of O‘ahu in the valley of Nu‘uanu (Kamakau 1992:135). Kahekili killed the O‘ahu chiefs and redistributed their lands among his warriors (Kamakau 1992:138).

During Kamehameha’s conquest of O‘ahu in 1795, his fleet landed near Makapu‘u and on the beaches of Waikīkī. Prior to the invasion, Kamehameha sent a messenger to Kahekili, the ruler of O‘ahu:

> Ki-kane, Kamehameha’s messenger to Kahekili, threw down two *maika* [ancient game similar to bowling] stones, a black one and a white one. Ka-hekili said when he saw these stones, ‘This stone (the white) brings life through farming and fishing, rearing men, and providing them with food; this other stone (the black) brings war.’ Let the reader ponder the meaning of this answer. Kahekili asked, ‘Is Kamehameha coming to Oahu to fight?’ ‘Yes,’ answered Ki-hane. ‘What harbor will he choose?’ ‘It was Kiko‘o’s counsel to make Waimanalo the harbor and battle site.’ ‘It is too low there to cast sling stones to reach the heights. It is good only for food and fish. If stones are thrown from above nothing can save the battlefield . . . ’ [Kamakau 1992:150]

The final stage of Kamehameha’s campaign took place at the Nu‘uanu Pali during the battle of Kaleleka‘anae, which means “leaping *‘anae*” (mullet; *Mugil cephalus*) and refers to the way many O‘ahu armies and some of their families chose or were forced to jump to their deaths from the *nuku* (mountain pass) of the steep *pali* (cliff) rather than accept defeat from the warriors of Kamehameha (James 2004). After this battle at the Nu‘uanu Pali, Kamehameha became the sole ruler of O‘ahu, Moloka‘i, Lāna‘i, Hawai‘i, and Maui (Kamakau 1992:172–173).

When Kamehameha conquered the island of O‘ahu in 1795, it was devastated by 20 years of inter-island war. Kamehameha encouraged the reconstruction of agricultural fields and fishponds by helping with the rebuilding. Maunalua (Kuapā) Fishpond was one of the fishponds he is supposed to have helped rebuild himself (Kamakau 1961:192) Kamehameha “encouraged the chiefs and commoners to raise food and he went fishing and would work himself at carrying rock or timber . . . He worked at the fishponds at Kaiwai-nui, Ka-‘ele-pulu, Uko‘a, Mauna-lua, and all south O‘ahu” (Kamakau 1961:192).

Kamehameha gave the *‘ili* of Maunalua to Kuihelani, a steward of his, who he also made governor of O‘ahu in 1796 (Kamakau 1992:173). Kuihelani was forced to forfeit the land later to Kamehameha because Kuihelani’s wife, Kao‘o, was seduced by a young chief, Kuakini (‘Ī‘ī 1959:101; Kamakau 1992:389). Kamehameha reassigned the land to Ke‘eaumoku, the father of his wife Ka‘ahumanu. When he died in 1804, Ka‘ahumanu retained the lands and later bequeathed Maunalua to Kīna‘u, a daughter of Kamehameha and mother of Victoria Kamāmalu. When Kīna‘u died, the lands of Maunalua were given to Victoria Kamāmalu.

4.2 Early Historic Period

John ‘Ī‘ī, a member of Kamehameha’s court, visited Kuli‘ou‘ou sometime around 1810. Traveling aboard the ship *Apuakehau* from Honolulu to the island of Hawai‘i, ‘Ī‘ī stopped at Kawaihoa, the landing at Maunalua Bay that was a common stop-over point for inter-island and circle-island navigation at this time (‘Ī‘ī 1983:108). ‘Ī‘ī also discusses the old trail systems extant on O‘ahu circa 1810. Regarding the route to southeast O‘ahu from Honolulu ‘Ī‘ī notes several trails that met at “the sand and go along Keahia and so on to Maunalua, to the sea of Koko, to Makapuu, and so on” (‘Ī‘ī 1983:94). Undoubtedly the route ran through Kuli‘ou‘ou, through Kealakīpapa Valley, to Waimānalo via the cliff at the Waimānalo Gap. There are several accounts of early missionaries taking this route in their tours of O‘ahu.

Gilbert Mathison most likely followed this same route during his excursion around the island of O‘ahu in 1821. Within Kuli‘ou‘ou he noted the large salt water lake (Kuapā Fishpond) around which he saw scattered approximately 100 huts. The people of the area were described as fisherman (Takemoto et al. 1975:17).

Levi Chamberlain visited the area in 1826 and 1828 to view the new language schools. He described Kuapā Fishpond:

> Thence I walked on by the side of the pond in a southerly direction about a mile, having the eminences Moaualua [*sic*] on my left.—I then came to a narrow strip of land resembling a causeway partly natural and partly constructed extending in a North west direction across what appeared to be considerable of a bay forming a barrier between the sea and the pond. At the further end of this causeway sluices are constructed and the waters of the sea unite with the pond and at every flood tide replenish it with a fresh supply of water. [Chamberlain 1826:26]

Two years later, he wrote the following:

> It was once a small estuary, narrow at its communication at the sea, and so shallow that a cossway [*sic*] could conveniently be built to a low, sandy point on one side of the little bay which is here made by the sea. On this point is built the settlement of Maunalua. Our path was wet and muddy till we reached the extremity of the pond. [Chamberlain 1828:29]

In 1826, he counted 18 houses in this village, which was located on a causeway on the pond. This may mean there was a population of about 90 to 100 at this time. In 1828, he talked to a group of about 30 people in the village, perhaps suggesting the population was about 60 or more at this time. In 1828, 65 students attended school in the area. Four years later, the number had dropped to only 19. This may be an indication of the rapid depopulation of the area.

Kuli‘ou‘ou was not only known for its fish resources, but was also associated with agriculture. Economic activities of Hawaiian settlements focused on the cultivation of crops that could be exchanged with the foreign sailing vessels, in particular those of the whaling industry, which had its boom period from 1820-1850 (Figure 12 and Figure 13) (Jones 1996:20; Takemoto et al. 1975:18). In 1940, Handy described sweet potato cultivation in Maunalua:

> Sweet potatoes were cultivated on Oahu on the coastal plain and in sandy soil . . . The *kula* lands below the cliffs of Waimanalo also supported sweet potato plantations . . .
>
> On the south side of the ridge at this end of the island, Maunalua and Hahaione districts were famous for their sweet potatoes. In this section there are various enclosures and walls which were thrown up around the old plantations before Hawaiians abandoned the land and it was utilized for ranching.
>
> According to the last surviving *kamaaina* (commoner resident) of Maunalua, sweet potatoes were grown in the small valleys, such as Kamilonui, as well as on the coastal plain. The plain below Kamiloiki and Kealakipapa was known as Ke-kula-o-Kamua wa. This was the famous potato-planting place from which came the potatoes traded to ships that anchored off Hahaione in whaling days. The village at this place, traces of which may still be seen, was called Wawamalu. [Handy 1940:155]

The area maintained resident populations that would have otherwise become severely reduced under the dual effects of epidemics and the relocation of inhabitants to growing towns such as Honolulu. When the victualing trade gave out, settlement in these regions declined. By the early 1850s the zenith of whaling was passing. In 1852, the Hawaiian government passed legislation requiring all foreign vessels to call at Honolulu where they could be taxed. This further reduced the number of ships that anchored at smaller landing sites such as those at Maunalua (Jones 1996:21; Takemoto et al. 1975:20). “It is clear that Maunalua lost much of its population and economic independence as an agricultural ili with the end of the whaling ships” (Takemoto et al. 1975:25).

4.3 The Māhele and the Kuleana Act

The Organic Acts of 1845 and 1846 initiated the process of the Māhele—the division of Hawaiian lands—that introduced private property into Hawaiian society. In 1848, the Crown and the *ali‘i* (chief) received their land titles as *konohiki* (land manager) awards. *Kuleana* (Native land rights) awards to commoners for individual parcels within the *ahupua‘a* were subsequently granted in 1850 and thereafter. The Crown Lands were considered the private lands of the monarch, and many lands were sold or mortgaged during the reigns of Kamehameha III and Kamehameha IV to settle debts to foreigners. To end this practice, the Crown Lands were made inalienable in 1865, and their dispensation was regulated by a Board of Commissioners of Crown Lands, which effectively put them under the administrative control of foreign-born residents (Kame‘eleihiwa 1992:310).

To apply for simple title to their lands, native tenants were required to file their claim with the Land Commission on or before 14 February 1848. In 1850, the Privy Council passed resolutions that affirmed and protected the rights of the commoners or native tenants, including the Kuleana

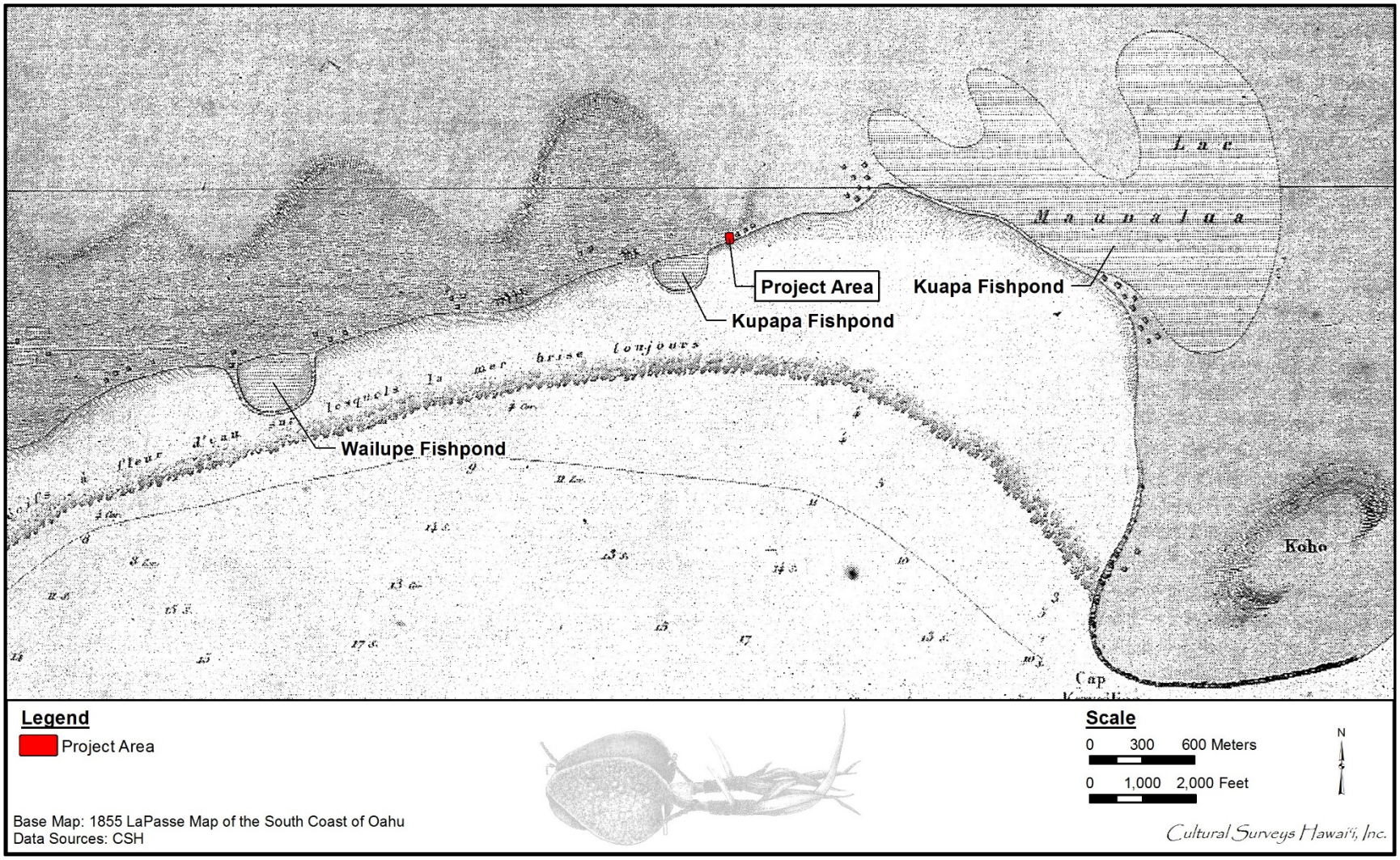


Figure 12. 1855 LaPasse map of the south coast of O‘ahu depicting project area and nearby fisheries

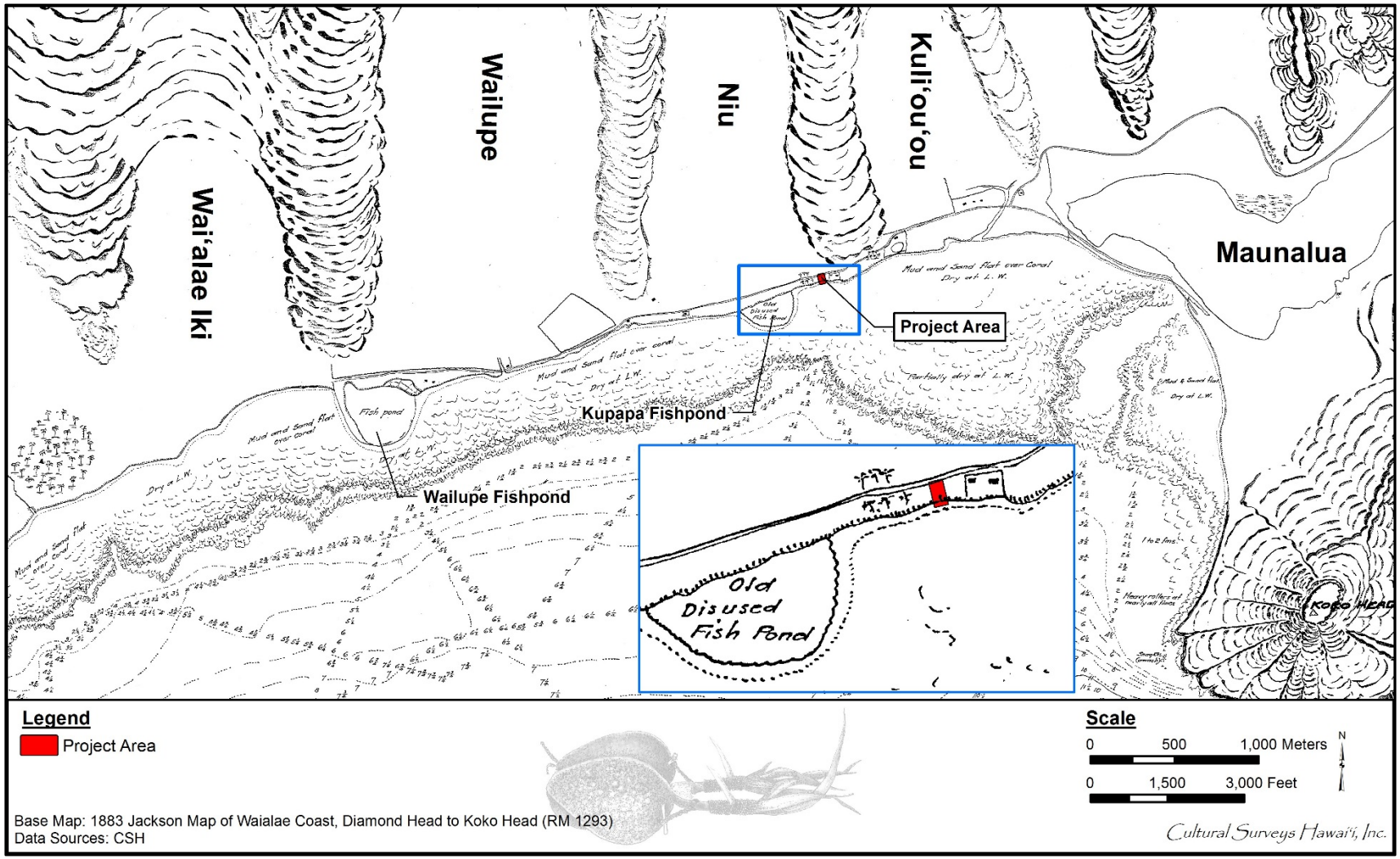


Figure 13. 1883 Jackson map of Waialae Coast, Diamond Head to Koko Head, with project area; note that nearby Kupapa Fishpond is no longer in use

Act. Under this act, the claimant was required to have two witnesses who could testify they knew the claimant and the boundaries of the land, knew that the claimant had lived on the land for a minimum of two years, and knew that no one had challenged the claim. The land also had to be surveyed (Chinen 1958:31). These awards were presented to tenants, Native Hawaiians, naturalized foreigners, non-Hawaiians born in the Islands, or long-term resident foreigners who could prove occupancy on the parcels before 1845.

Not everyone who was eligible to apply for *kuleana* lands did so and not all of those claims were awarded. Some claimants failed to follow through and come before the Land Commission, some did not produce two witnesses, and some did not get their land surveyed. In addition, some *maka‘āinana* (commoners) may have been reluctant to claim *‘āina* (land) that had been traditionally controlled by their *ali‘i*, some may have not been familiar with the concept of private land ownership, and some may have not known about the Māhele, the process of making claims (which required a survey) or the strict deadline for making claims. Further, the Land Commission was comprised largely of foreign missionaries, so the small number of claimants and awards may reflect only those *maka‘āinana* who were in good standing with the church. Significantly, the surveying of the land was not standardized (Kame‘eleihiwa 1992:296–297).

A total of 14,195 claims were filed and 8,421 awards were approved to about 29% of the 29,220 adult Native Hawaiian males living at the time of the Māhele, averaging 3 acres each (Kame‘eleihiwa 1992:295). Out of the potential 2,500,000 acres of Crown and Government lands, 28,658 acres of land were awarded to the *maka‘āinana*, less than 1% of the total acreage of Hawai‘i (Kame‘eleihiwa 1993:295). The small number of *kuleana* awards and their small size prevented the *maka‘āinana* from maintaining their independent subsistence (Chinen 1958:32), often forcing them to abandon their newly acquired property (Lyons 1875).

Although many Hawaiians did not submit or follow through on claims for their lands, the distribution and written testimonies of LCAs can provide insight into patterns of residence and agriculture. Many of these patterns probably had existed for centuries. Four LCA claims were made for Niu Ahupua‘a, however, only one was awarded. LCA 802 was awarded to Captain Alexander Adams who stated that the lands of Niu were given to him by Kamehameha I. According to land documents, the Niu lands awarded to Captain Adams consisted of 2,446 acres. The lands of Niu were eventually passed down to Mary Papapaupu Bannister Lucas, granddaughter of Captain Alexander Adams and Papapaupu Harbottle Adams. Archival documents give further insight into how the property was acquired by her grandfather:

> The estate, comprising two thousand acres extending from seashore to the top of the mountains, was granted in perpetuity to Captain Adams just before the coming of the first New England missionaries in 1820, as a reward for thwarting an attempted Russian invasion of the Island of Kauai in 1815 [see Figure 14].
>
> It had been the country home of Kamehameha the Great and Kaahumanu and it was there that the great Kaluhaihai assembly was held in 1919, when the ancient tabu laws were broken on Oahu. The property is held intact and is largely devoted at the present time to the extensive dairying interests of Charles Lucas and his son, Charles W. Lucas. [Hawai‘i State Archives 1930:44]

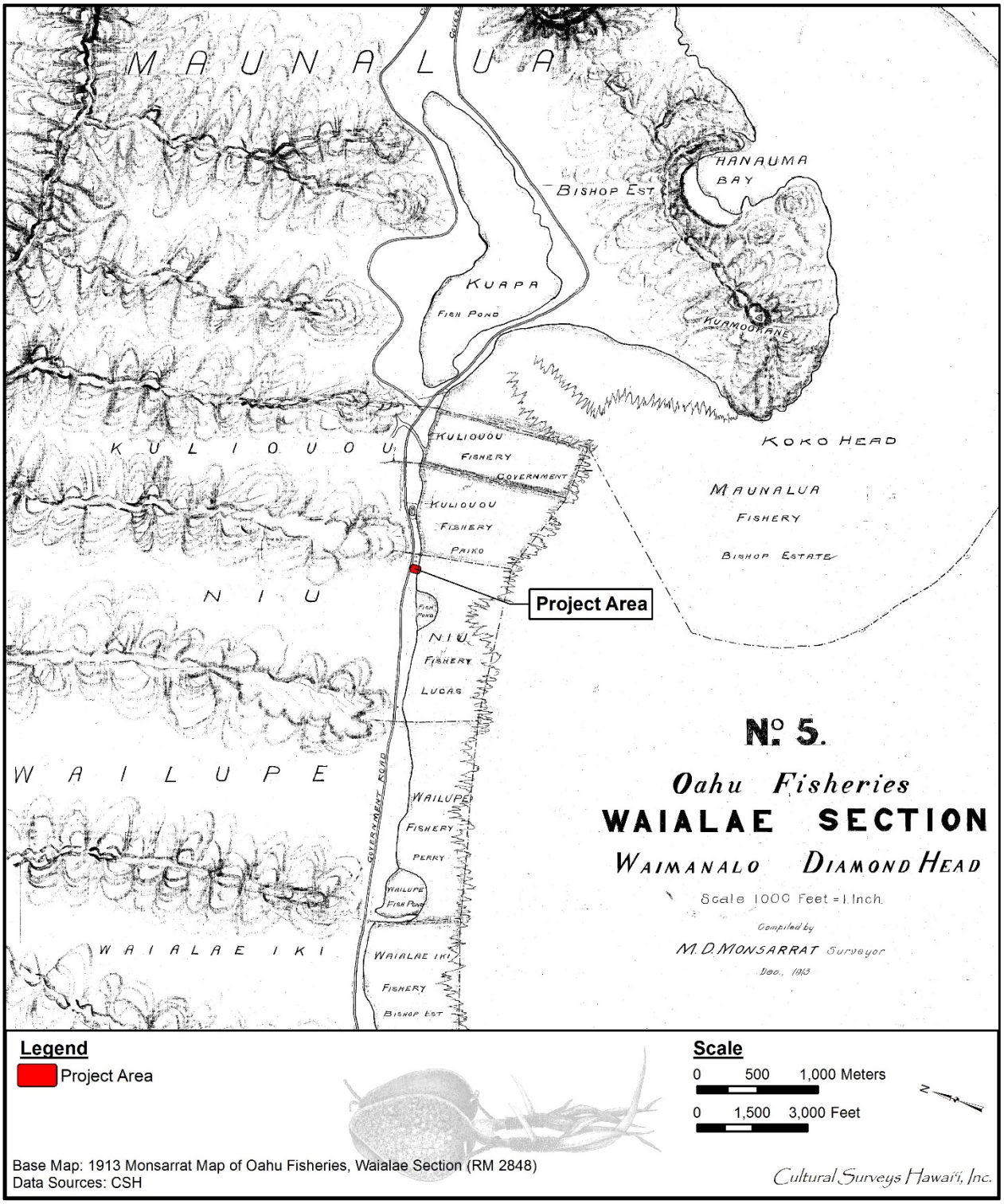


Figure 14. 1913 Monsarrat Map of Oahu Fisheries, Waialae Section with project area; note that the Niu fishery is owned by the Lucas family as noted

4.4 **Late 1800s**

From 1850 to 1900, the southeastern shore of O‘ahu witnessed the decline of traditional Hawaiian settlement, land use, and population and the rise of commercial ranching and fishing.

4.4.1.1 Ranching

In 1856, Victoria Kamāmalu leased all of neighboring Kuli‘ou‘ou Ahupua‘a, except for Kuapā Fishpond, to William Webster, the government employee and land surveyor who had surveyed the region five years earlier. Webster, who was ranching in Waimānalo, began to use the land of Kuli‘ou‘ou for ranching. When Webster died in 1864, the remainder of his Kuli‘ou‘ou lease was taken over by Manuel Paiko, who was leasing the adjacent lands near Niu Ahupua‘a (Kame‘eleihiwa 1992:244–245).

The fishing rights to the Kuapā Fishpond and Kuli‘ou‘ou’s offshore fishing grounds were important resources that were leased out to various parties from the time Victoria Kamāmalu obtained the land title to Maunalua (Figure 15). The Kuapā Fishpond was leased in 1856 at a high yearly sum for the time, indicating the value placed on fishing resources. The offshore fishing rights were leased and sold to various individuals until 1900 when Territorial and United States legislation began deconstructing the legality of the traditional idea of ownership of offshore fishing rights. It is clear from the high lease rates for the time period that the fishing resources of Kuli‘ou‘ou were productive and highly valued (Takemoto et al.1975:21–27).

When Kamāmalu died in 1866 it fell to her father, Kekuanaoa, to pay off the debts and the mortgage in order to be awarded the title to Kuli‘ou‘ou (Jones 1996; Takemoto et al. 1975). With the death of Kekuanaoa, the land of Kuli‘ou‘ou passed into the hands of Lot Kamehameha V. When Lot died without a will, the probate court decided that his half-sister, Ruth Ke‘elikolani, would inherit his entire land holdings. When Ruth died in 1883, Kuli‘ou‘ou was passed down to Bernice Pauahi Bishop. When Bernice Pauahi Bishop died in 1884 her husband Charles Bishop, followed her will and set up the Bishop Estate Trust, of which Kuli‘ou‘ou became a part (Takemoto et al. 1975).

After the mid-1800s, Kuli‘ou‘ou became predominantly ranch land for the next 80 years, with the start of the Maunalua Ranch Company in 1900. Land ownership and land use rights were complicated through much of this period by numerous leases, frequent litigation, and the frequent deaths of land holders and/or lease-holders (Takemoto et al. 1975).

In 1920, the Maunalua Ranch Company leased the Kuli‘ou‘ou lands and sublet portions to tenants, including the Honolulu Honey Company, Ltd. and charcoal makers (Henry 1959:44). Maunalua Ranch controlled most of the land of Kuli‘ou‘ou outside of the Kuapā Pond. From its inception in 1900 until it closed in 1926, over 1,500 cattle made up the ranch’s stock (Jones 1996:23).

By 1926, the Maunalua Ranch discontinued cattle grazing itself, and land was rented directly from the Bishop Estate. In 1932, a ranching lease was given to Alan S. Davis, who established Wāwāmalu Ranch. The Davis home and swimming pool were constructed near the shore at Ka‘ili‘ili, while various ranch infrastructure, such as corrals, wall, and water tanks was situated at Kaloko (Kelly et. al 1984:56).

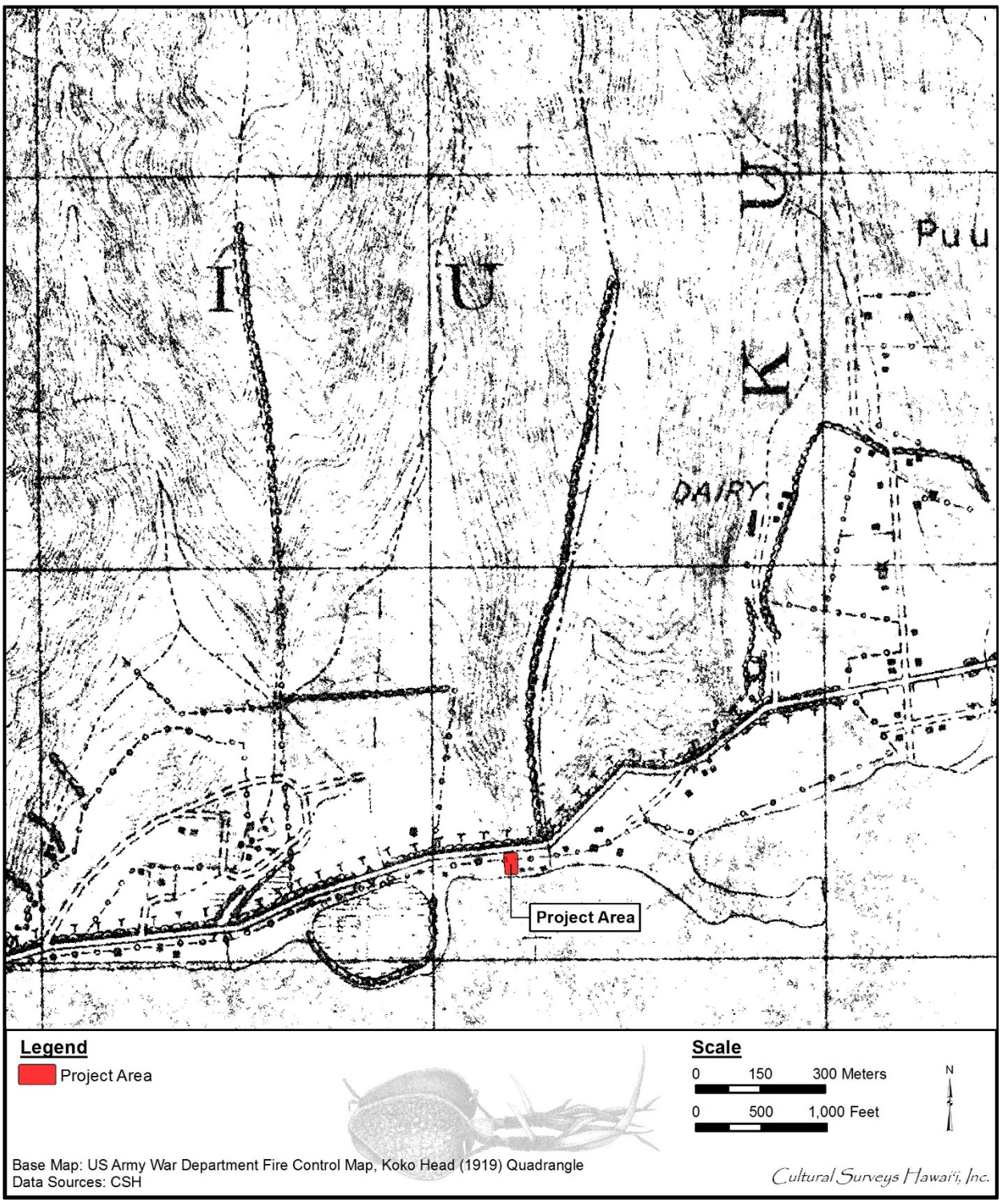


Figure 15. 1919 U.S. Army War Department fire control map, Koko Head quadrangle; note the boundary walls for Niu Ahupua‘a that run *mauka* to *makai*; neighboring Kupapa Fishpond also has a wall that surrounds the *makai* perimeter

The Alan Davis ranch house at Kaloko was the easternmost private residence on O‘ahu during the 1930s and 1940s, until its destruction in the 1946 tsunami. Ranching didn’t prove profitable enough, so the subleasing of Maunalua land for truck and flower farms, chicken farms, and piggeries was expanded. Pig farmers and other were pushed out of the Hawaii Kai area and moved over the hill back of Koko Crater and into Kalama and Wāwāmalu Valleys. As farmers were evicted from other communities, such as when Wai‘alae-Kamala, Wailupe, and Niu were urbanized, more of them moved to Maunalua with short-term leases.

Between 1932 and 1946, ranching was less economically viable at Wāwāmalu Ranch. Increasingly, ranch land was sublet to farmers, who were being displaced by the expansion eastward of Honolulu and its suburbs. In 1937 and 1938, Alan Davis began subleasing lands mostly for truck farms, flower growing, pig farming, and chicken farms (Kelly et al. 1984:47). In 1959, there were 178 families in the area around Koko Head, producing 60% of the hogs, flowers, and lettuce grown on O‘ahu.

4.5 **1900s**

4.5.1.1 Residential Development and Modern Land Use

In 1959, the Hawaii Kai Development Corporation, a subsidiary of Kaiser Industries, received the development rights for Bishop Estate property in Maunalua and began to develop the planned community of Hawai‘i Kai (Kelly et. al 1984:vii). Kuapā Fishpond was dredged to a consistent depth of 6 ft and dredge material was used to fill the swampy lands on the north side to make a new residential area (Hancock 1983:4). Large portions of former fishpond and ranch land were graded and prepared for construction of housing developments, golf courses, and shopping centers.

The construction of Kalaniana‘ole Highway between Kuli‘ou‘ou and Waimānalo began in the late 1920s and was finally completed in 1932. In 1946, the coastal portions of Kalaniana‘ole Highway from Sandy Beach to Kaloko were washed out by a tsunami. The highway was reconstructed slightly further inland, with a new bridge at Wāwāmalu, between 1946 and 1948 (Kelly et al. 1984:vii). The roadway and sequential development of the highway and residences can be seen in a series of maps between 1927 and 1969 (Figure 16 through Figure 20).

The tsunami of 1946 was one of many that undoubtedly affected the coastal sections of Maunalua to varying degrees. Before 1946, tsunami of similar scale had occurred in 1837, 2 April 1868, and 1877. These tsunami are among the nearly 40 tsunami that were recorded to hit Hawai‘i, with effects ranging from none to severe, between 1819 and 1946 (Shepard et al. 1950:400-1). Tsunami are known to scour coastlines by both washing material landward with the inrushing waves as well as washing material seaward with the retreating waves. Coastal vegetation, coastline formation, and the force of the wave are some of the factors that influence the destructive force of tsunami (Shepard et al. 1950:460-2).

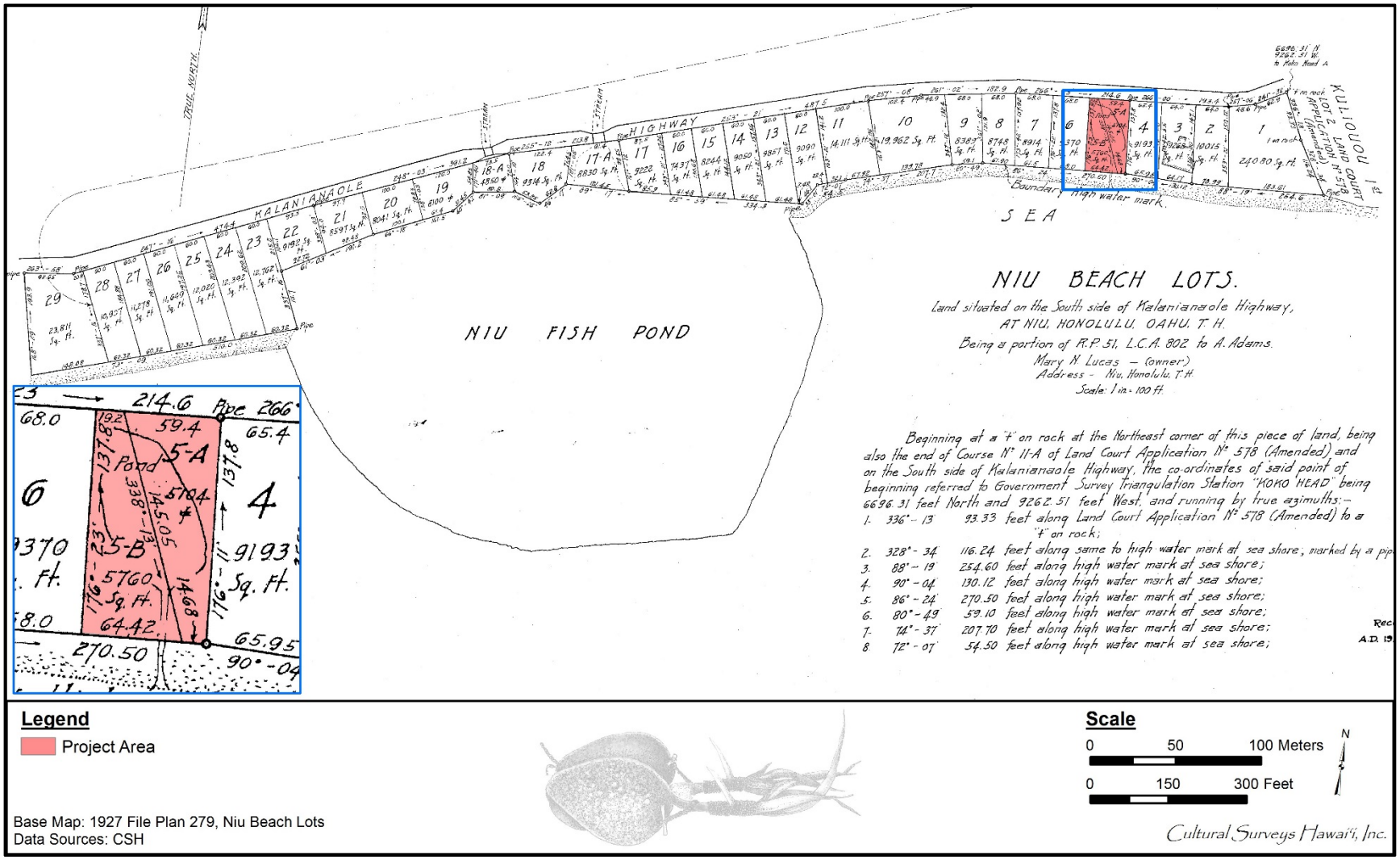


Figure 16. 1927 File Plan 279, Niu Beach Lots with project area shaded in red; a pond is noted within the property and includes an outlet to the south of the project area

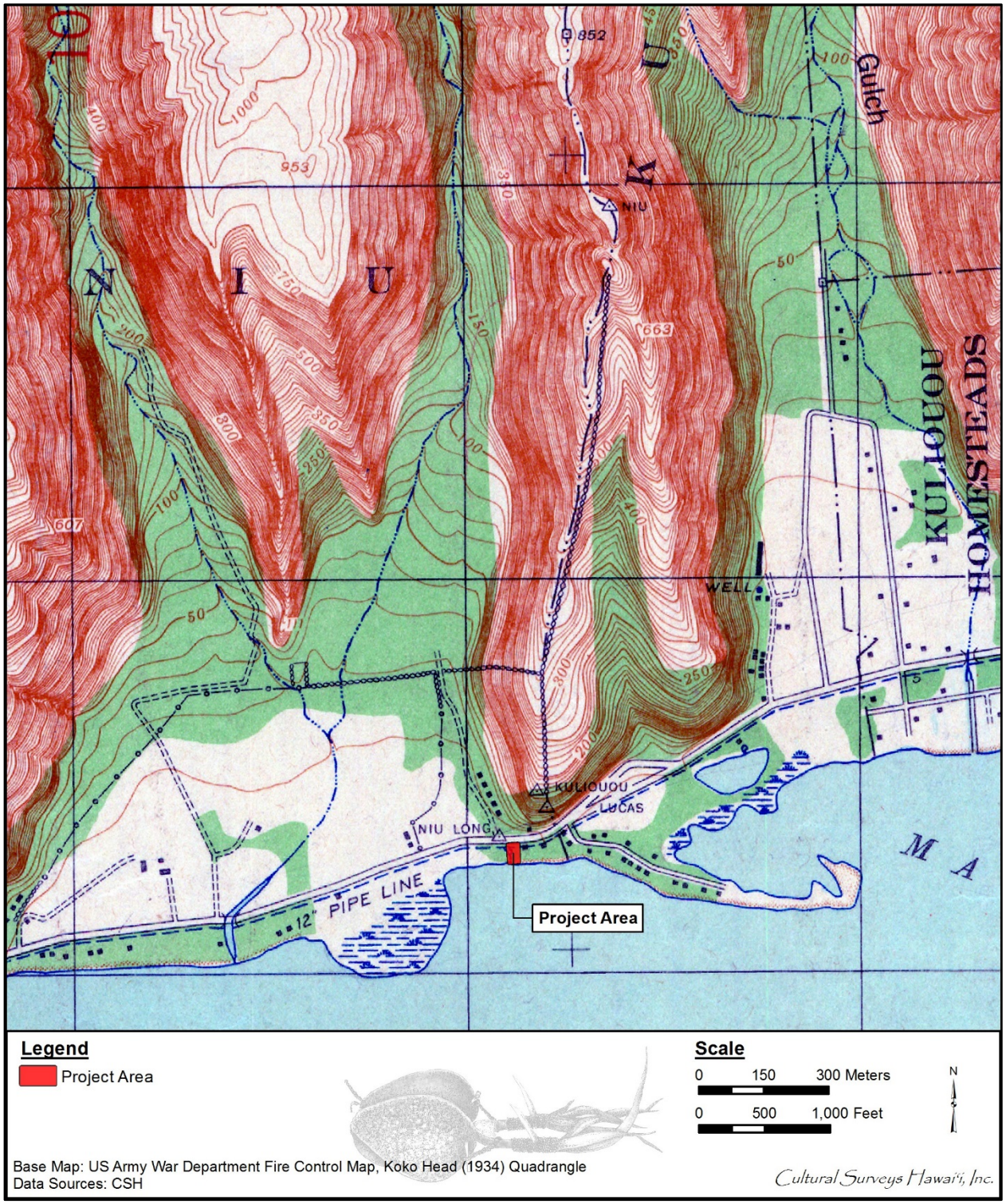


Figure 17. 1934 U.S. Army War Department fire control map, Koko Head quadrangle with project area; a boundary wall marker for Niu Ahupua‘a can be found to the east bordering Kuli‘ou‘ou; Kupapa Fishpond has now been filled in

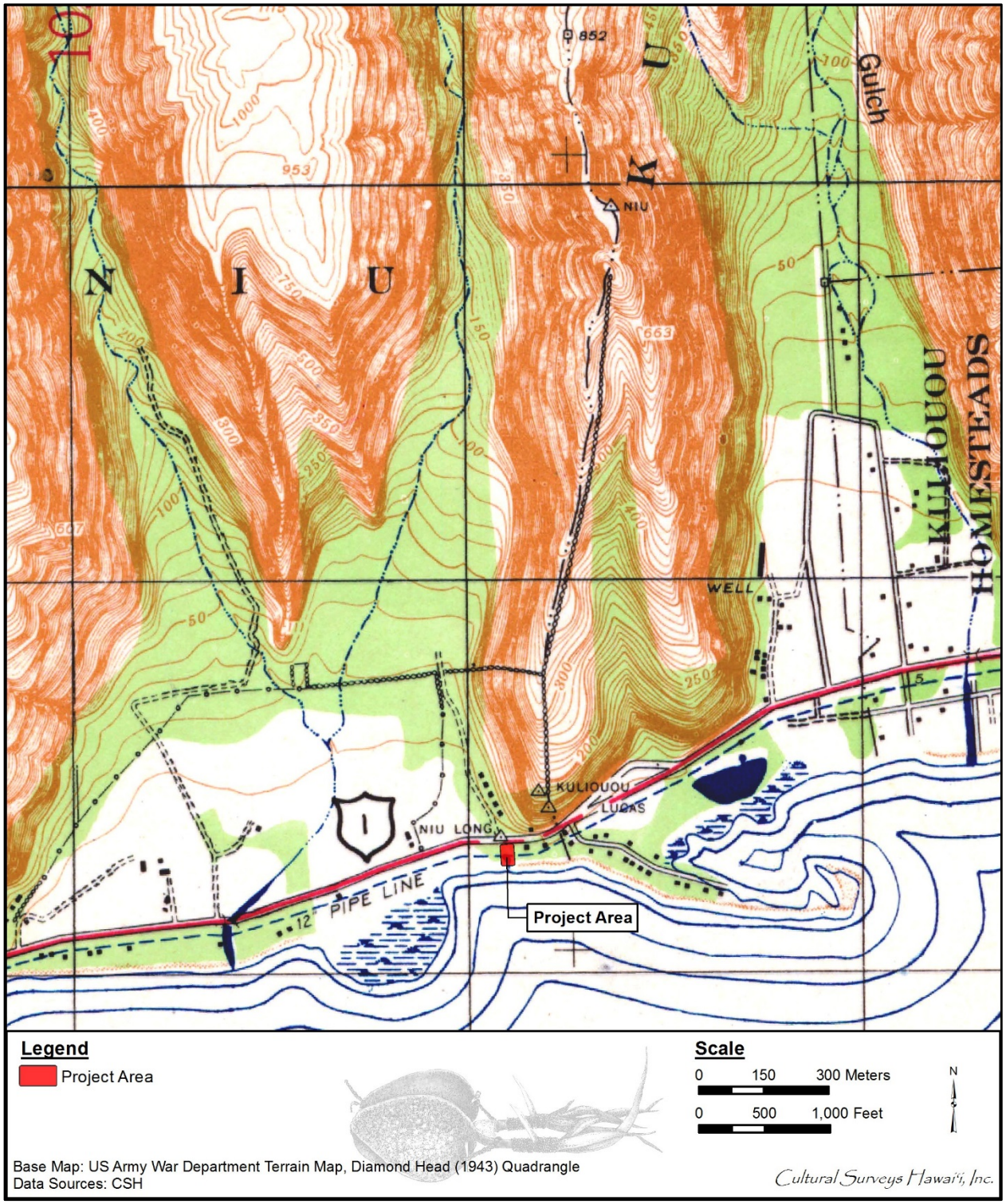


Figure 18. 1943 U.S. Army War Department terrain map, Diamond Head quadrangle with project area; portions of the wall that bordered Niu and Kuli‘ou‘ou Ahupua‘a are still intact; Kalaniana‘ole Highway is outlined in red and runs west to east

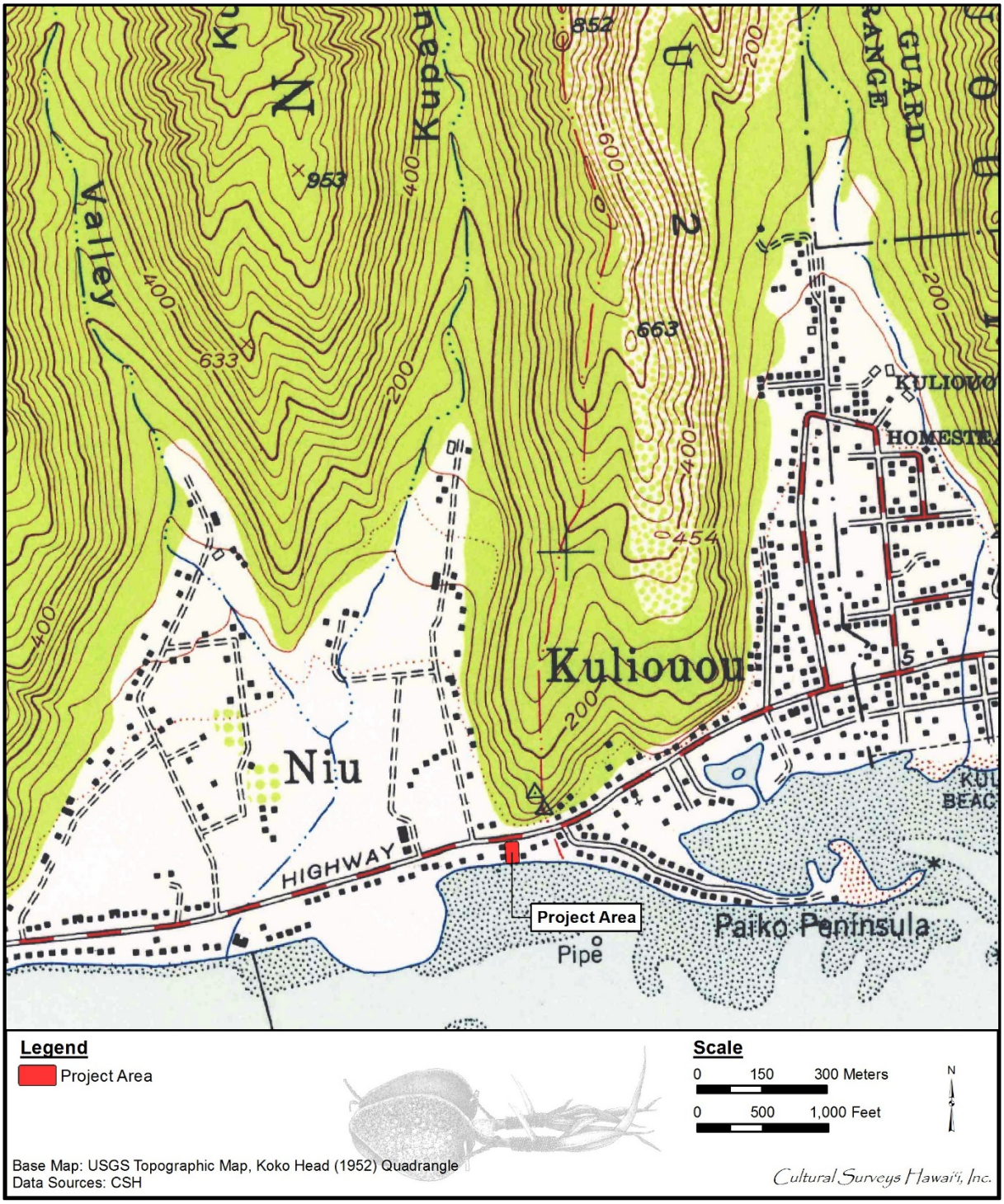


Figure 19. Portion of 1952 Koko Head USGS topographic quadrangle with project area; the boundary wall that bordered Niu and Kuli‘ou‘ou Ahupua‘a is no longer present on the map; private residences can be found along Kalaniana‘ole Highway and in both Niu and Kuli‘ou‘ou Valley

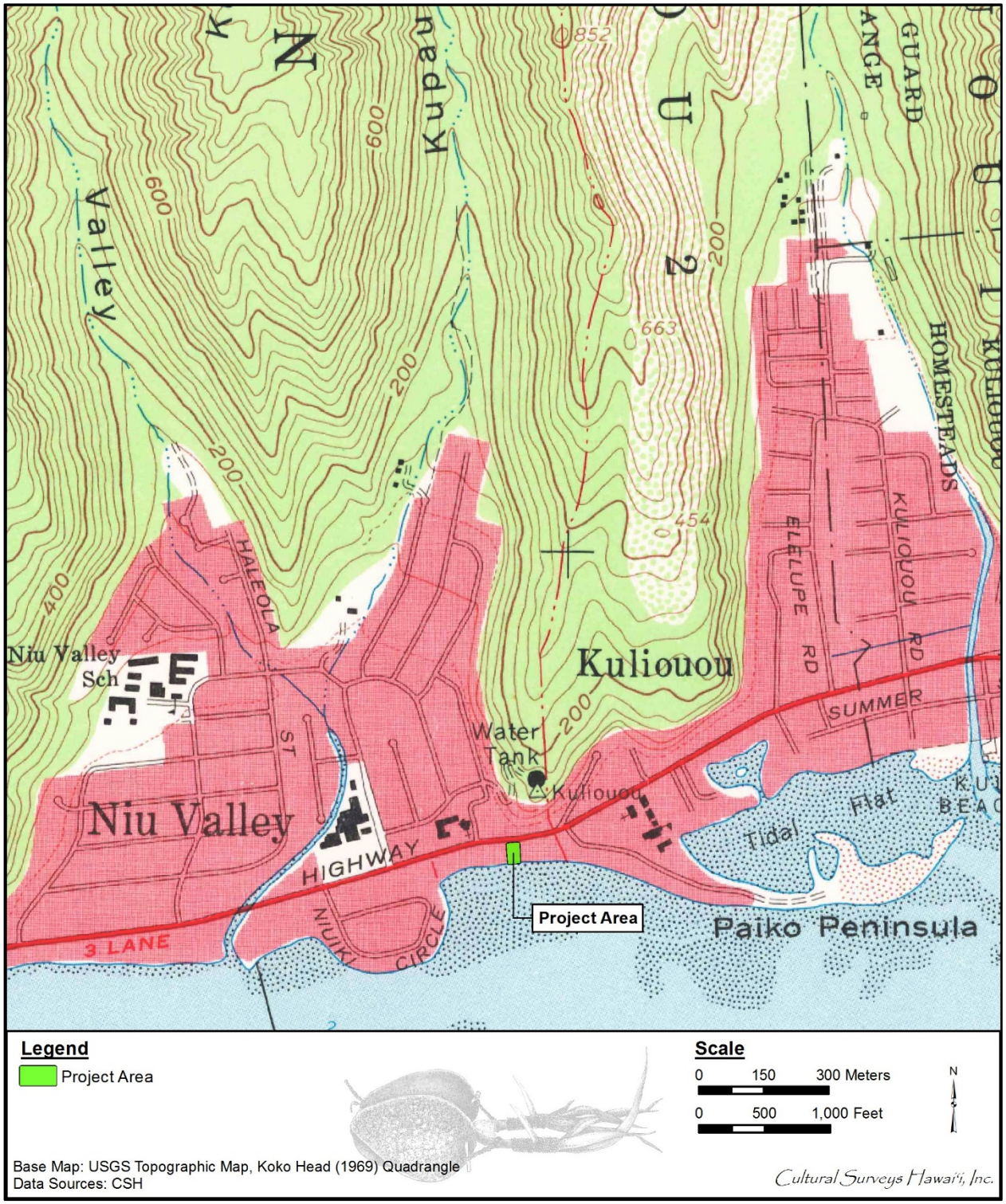


Figure 20. Portion of 1969 Koko Head USGS topographic quadrangle with project area in green; the former Kupapa Fishpond is now Niuiki Circle; both Niu and Kuli‘ou‘ou Valley now include a multitude of streets, businesses, and a school

4.6 Previous Oral Histories

This section draws from previous oral histories and articles from the residents of Niu Ahupua‘a. Their *mo‘olelo* color the cultural and historical background with nuanced recollections, adding depth to the LRFI and cultural study. Summaries and excerpts are presented below:

4.6.1 Laura Lucas Thompson

An affidavit from Laura Lucas Thompson dated 31 August 2012 was written to “encourage action to improve the health of Maunalua Bay by allowing ground water to once again flow from the mountains to the sea” to the current project area, Lucas Spring (Figure 21) (Kalauha‘iha‘i Pond). Ms. Thompson has also provided a brief history of Niu and the surrounding areas in her affidavit.

> My family has owned the Ahupuaa of Niu since it was conveyed by King Kamehameha I to our ancestor, Alexander Adams. I am the fifth generation since that time and lived as a child on Niu beach on a large property that included the Pond [Kalauha‘iha‘i]. I remember how cold the water was, how clouds of opae would cluster near the rocks and how the pungent strings of limu eleele could be rolled into a ball. At high tide salt water would wash into the pond, at low tide, fresh water would flow out. There were lots and lots of baby fish, and sometimes bigger ones—but not the size of those raised in Kuapa Pond at Koko Head.
>
> My father owned Niu Dairy. The milk barn, cattle pens and grass fields encompassed what is now Niu Estates. The pasture across the street on the makai side allowed the cows and horses to wander down a slope to drink fresh water from the pond. Bishop Museum has a photo of horses standing in the ocean makai of Kalauha‘iha‘i, with water up to their bellies, drinking fresh water [Figure 22].
>
> My father’s dairy cattle were fed grain when being milked but their main food was napier grass, cultivated, then chopped and fed to them. Niu is a dry area (a lot drier now than then). Those grass fields were irrigated by flume and ditch. The irrigation water was pumped out of a deep well located at the bottom of Kulepeamoa. We were not allowed to go into the well but I remember watching two young guys from the dairy swimming and saying that two “tunnels” (lava tubes) were the water source.
>
> Water is precious, needs to be honored and protected—nobody denies that. I would very much like to be on a team to have that happen.

A copy of Ms. Thompson’s affidavit can be found in Appendix B.

4.6.2 Tad Hara

An article in the *Hawaii Reporter* discusses Tad Hara’s former residence, which was a two-story home above Kalauha‘iha‘i Fishpond. The article describes Mr. Hara’s property and the abundance of aquaculture that he observed regularly with his family:

> The home was special in that its living room floor was transparent glass, so from inside, or from his outside porch, he could watch his exotic Koi swirling and swimming with wild mullet, prawns, crabs, and other sea and fresh water creatures.

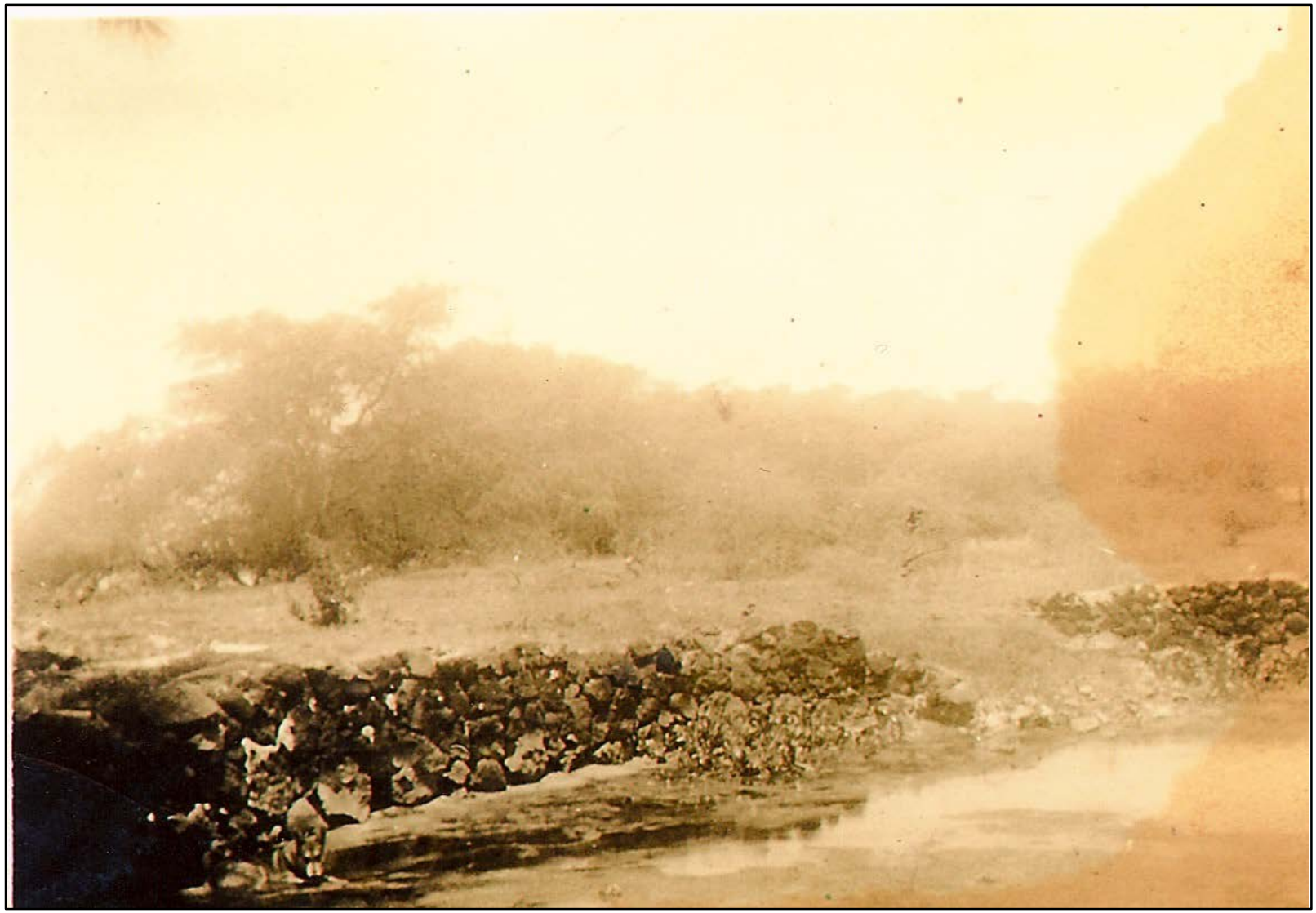


Figure 21. Photo of Kalauha‘iha‘i and wall surrounding the pond, n.d. (courtesy of Laura Lucas Thompson)

Figure 22. Photo of cows drinking water in Niu Ahupua‘a, as described by Laura Lucas Thompson (courtesy of Laura Lucas Thompson)

> After serving in the Army during WWII, he graduated from the University of Hawaii, and later worked in insurance and real estate. He says the peace he found in his home meant so much to him.
>
> Hara had a state champion Koi, which two years in a row, was deemed the most prized in Hawaii because it had four colors (white, red, blue and black). That Koi alone was valued at $1,500, and he had another 150 Koi in his pond as well. At night, he could turn on a rainbow of lights, and through the glass floor, watch the fish come and greet him and his three children.
>
> For 23 years, Hara and his son and two daughters had many happy memories in that home. They enjoyed walking up to a mile out in the ocean to catch their dinner. They looked for octopus, crab, Papio and other reef fish.
>
> And they cherished caring for the beloved fishpond, which continued to flourish. [*Hawaii Reporter* 23 May 2010]

Mr. Hara registered the spring and pond with the Department of Land and Natural Resources stating, “Ancient Hawaiians valued their water. I tried to respect the Hawaiian culture by maintaining and caring for the pond.”

In the early 1990s, the State of Hawai‘i – Department of Transportation (DOT) began widening Kalaniana‘ole Highway. The four-lane highway was now expanding to six lanes. To accommodate for the extra two lanes, the DOT condemned 3 ft of his street-front property, totaling 50+ ft. During construction, DOT contractors had damaged the fresh water spring that fed Kalauha‘iha‘i Pond that runs *mauka* to *makai*:

> He walked across the street to warn the project manager several times that the workers needed to be careful of the natural underground spring but they ignored him, and laid cement conduits and electrical and cable wires on top of the treasured waterway. His neighbor called him at work on day to tell him that his pond was dry, and the fish were flopping around on the now muddy area. The fish died.
>
> Hara fought the state for four years to get the spring ‘Kaluaha‘eha‘e’ restored.
>
> At first, the state promised to fix its mistake, but then took that option away citing cost. In a fierce legal battle, the state refused to meet his requests at every turn until he finally, after being drained financially, he surrendered his property and home.
>
> His property value was slashed nearly in half by the loss of the spring and pond. [*Hawaii Reporter* 23 May 2010]

Today, Mr. Hara’s property and the adjacent lot have been condemned. Mr. Hara has since relocated to Aiea Heights.

4.7 **Previous Archaeological Research**

Several previous archaeological studies have been conducted in the vicinity of the current project. These studies typically have been located in the coastal areas along Kalaniana‘ole Highway or within lava tubes/caves *mauka* of the highway. These studies are shown in Figure 23 and presented in Table 1; historic properties in the vicinity of the project area are shown in Figure 24 and Table 2. Previously identified historic properties in the vicinity of the current project

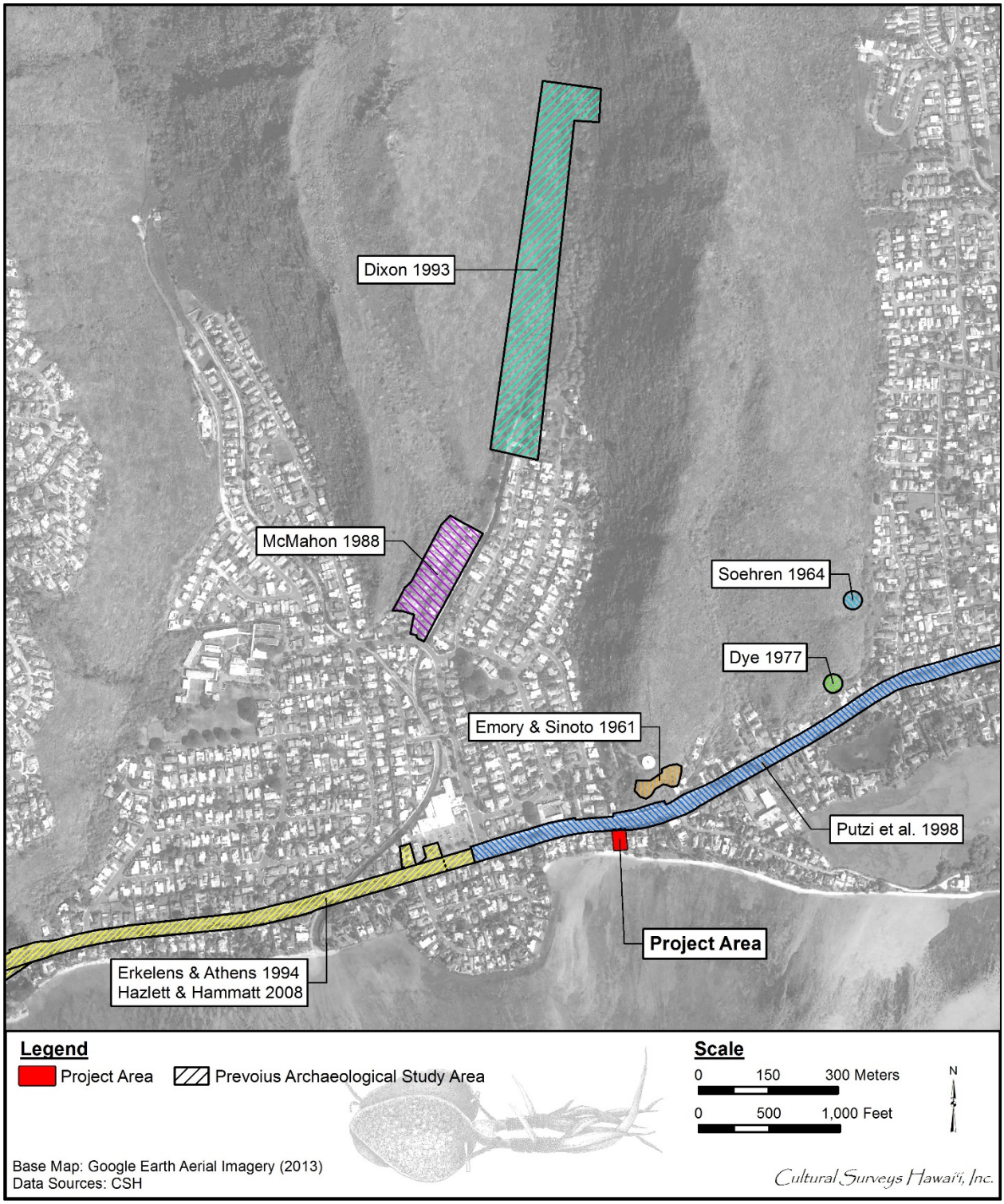


Figure 23. Previous archaeological studies in the vicinity of the project area

Table 1. Previous Archaeological Studies in the Vicinity of the Project Area

Reference	Type of Study	Location	Results (SIHP # 50-80-15)
McAllister 1933	Island-wide survey	O‘ahu Island	Four sites identified within the vicinity of the current project: Site 50 (terrace remains), Site 51 (Kupapa Fishpond), Site 52 (Kūlepeamoa Heiau), and Site 53 (burial caves)
Emory and Sinoto 1961	Excavation	Kuli‘ou‘ou Shelter (SIHP # -4000)	SIHP # -4000 contained a thick cultural layer with abundant midden and artifacts
Soehren 1964	Archaeological reconnaissance survey	Kuli‘ou‘ou 2	Identified SIHP # -2500, burial cave with midden at the entrance
Dye 1977	Burial study	Lava tube at the southern end of Kuli‘ou‘ou 2 Ridge	SIHP # -9536 comprised incomplete human remains (left in place)
McMahon 1988	Archaeological inventory survey	5-acre parcel in Niu Valley	Two walls (SIHP # -1972) observed; three backhoe trenches yielded no subsurface cultural features or deposits
Dixon 1993	Archaeological reconnaissance survey	Waimānalo, Waipahu, Kāne‘ohe, Mānoa, and Niu Ahupua‘a	One site (SIHP # -2465, modified cobble terrace) identified on east bank of Kūpaua Stream in Niu Ahupua‘a
Erkelens and Athens 1994	Archaeological monitoring and burial recovery excavations	Kalaniana‘ole Hwy, fronting Wailupe and Niu valleys	Eight burials with associated cultural layers and features designated as SIHP # -4497
Putzi et al. 1998	Archaeological monitoring	Kalaniana‘ole Hwy between East Halema‘uma‘u Rd and Keahole St	Seven burial sites (SIHP #s -4837, -4838, -4840, -4841, -4938, -4939, and -5084) and three non-burial sites (SIHP #s -4694, -4733, and -5083) identified
Hazlett and Hammatt 2008	Archaeological monitoring	Kalaniana‘ole Hwy between Pu‘u‘ikena Street and Niuiki Circle	No archaeological deposits, artifacts, or other significant cultural materials identified within the project area

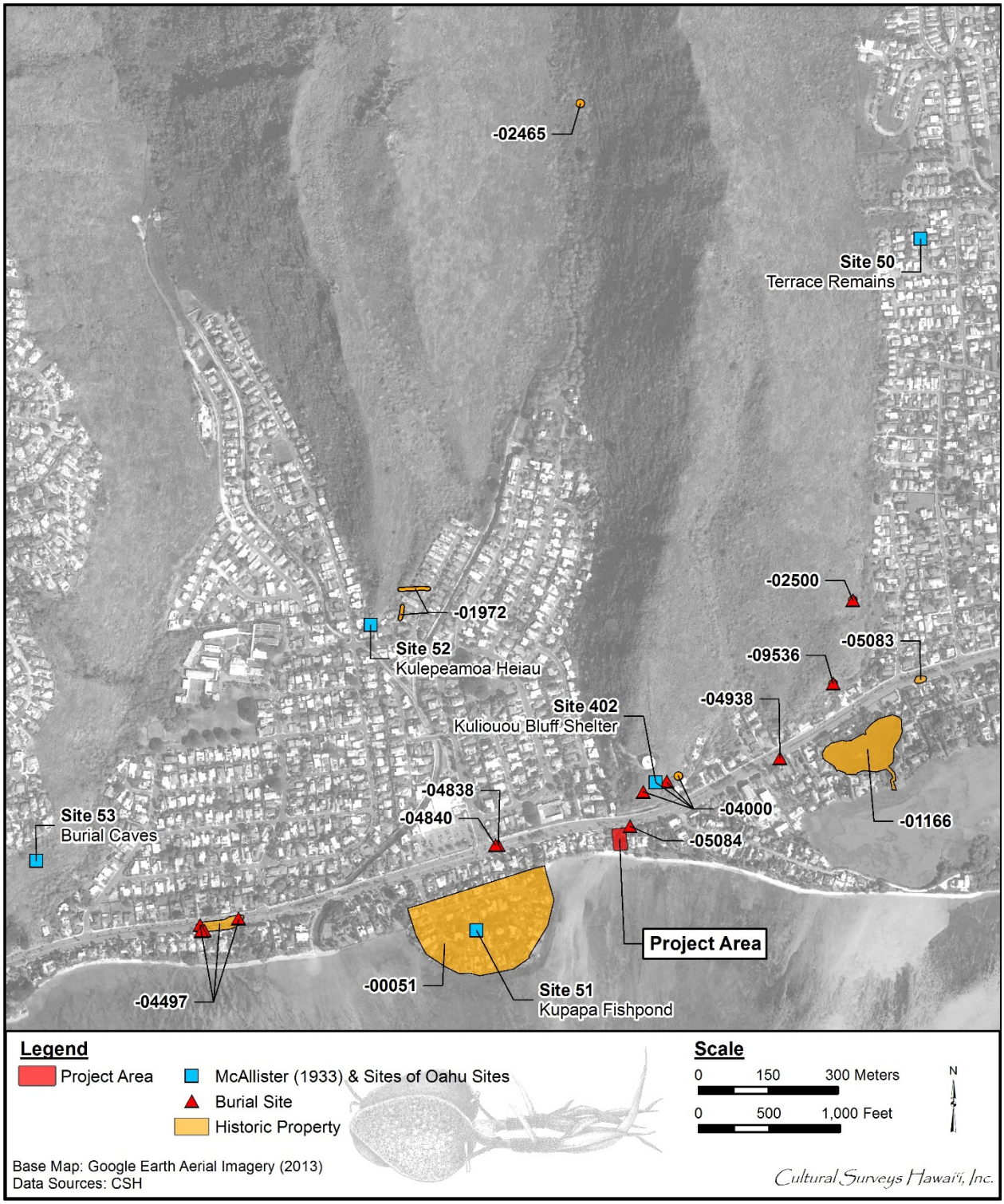


Figure 24. Historic properties in the vicinity of the project area

Table 2. Historic Properties Identified in the Project Area Vicinity

SIHP # 50-80-15	Reference	Description	Function
Site 50	McAllister 1933	Terrace remains	Possible house site or *heiau*
Site 51	McAllister 1933	Kupapa Fishpond	Aquaculture
Site 52	McAllister 1933	Kūlepeamoa Heiau	Religious/ceremonial
Site 53	McAllister 1933	Burial caves	Burial
Site 402	Sterling and Summers 1978	Kuli‘ou‘ou Bluff Shelter	Habitation
-1166	State Inventory of Historic Places	Paiko Pond	Aquaculture
-1972	McMahon 1988	Two walls	Boundary/agriculture
-2465	Dixon 1993	Terrace	Agriculture
-2500	Soehren 1964	Lava tube shelter	Burial/habitation
-4000	Emory and Sinoto 1961	Kuli‘ou‘ou Shelter	Habitation
-4497	Erkelens and Athens 1994	Subsurface cultural deposit	Burial/habitation
-4838	Putzi et al. 1998	Burial site	Burial
-4840	Putzi et al. 1998	Burial site	Burial
-4938	Putzi et al. 1998	Burial site	Burial
-5083	Putzi et al. 1998	Subsurface cultural deposit	Habitation
-5084	Putzi et al. 1998	Burial site	Burial
-9536	Dye 1977	Burial cave	Burial

include terraces/walls, subsurface cultural deposits, fishponds, and a *heiau*, as well as numerous human burials located both east and west of the current project. The following is a summary of these archaeological studies and sites.

4.7.1 McAllister 1933

During his island-wide survey in 1930, J. Gilbert McAllister recorded four sites in the vicinity of the current project: Site 50 (terrace remains), Site 51 (Kupapa Fishpond), Site 52 (Kūlepeamoa Heiau), and Site 53 (burial caves). McAllister (1933) described them as follows:

> Site 50. Terrace remains, Honolulu side of Kuliouou Valley.
>
> On the edge of the elevation just inland of the Perry place are the remains of what may have been a pretentious house site, or a heiau. Only a tumbled-down corner of what was apparently a terrace remains. It can be traced for 25 feet in one direction and for 33 feet in the other. There are a few pieces of old coral about the site.
>
> Site 51. Kupapa Fishpond, Niu.
>
> The pond is now filled and has been used for agricultural purposes. The wall of waterworn basalt was 3 feet high by 8 feet in width and formed a semicircle 2000 feet long. It inclosed several acres. The name was given to me by Kalaluhi Akana Kapiiohe.
>
> Site. 52. Kulepeamoa heiau, Niu, at the foot of the middle ridge which takes its name from the heiau.
>
> Portions of a terrace are still to be seen, 120 feet wide and 5 feet high, with the length ranging from 40 to 100 feet according to the rise of the ridge. There were no terraces above this one, but there may have been one or more on the sea side. The stones are waterworn basalt of varying size, most of which have been used in walling a cattle pen in the vicinity. A small section in the center of the remaining terrace and also the southwest corner appear to have been stepped. The heiau faces the sea on the south. A pit 10 feet deep and 10 by 15 feet in extent, located 60 feet south of the center of the terrace, appears to be modern.
>
> Site 53. The caves at Niu have long been famous. Westervelt (84, 2, p. 149) writes: ‘Sometimes the bodies of chiefs were placed in small canoes, or parts of a canoe, and hidden in roomy caverns, watched over by devoted guards. This was done at Niu, where decayed remnants of canoes can still be seen,’ and remarks (84, 2, p. 147): ‘On Oahu the caves of Niu…were abundantly used for burial.’
>
> Chief Justice Antonio Perry kindly directed me to the Niu cave. It is a tunnel approximating 100 feet in length. Near the mouth are remnants of numerous burials. Not far from the entrance is a wooden coffin which contains a few bones. Back of the coffin are fragments of tapas, cloth, lauhala mats, and portions of many skeletons. A small part of a canoe was seen. All of the burials have been disturbed and plundered. [McAllister 1933:70]

4.7.2 Emory and Sinoto 1961

In 1950, Kenneth Emory and University of Hawai‘i students conducted archaeological investigations at the Kuli‘ou‘ou Shelter (SIHP # 50-80-15-4000; Sterling and Silver Site # 402), which is one of the most renowned sites in the Islands due to the amount of information gleaned from its investigation. Emory and Sinoto (1961) describe the shelter as a lava tube remnant situated below a bluff on the eastern face of the tip of the western ridge flanking Kuli‘ou‘ou Valley. A thick cultural layer was recorded at the rock shelter, and an abundance of midden and artifacts was recovered. Midden included marine shell, faunal remains, and plant remains. Artifacts included fire sticks, cooking stones, bone needles, picks, awls, bamboo and basalt cutting implements, stone and coconut shell scrapers, fishhooks and fishhook blanks, files, octopus lure sinkers, net sinkers, netting needles, net mesh gauges, adzes, chisels, grinding stones, *‘ulu maika*, and bamboo *kapa* cloth stamps, among other items. The 1950 Kuli‘ou‘ou Shelter excavations also provided samples for the first radiocarbon dates in Hawai‘i.

4.7.3 Soehren 1964

In 1964, the Bernice Pauahi Bishop Museum (BPBM) conducted an archaeological reconnaissance survey, which identified SIHP # -2500 (burial cave) (Soehren 1964). SIHP # -2500 is described as an extensive lava tube with burials in back, behind a wall that was broken open. Some midden was present at the entrance, but was disturbed.

4.7.4 Dye 1977

In 1977, the BPBM investigated a lava tube at the southern end of Kuli‘ou‘ou 2 Ridge (Dye 1977). The tube contained human remains (SIHP # -9536) that were incomplete, possibly as a result of disturbance by vandals. Three concentrations of human bones were found scattered on the cave floor. These included bones of the hand, foot, spine, sternum, and ribs. The remains were left within the tube.

4.7.5 McMahon 1988

In 1987, the BPBM surveyed a 5-acre parcel in Niu Valley (McMahon 1988). A terrace wall was recorded in the vicinity of the reported location of Kūlepeamoa Heiau (McAllister Site 52), although it could not be determined if the terrace was associated with the *heiau*. A second wall was observed on the western face of Kuli‘ou‘ou 2 Ridge. The walls were designated as Features 1 and 2 of SIHP # -1972. Three backhoe trenches were excavated, but no cultural features or deposits were encountered.

4.7.6 Dixon 1993

In 1992, the BPBM conducted an archaeological reconnaissance survey of five board of water supply exploratory water well locations on O‘ahu (Dixon 1993). Two well locations (the Kūpaua Wells) were located within Niu Ahupua‘a, where the current project is located. One site, SIHP # -2465 was identified in this area. SIHP # -2465 consists of at least one modified, cobble terrace wall located on the east bank of Kūpaua Stream. Several large, primary basalt flakes were observed within and around the site, and a small, polished stone adze was recovered near the terrace wall.

4.7.7 Erkelens and Athens 1994

In 1992, International Archaeological Research Institute, Inc. (IARII) conducted archaeological monitoring and burial recovery excavations along Kalaniana‘ole Highway, fronting Wailupe and Niu Valleys (Erkelens and Athens 1994). Eight burials with associated cultural layers and features were designated as SIHP # -4497. The features included historic trash pits, fire pits, midden pits, and a possible posthole. Two radiocarbon dates from a midden pit yielded calibrated dates of AD 1649-1800 and 1489-1800.

4.7.8 Putzi et al. 1998

From 1993-1995, Garcia and Associates (GANDA) conducted archaeological monitoring during construction activities for the Phase II widening of Kalaniana‘ole Highway (Putzi et al. 1998). Phase II construction activities were undertaken within a 1.4-mile corridor of Kalaniana‘ole Highway between East Halema‘uma‘u Road and Keahole Street in Niu, Kuli‘ou‘ou and Maunalua Ahupua‘a. Seven burial sites (SIHP #s -4837, -4838, -4840, -4841, -4938, -4939, and -5084) and three non-burial sites (SIHP #s -4694, -4733, and -5083) were identified. Of these, SIHP #s -4838, -4840, -4938, -5083, and -5084 are located nearest to the current project area, with # -5084 adjacent to the northeast corner of the project area.

SIHP) # -5084 consists of a subsurface human burial (Minimum Number of Individuals [MNI]: 1) and associated burial pit (Putzi et al. 1996f cited in Putzi et al. 1998:55). The recovered human skeletal remains associated with SIHP # -5084 were “returned to representatives of the State Historic Preservation Division (SHPD) Burials Program of the Department of Land and Natural Resources,” and relocated (Putzi et al. 1998:109).

The seven burial sites contained skeletal remains representing 40 human individuals interred within 29 discrete burial features. Burial site boundaries were determined according to spatial arrangements. Some burials were recovered and later reinterred in two burial vaults adjacent and west of Kuli‘ou‘ou Stream, while others were preserved in situ.

SIHP # -4733 consisted of three historic trash pits, a posthole, and a pig (*Sus scrofa*) interment; it is associated with early to late historic occupation and artifact manufacture. SIHP # -5083 consisted of a trash pit, stone septic tank, and stone alignment with trash pit; it is associated with late historic habitation.

4.7.9 Hazlett and Hammatt 2008

From 2005-2007, CSH conducted archaeological monitoring for the Niu Valley force main replacement project on Kalaniana‘ole Highway between Pu‘u‘ikena Street and Niuiki Circle (Hazlett and Hammatt 2008). With the exception of a discontinuous, buried road surface in Kawaikui Beach Park, no cultural material was encountered. The stratigraphy of the project area primarily consisted of a variety of fill layers associated with the construction of the road and back-filled soil from previous excavations. Natural soils encountered included a limestone coral layer. No archaeological deposits, artifacts, or other significant cultural materials were identified.

Section 5 Field Inspection Results

A reconnaissance-level pedestrian inspection of the project area was completed on 20 May 2016 by Brittany Beauchan, M.A., and David Shideler, M.A., under the overall supervision of Hallett H. Hammatt, Ph.D. (principal investigator). The project area is a residential lot containing the Kalauha‘iha‘i Fishpond and three dilapidated structures measuring approximately 10,827 sq ft. The inspection included the documentation of Kalauha‘iha‘i Fishpond and associated features. In addition to anthropogenic features, natural features associated with fishpond hydrology were also documented. Fieldwork included photographic documentation of the three existing historic-era structures within the project area and a visual surface inspection of the adjacent SIHP # -5084.

Fieldwork was primarily focused on the inspection and documentation of the existing *loko pu‘uone* (nearshore fishpond fed by both fresh and salt water) and associated features, including a basalt stone and mortar *kuapā* (wall), a basalt stone and mortar *‘auwai* (channel or ditch), and concrete posts for a double *mākāhā* (sluice gate) (Figure 25 through Figure 30). The field inspection also examined three existing historic-era structures within the project area; two of these structures once functioned as private residences, with the third structure designated as a car garage (Figure 31 through Figure 33). The two residential structures are currently vacant. The property was subsequently condemned following the damage and disruption of the water supply to Kalauha‘iha‘i Pond during the DOT’s Kalaniana‘ole Highway widening project in the early 1990s. During field inspection, all three structures were noted to be in a dilapidated state, with extensive termite damage and graffiti. These structures currently occupy the northern (*mauka*) portion and southwestern (*makai*, ‘Ewa) corner of the project area.

Generally, fieldwork included a visual inspection of the entire project area in order to identify any previously undocumented cultural resources. The field inspection began at the northeast corner of the project area along Kalaniana‘ole Highway, immediately adjacent to SIHP # -5084. SIHP # -5084 consists of a subsurface human burial (MNI: 1) and associated burial pit (Putzi et al. 1996f in Putzi et al. 1998:55). The recovered human skeletal remains associated with SIHP # -5084 were “returned to representatives of the State Historic Preservation Division (SHPD) Burials Program of the Department of Land and Natural Resources.” These remains have since been relocated (Putzi et al. 1998:109). Visual surface inspection indicated SIHP # -5084 was located immediately northeast of the project area, within the *makai* sidewalk easement of Kalaniana‘ole Highway (Figure 34).

The northern boundary of the project area runs parallel to the southern (*makai*) edge of the sidewalk easement, and is slightly elevated from the adjacent Kalaniana‘ole Highway. The existing garage structure occupies the northwest corner of the project area. Extending south (*makai*) from the garage structure, a set of stairs leads into the interior portion of the project area. When viewed from the foot of these stairs, Kalaniana‘ole Highway and its sidewalk easement are elevated approximately 2.5 to 3 m above the interior portion of the project area, including Kalauha‘iha‘i Fishpond (see Figure 35).

CSH has identified Kalauha‘iha‘i Fishpond, a *loko pu‘uone*, as a potential cultural resource. Kalauha‘iha‘i Fishpond occupies the majority of the interior portion of the project area. The fishpond extends to the northern, eastern, and western boundaries of the project area.

Figure 25. Aerial photograph depicting the locations of features associated with Kalauha‘iha‘i Fishpond (CSH 1) observed during the field inspection (Google Earth 2013)

Figure 26. Aerial photograph of Kalauha‘iha‘i Fishpond, Kalaniana‘ole Highway, and Koko Head Crater, view to east (courtesy Maunalua Fishpond Heritage Center)

Figure 27. General view of Kalauha‘iha‘i Fishpond, view to southwest

Figure 28. General view of Kalauha‘iha‘i Fishpond wall, view to northeast

Figure 29. General view of *‘auwai* and existing historic-era structure, view to north

Figure 30. General view of *makai mākāhā*, view to southwest

Figure 31. General view of existing *mauka* structure; structure originally the private residence of Mr. Tad Hara, view to northeast

Figure 32. General view of garage structure, view to northwest

Figure 33. General view of existing *makai* structure, view to south

Figure 34. General view of the *makai* sidewalk easement of Kalaniana‘ole Highway and the general location of SIHP # -5084 (burial) documented by Putzi et al. (1998), view to west

Figure 35. General view toward Kalaniana‘ole Highway and its sidewalk easement; elevated approximately 2.5 to 3 m above the interior portion of the project area, view to north

Kalauha‘iha‘i Fishpond consists of two features. Feature 1 is a basalt stone and mortar *kuapā* (wall) running the perimeter of the pond, and partially enclosing a surface area of 368 sq m (Kennedy 2011:16). Basalt boulders and cobbles were utilized in the construction of the wall. The *kuapā* is four courses high and varies in height from 105 cm in its southwest (*makai*, ‘Ewa) section, 100 cm in its southeast (*makai*, Koko Head) section, 130 cm in its northwest (*mauka*, ‘Ewa) section, and 120 cm in its northeast (*mauka*, Koko Head) section (Figure 36 through Figure 39). A portion of the northeast (*mauka*, Koko Head) section of the *kuapā* is capped with concrete material mixed with subangular aggregate; this concrete cap is approximately 4 cm thick. During the field inspection, two members of Maunalua Fishpond Heritage Center, Ms. Alyssa Miller and Mr. Chris Cramer, informed CSH that the fishpond wall had been constructed prior to the ownership of the property by Mr. Tad Hara in the early 1970s.

A 104-cm wide gap was observed along the southern (*makai*) portion of the fishpond. This gap marks the northern limits of Feature 2, a basalt stone and mortar *‘auwai* and concrete posts for a double *mākāhā*. This gap also marks the location of the northern (*mauka*) *mākāhā.* The northern *mākāhā* consists of two concrete posts constructed directly into the basalt stone and mortar *kuapā,* and located on both the eastern (Koko Head) and western (‘Ewa) sides of the gap. These posts were intended to secure a wooden vertical slide gate. The northern *mākāhā* measures approximately 82 cm high, with its concrete posts measuring approximately 30 cm wide and 8 cm deep (See Figure 40 and Figure 41). The northern *mākāhā* also marks the northern end of the basalt stone and mortar *‘auwai* (labeled as “ditch” on Figure 25); this *‘auwai* is approximately 12.35 m in total length. The *‘auwai* walls are approximately 30 cm wide, with an approximately 4 cm thick concrete cap. The northern portion of the *‘auwai* measures approximately 90 cm high and appears to have been built in two separate phases. The lower courses, measuring three courses high, appear to represent an older phase of *‘auwai* construction. The upper courses, measuring two courses high, appear to have been a more recent addition. A cast iron utility, 10 cm in diameter, was observed within the upper courses of the *‘auwai* walls and may possibly be associated with the later phase of *‘auwai* construction (Figure 42). The interior width of the *‘auwai* varies between 90-104 cm. The *‘auwai* appears to represent an *‘auwai kai* (sea gate) due to its sloping nature and decrease in height near its southern (*makai*) end. In its central portion, the *‘auwai* walls measure approximately 65-68 cm high (Figure 43). At its southern (*makai*) end, the *‘auwai* walls measure approximately 36 cm high. The southern end of the *‘auwai* also marks the location of the southern (*makai*) *mākāhā*. The southern *mākāhā* consists of concrete post remnants (Figure 44 and Figure 45); the extent (height) of these posts could not be determined due to sediment and heavy overgrowth of *naupaka*, *pōhuehue*, and *koa haole*. These posts measure approximately 35 cm long and 20 cm wide, with a 3 cm deep groove designed to hold a wooden vertical slide gate. Loose basalt cobbles were also observed in the vicinity of the southern *mākāhā*. The two *mākāhā* and *‘auwai* possibly represent “a more recent innovation (introduced by Chinese immigrants in the mid-1800s) . . . of a double mākāhā, two parallel grates set a few feet apart in a fishpond wall, which permitted the trapping of fish between the grates and allowed for easier harvesting by small hand nets” (Apple 1975 in Keala et al. 2007:11).

Ms. Miller and Mr. Cramer also informed CSH of the location of a spring known to feed freshwater into the walled pond. Upon examination of the northwest (*mauka*, ‘Ewa) section of the fishpond, CSH identified the partially infilled spring responsible for feeding freshwater into the pond (Figure 46). The spring measures approximately 80 cm in diameter.

Figure 36. Southwest (*makai*, ‘Ewa) section of fishpond, view to southwest

Figure 37. Southeast (*makai*, Koko Head) section of fishpond, view to east

Figure 38. Northwest (*mauka*, *‘Ewa*) section of fishpond, view to northwest

Figure 39. Northeast (*mauka*, Koko Head) section of fishpond, view to northeast

Figure 40. Northern (*mauka*) *mākāhā*, view to northwest

Figure 41. Northern (*mauka*) *mākāhā*, view to northeast

Figure 42. Oblique view of northern (*mauka*) portion of *‘auwai* and cast iron utility, view to northwest

Figure 43. Profile view of central portion of *‘auwai*, view to east

Figure 44. Plan view of concrete posts for southern (*makai*) *mākāhā*, view to east

Figure 45. Close up of concrete posts for southern (*makai*) *mākāhā*, view to west

Figure 46. Location of the spring (marked by photo scale) responsible for supplying freshwater to Kalauha‘iha‘i Pond, view to north

Ms. Miller and Mr. Cramer also noted that Mr. Hara had previously identified the lava tube conduit that fed directly into the pond. According to Ms. Miller and Mr. Cramer, Mr. Hara had stated that the lava tube was large enough to fall into, and thus he was prompted to mark the circumference of the lava tube (or spring) with stones. During field inspection, CSH identified the location of the lava tube conduit damaged during Kalaniana‘ole Highway widening construction. The lava tube conduit responsible for feeding the Kalauha‘iha‘i Pond spring was observed north (*mauka*) of Kalaniana‘ole Highway, approximately 40 m from the project area; a large bougainvillea tree and stand of *koa haole* (*Leucaena leucocephala*) currently marks the original location of the lava tube conduit (Figure 47).

During field inspection, CSH also made note of the fishpond environment. During the pedestrian inspection within the fishpond, CSH noted the presence of an odor indicative of anaerobic decomposition typical for a low-oxygen or aquatic environment. Silt levels were noted to be 3-10 cm thick. Of aquatic species, *weke* (goatfish; *Mullidae*) and tilapia were observed; various species of ducks were also observed within the pond. During in-field consultation with CSH, Ms. Miller and Mr. Cramer stated the pond had also once contained *‘ama‘ama* (mullet; *Mugil cephalus*), *awa* (milkfish; *Chanos chanos*), *āholehole* (Hawaiian flagtail), *‘ōpae lolo* (brackish water shrimp), *‘ōpae‘ula* (Hawaiian red shrimp), and *hapawai* (brackish water snail). Vegetation observed within the project area includes California grass, *milo* (*Thespesia populnea*), *ki* (ti), *pōpolo* (black nightshade; *Solanum nigrum*), *niu* (coconut; *Cocos nucifera*), ficus, octopus tree, *makaloa* (perennial sedge; *Cyperus laevigatus*), *pōhuehue* (beach morning glory; *Ipomoea pes-caprae*), *naupaka* (*Scaevola*), and *koa haole*.

Kalauha‘iha‘i Pond may be considered a historic property/cultural resource as it is the only shoreline fishpond in Honolulu, besides nearby Kanewai Fishpond. The potential for the fishpond to yield information important for research is high. Potentially, the fishpond and surrounding project area may yield information relating to pre-Contact and early post-Contact habitation and traditional land use patterns within Niu Ahupua‘a. Additionally, archival documents have indicated the project area was given to a Captain Adams “just before the coming of the first New England missionaries in 1820, as a reward for thwarting an attempted Russian invasion of the Island of Kauai in 1815.” The project area was also once the country home of Kamehameha the Great and Ka‘ahumanu and was also the site of the “great Kaluhaihai assembly . . . [of] 1919, when the ancient tabu laws were broken on Oahu.” Thus, the fishpond and project area may possibly be associated with events that have made a significant contribution to broad patterns of Hawai‘i’s history, in addition to being associated with the lives of persons significant in Hawai‘i’s past.

Figure 47. General view of area *mauka* of Kalaniana‘ole Highway and the general location of the lava tube feeding Kalauha‘iha‘i Pond spring; note truncated lava tube in far right middle ground, view to northwest

Section 6 Traditional Cultural Practices

6.1 *Ka‘ao* and *Mo‘olelo*

There are two stories regarding Hi‘iaka, the sister of the fire goddess Pele. Nathaniel B. Emerson places Hi‘iaka on the eastern coast of O‘ahu while she searches for food and encounters the residents of the area. Hi‘iaka begs some women who had caught small fish and crabs if she could have a portion of their catch. The women refused Hi‘iaka a portion and suggested she would do much better catching her own fish. As the sister of the fire goddess, Hi‘iaka could not let their insults go unpunished and stated,

> He makani holo uha (*a*)
>
> Ko Ka-ele-kei a Pau-kua (*b*)
>
> Pau wale kea ho I ka noi ana,
>
> O ka loa ho‘i, e!
>
> Translation:
>
> Here’s a blast shall posset the blood,
>
> As the chant of kahuna the back.
>
> Our patience exhausts with delay;
>
> We’re famished from the length of the way. [Emerson 1915:187]

Ho‘oulumāhiehie gives a slightly different version from Emerson. Hi‘iaka is traveling from south to east on O‘ahu with her companions, Wahine‘ōma‘o and Lohiau. The trio had defeated several monsters in Palolo Valley and were headed toward the Maunalua to meet with chief Kaulanakalā who offered them a ride in his canoe to Moloka‘i (Ho‘oulumāhiehie 2008b:317).

6.2 *Wahi Pana*

Niu, literally translates to “coconut” (Pukui et al. 1974:166). The *ahupua‘a* is divided into two valleys, separated by Kūlepeamoa (“flapping of chicken”) Ridge. To the west is Pia (“arrowroot”) Valley and to the east Kupaua (“upright clam”) Valley. A *heiau* sits at the foot of Kūlepeamoa Ridge called Kūlepeamoa Heiau. Archaeologist J.Gilbert McAllister surveyed the entire island of O‘ahu in 1930. During his survey, he stated that portions of a terrace could still be observed measuring 120 ft wide, 5 ft high, and 40 to 100 ft in length (depending on the rise of the ridge). The *heiau* also faced the ocean.

In 2012, Laura Lucas Thompson, descendant of Alexander Adams who once owned the *ahupua‘a* of Niu, attested to the cultural landscape of the area. In her affidavit, she recalls a well at the bottom of Kūlepeamoa Heiau. The water from the well was used for her father’s dairy. She shared her memory of the well, “We were not allowed to go into the well but I remember watching two young guys from the dairy swimming and saying that two ‘tunnels’ (lava tubes) were the water source.” At the border of Wailupe and Niu was a well called Wai Ku‘i a Kamehameha at a place called Papalea. The water originated from a large inland cave called Kaluapani‘o. Near the border of Kuli‘ou‘ou and Niu was another spring called Ke Puhi o Kanau. A spring could also be found

within the current project area. Although the traditional name is not known, it was frequently called Lucas Spring, named for the Lucas family who owned the land (Clark 1977:35). Lucas Spring is also known as Kalauha‘iha‘i Pond, the current project area. Ms. Laura Lucas Thompson once resided at Kalauha‘iha‘i and recalls the cold water and the abundance of aquaculture in the pond. In an article, former resident of Kalauha‘iha‘i Tad Hara also shared his memories of the pond where he raised champion koi fish and also witnessed the variety of aquatic life. According to Mr. Hara, during the early 1990s the State of Hawai‘i – DOT began widening Kalaniana‘ole Highway. The four-lane highway was now being expanded to six lanes. To accommodate the extra two lanes, the DOT condemned 3 ft of Mr. Hara’s property. During construction, Mr. Hara warned DOT contractors to be careful of a natural underground spring. Ignoring Mr. Hara’s pleas, DOT contractors struck the waterway that supplied fresh water to Kalauha‘iha‘i Pond. Mr. Hara came home to dead fish and a muddy pond. In addition to Kalauha‘iha‘i Pond, there was also Kūpapa Fishpond (also called Niu Pond). Kūpapa was once part of a large tract of land that Kamehameha I used as a summer home. Kūpapa Fishpond has since been covered and is now a roadway (Niuiki Circle) and residential area.

6.3 Burials

Another important feature of the *ahupua‘a* are the many burial caves that line the valleys. During McAllister’s survey, he cataloged Site 53 consisting of burial caves:

> The caves at Niu have long been famous. Westervelt (84, 2, p. 149) writes: ‘Sometimes the bodies of chiefs were placed in small canoes, or parts of a canoe, and hidden in roomy caverns, watched over by devoted guards. This was done at Niu, where decayed remnants of canoes can still be seen,’ and remarks (84, 2, p. 147): ‘On Oahu the caves of Niu . . . were abundantly used for burial.’
>
> Chief Justice Antonio Perry kindly directed me to the Niu cave. It is a tunnel approximating 100 feet in length. Near the mouth are remnants of numerous burials. Not far from the entrance is a wooden coffin which contains a few bones. Back of the coffin are fragments of tapas, cloth, lauhala mats, and portions of many skeletons. A small part of a canoe was seen. All of the burials have been disturbed and plundered. [McAllister 1933:70]

Previous archaeological reports indicate several burial caves have been cataloged including SIHP # -2500, burial cave with midden at entrance (Soehren 1964); SIHP # -9536, incomplete human remains in a lava tube left in situ (Dye 1977); SIHP # -4997, eight burials with associated cultural layers and features (Erkelens and Athens 1994); SIHPs # -4837 through -4841 and -5084, seven burial sites (Putzi et al. 1998).

6.4 Settlement Patterns and Cultivation

Previous archaeological research and findings indicate Niu Ahupua‘a was a once flourishing community during pre-Contact times. The presence of fishponds, terraces, springs, religious structures, burial caves, and midden suggest the *ahupua‘a* was ideal and used for settlement.

In her affidavit, Ms. Laura Lucas Thompson recalls the “cloud of opae” and “the pungent strings of limu eleele” at Kalauha‘iha‘i Pond. Fish were also observed at the pond “but not the size of those raised in Kuapa Pond at Koko Head.” Mr. Tad Hara later lived in a two-story home above

Kalauha‘iha‘i Pond. The home’s living room floor was constructed with glass from the inside so the homeowners could enjoy the pond. Besides Mr. Hara’s prize-winning koi fish, the pond also contained wild mullet, prawns, crabs, and other aquatic life. Mr. Hara would also often take his children a mile out into the ocean to catch dinner. They often caught octopus, crab, *papio* (juvenile crevalle), and other reef fish.

Section 7 Summary and Recommendations

CSH undertook this LRFI with cultural study at the request of Maunalua Fishpond Heritage Center. The research broadly covered the entire *ahupua‘a* of Niu, which includes the current project area.

7.1 Results of Background Research

Background research for this study yielded the following results:

1. Niu literally means “coconut” (Pukui et al. 1974:166). Frank (1985:22) stated that the name was given to the *ahupua‘a* after a women who husked coconuts.
2. Several springs are located in Niu Ahupua‘a including Papalea (located near the Wailupe Ahupua‘a border) and Lucas Spring, which is part of the current project area. The traditional name for Lucas Spring is unknown, however, it was named after the Lucas family who owned the land.
3. An ancient trail once led from the coast into Niu, toward the Ko‘olau Mountains, and down into the windward side of the island. The trail went through the valley of Kaiiliili-iki, possibly another name for Pia or Kupaua Valley, the two valleys that are separated by Kūlepeamoa Ridge (Sterling and Summers 1978:274).
4. Niu Ahupua‘a consisted of two fishponds: Kūpapa and Kalauha‘iha‘i. Kūpapa Fishpond (also known as Niu Pond) was later covered and became a roadway (Niuiki Circle) and residential area.
5. LCA documents indicate four claims were made for Niu Ahupua‘a, however, only one was awarded. LCA 802 was awarded to Captain Alexander Adams. The Niu lands awarded to Captain Adams consisted of 2,446 acres and were eventually passed down to his granddaughter, Mary Papapaupu Bannister Lucas.
6. Archival documents state Niu lands were given to Captain Adams “just before the coming of the first New England missionaries in 1820, as a reward for thwarting an attempted Russian invasion of the Island of Kauai in 1815.” The property is very significant in that it was once the country home of Kamehameha the Great and Ka‘ahumanu and was also the site of the “great Kaluhaihai assembly was held in 1919, when the ancient tabu laws were broken on Oahu.”
7. Kalauha‘iha‘i later became the site of a dairy owned and operated by Charles Lucas and his son, Charles W. Lucas.
8. An affidavit submitted by Laura Lucas Thompson, a direct descendant of Alexander Adams and fifth generation resident of Niu, states that her father owned and operated Niu Dairy. The milk barn, cattle pens, and grass fields are now in the area known as Niu Estates. Water for the dairy was pumped out of a well located at the bottom of Kūlepeamoa. Although she was not allowed to swim in the well, she recalls two dairy workers swimming in the well and locating two “tunnels” (lava tubes) as the water source.
9. Tad Hara, a former resident who lived above Kalauha‘iha‘i, recalls raising prize-winning koi in the pond. In addition to his koi, other aquatic life such as wild mullet, prawns, and crabs could be found in Kalauha‘iha‘i Pond.
10. SIHP # -5084 consists of a subsurface human burial (MNI: 1) and associated burial pit (Putzi et al. 1996f in Putzi et al. 1998:55). The recovered human skeletal remains associated

with SIHP # -5084 were “returned to representatives of the State Historic Preservation Division (SHPD) Burials Program of the Department of Land and Natural Resources,” and relocated (Putzi et al. 1998:109). SIHP # -5084 was immediately northeast of the project area, within the *makai* sidewalk easement of Kalaniana‘ole Highway.

11. A field inspection of the project area was conducted and one potential cultural resource was identified: Kalauha‘iha‘i Fishpond and its associated fishpond features. Feature 1 consists of a basalt stone and mortar *kuapā* marking the limits of and partially enclosing the freshwater pond. Feature 2 consists of a basalt stone and mortar *‘auwai* and the concrete remnants of a double *mākāhā*. Kalauha‘iha‘i Fishpond is located within TMKs: [1] 3-7-002:018 and 077 and occupies approximately 368 sq m within the project area. Based on information provided by Maunalua Fishpond Heritage Center, Kalauha‘iha‘i Pond is one of only six remaining fishponds on O‘ahu, and is currently in the process of being revitalized and returned to a functional fishpond. Additionally, one subsurface cultural resource initially documented by Putzi et al. (1998) is located in the immediate vicinity of the project area.

7.2 Recommendations

Based on the information gathered from archival documents, previous archaeological reports, previous oral histories focusing on the project area, and field inspection, CSH recommends the following:

1. Consultation with the SHPD to request an SIHP number for Kalauha‘iha‘i Fishpond and the associated fishpond features.
2. The preservation of the Kalauha‘iha‘i Fishpond wall and *‘auwai*.
3. Consultation with the SHPD regarding a preservation plan in compliance to HAR 13-277-3.
4. Consultation with the SHPD regarding a monitoring program in regards to the demolition of two house structures within the current project.

Section 8 References Cited

Akana, Collette Leimomi and Kiele Gonzalez
2016 *Hānau Ka Ua*. Kamehameha Schools Publishing, Honolulu.

Ava Konohiki
2015 Ancentral Visions of ‘Āina website. Available online at http://www.avakonohiki.org/.

Bishop Museum Archives
1890 Photograph of men spearing *he‘e* along Niu Ahupua‘a coastline. Bishop Museum Archives, Honolulu.

Chamberlain, Levi
1826 *Trip around Oahu in 1826*. Manuscript on file, Hawaii Mission Houses Library. Honolulu.
1828 *Tour Around Oahu in 1828*. Manuscript on file, Hawaii Mission Houses Library. Honolulu.

Chinen, Jon J.
1958 *The Great Māhele, Hawai‘i’s Land Division of 1848*. University of Hawaii Press, Honolulu.

Clark, John R.K.,
1977 *The Beaches of O‘ahu*, University of Hawai‘i Press, Honolulu.

Dale, John G.
1845 *Burial Cave Valley of Niu* [painting]. J. Welles Henderson Collection.

Dixon, Boyd
1993 *An Archaeological Reconnaissance of Five Board of Water Supply Wells on O‘ahu, Hawai‘i*. Bernice Pauahi Bishop Museum, Honolulu.

Dye, Thomas S.
1977 *Archaeological Inspection of a Cave on Kuli‘ou‘ou Ridge.* Bernice Pauahi Bishop Museum, Honolulu.

Emerson, Nathaniel B.
1915 *Pele and Hi‘iaka.* ‘Ai Pōhaku Press, Honolulu.

Emory, Kenneth P. and Yosihiko H. Sinoto
1961 Oahu Excavations. Special Publication 49, Bernice Pauahi Bishop Museum, Honolulu.

Erkelens, Conrad and J. Stephen Athens
1994 *Burials, Highways, and History: Archaeology along Kalanianaole Highway, East Honolulu, O‘ahu, Hawai‘i*. International Archaeological Research Institute, Inc., Honolulu.

Foote, Donald E., Elmer L. Hill, Sakuichi Nakamura, and Floyd Stephens

1972 *Soil Survey of the Islands of Kauai, Oahu, Maui, Molokai, and Lanai, State of Hawaii.* U.S. Department of Agriculture, Soil Conservation Service, in cooperation with the University of Hawai‘i Agricultural Experiment Station. U.S. Government Printing Office, Washington, D.C.

Frank, Lilia

1958 Oahu Place Names—Trip from Ka-imu-iki and Vicinity, Kona District, March 19, 1958. Manuscript available at Box M-445, Item # 81. Hawai‘i State Archives, Honolulu.

Google Earth

2013 Aerial photographs of Hawai‘i. Google Inc., Mountain View, California. Available online at www.google.com/earth.html.

Hancock, Lambreth

1983 *Hawaii Kai: The First 20 Years.* Rotary Club of Hawaii Kai, Honolulu.

Handy, E.S. Craighill

1940 *The Hawaiian Planter. Volume 1. His Plants, Methods and Areas of Cultivation.* Bishop Museum Bulletin 161. Bernice Pauahi Bishop Museum, Honolulu.

Hawaii Reporter

2010 Article, 23 May.

Hawai‘i State Archives

1925 Photograph of Kupapa Fishpond and the Niu Ahupua‘a coastline. Hawai‘i State Archives, Honolulu.

Hawai‘i TMK Service

2014 Tax Map Key [1] 3-7-02. Hawai‘i TMK Service, Honolulu.

Hazlett, Alexander and Hallett H. Hammatt

2008 *Niu Valley Force Main Replacement Project, Niu Ahupua‘a, Kona District, O‘ahu TMK: [1] 3-6-003:001-002; 3-7-001, 002, 003, 005, 007, 009, 010, and 016.* Cultural Surveys Hawai‘i, Inc., Kailua, Hawai‘i.

Henry, Lehman L.

1959 A Geographical Study of the Central Maunalua Region, Island of Oahu, State of Hawaii. Unpublished M.A. Thesis, University of Hawaii.

Historic Hawai‘i Foundation

n.d. Photograph of Kalauha‘iha‘i Pond. Historic Hawai‘i Foundation, Honolulu.

Ho‘oulumāhiehie

2008a *Ka Mo‘olelo O Hi‘iakaikapoliopele*. Awaiaulu Press, Honolulu.

2008b *The Epic Tale Of Hi‘iakaikapoliopele*. Puakea Nogelmeier, translator. Awaiaulu Press, Honolulu.

‘Ī‘ī, John Papa

1959 *Fragments of Hawaiian History as Recorded by John Papa ‘I‘i.* Bishop Museum Press, Honolulu.

1983 *Fragments of Hawaiian History as Recorded by John Papa ‘Ī‘ī.* Revised edition. Bishop Museum Press, Honolulu.

Jackson, George E.G.
1883 Waialae Coast, Registered Map 1293. Hawai‘i Land Survey Division, Department of Accounting and General Services, Honolulu.

James, Rob
2004 *The Battle of Nu‘uanu, May 1795*. Kamehameha Schools Press, Honolulu.

Jones, Bruce A.
1996 *Aspects of Inland Settlement in the Hawaii Kai Region: Results of an Archaeological Inventory Survey of Nine Parcels, Ahupua‘a of Maunalua, Honolulu District, Island of Oahu (TMK: 3-9-8: Por. 13 and 3-9-10: Por. 1).* Aki Sinoto Consulting, Honolulu.

Kamakau, Samuel M.
1961 *Ruling Chiefs of Hawai‘i.* Kamehameha Schools Press, Honolulu.

1992 *Ruling Chiefs of Hawai‘i.* Revised edition. Kamehameha Schools Press, Honolulu.

Kame‘eleihiwa, Lilikalā
1992 *Native Land and Foreign Desires.* Bishop Museum Press, Honolulu.

Keala, Graydon “Buddy,” James R. Hollyer, and Luisa Castro
2007 *Loko I‘a: A Manual on Hawaiian Fishpond Restoration and Management.* College of Tropical Agriculture and Human Resources, University of Hawai‘i, Honolulu.

Kelly, Marion, Hiro Kurashima, and Akihiko Sinoto
1984 *Cultural Resources Overview for the Queen's Beach Park Feasibility Study, Maunalua, Kona, O‘ahu. Part I: Legends of Maunalua, O‘ahu; Part II: Archaeological Assessment; and Part III: Historical Notes on Queen's Beach and Other Places in Maunalua, O‘ahu.* Anthropology Department, Bernice Pauahi Bishop Museum, Honolulu.

Kennedy
2011 Evaluation of Anthropogenic Impacts on the Flow of Two Coastal Springs in Maunalua Bay, South Shore, O‘ahu. Unpublished B.S. Thesis, University of Hawaii.

LaPasse, Lt. Joseph de
1855 Plan du Mouillage [Anchorages] d’Honolulu. Map by Lt. Joseph de LaPasse. In *The Early Mapping of Hawai‘i* by Gary L. Fitzpatrick, 1986, pp. 82–83. Editions Limited, Honolulu.

Lyons, C.J.
1875 Land Matters in Hawaii, No. 6. *The Islander*, 6 August:143.

McAllister, J. Gilbert
1933 *Archaeology of Oahu*. Bishop Museum Bulletin 104. Bernice Pauahi Bishop Museum, Honolulu.

McGregor, Davianna Pōmaika‘i
1996 *Na Kua‘āina: Living Hawaiian Culture.* University of Hawai‘i Press, Honolulu.

McMahon, Nancy

1988 *Archaeological Reconnaissance Survey of a Five-Acre Parcel in Niu Valley, O‘ahu Island, Hawai‘i*. Bernice Pauahi Bishop Museum, Honolulu.

Nakuina, Moses K.

1992 *The Wind Gourd of La‘amaomao*. First edition. Esther T. Mookini and Sarah Nākoa, translators. Kalamakū Press, Honolulu.

Office of Hawaiian Affairs

2015 *Papakilo Database.* Office of Hawaiian Affairs cultural and historical database. Electronic document, http://papakilodatabase.com/main/index.php

Pukui, Mary K., Samuel H. Elbert, and Esther Mookini

1974 *Place Names of Hawaii.* University of Hawaii Press, Honolulu.

Pukui, Mary K.

1983 *‘Ōlelo No‘eau, Hawaiian Proverbs & Poetical Sayings*. Bishop Museum Special Publication 71. Bishop Museum Press, Honolulu.

Putzi, Jeffrey L., Tim Denham, Francis J. Eblé, and Jeffrey Pantaleo

1998 *Archaeological Monitoring Report for Phase II Widening of Kalaniana‘ole Highway, East Halema‘uma‘u Road to Keāhole Street, East Honolulu, O‘ahu Island*. Garcia and Associates, Honolulu.

Shepard, F.P., Gordon A. Macdonald, and D.C. Cox

1950 *The Tsunami of April 1, 1946*. University of California, Berkeley, California.

Soehren, Lloyd

1964 Site Survey Record and Attached Field Records. Bernice Pauahi Bishop Museum, Honolulu.

Sterling, Elspeth P. and Catherine C. Summers

1978 *Sites of Oahu*. Bernice Pauahi Bishop Museum, Honolulu.

Takemoto, Anne H., Pauline King Joerger, Merie-Ellen Fong Mitchell, and Cassandra E. Bareng

1975 *Historical/Cultural Essay Report on the Kuapa Pond Area.* Joerger-Takemoto Historical Research, Honolulu.

Thrum, Thomas G.

1920 Captain Alexander Adams and the Hawaiian Flag. *Hawaiian Almanac and Annual for 1921*. Thomas G. Thrum, Honolulu.

Ulukau

2014 *Māhele Database.* Hawaiian Electronic Library, http://ulukau.org/cgi-bin/vicki?l=en..

U.S. Army War Department

1919 U.S. Army War Department fire control map, Koko Head quadrangle. USGS Information Services, Denver, Colorado.

1934 U.S. Army War Department fire control map, Koko Head quadrangle. USGS Information Services, Denver, Colorado.

1943 U.S. War Department terrain map, Diamond Head quadrangle. USGS Information Services, Denver, Colorado.

USDA (U.S. Department of Agriculture)

2001 Soil Survey Geographic (SSURGO) database. U.S. Department of Agriculture, Natural Resources Conservation Service. Fort Worth, Texas. http://www.ncgc.nrcs.usda.gov/products/datasets/ssurgo/ (accessed March 2005).

USGS (U.S. Geological Survey)

1952 Koko Head USGS Survey 7.5-minute series topographic quadrangle. USGS Information Services, Denver, Colorado.

1969 Koko Head USGS Survey 7.5-minute series topographic quadrangle. USGS Information Services, Denver, Colorado.

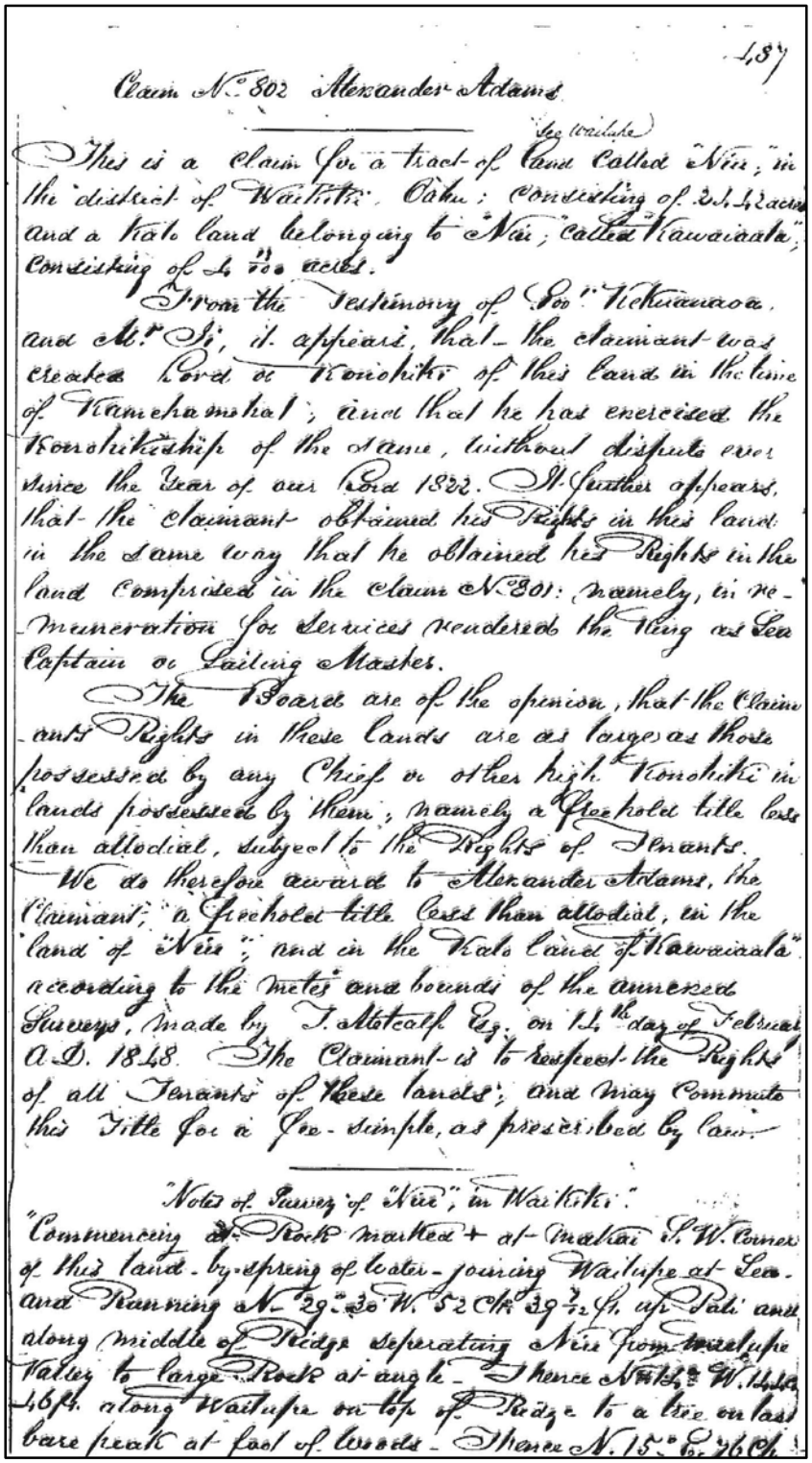
1998 Honolulu USGS Survey 7.5-minute series topographic quadrangle. USGS Information Services, Denver, Colorado.

2011 USGS Orthoimagery Aerial photograph. USGS Information Services, Denver, Colorado.

Waihona ‘Aina

2000 *The Māhele Database*. Electronic document, http://waihona.com (accessed 10 April 2014).

Appendix A LCA 802



187

Claim No. 802 Alexander Adams

This is a claim for a tract of land called "Niu", in the district of Waikiki, Oahu; consisting of 23 Kacas (See Waikiki) and a Kalo land belonging to "Niu", called "Kawaiaala", consisting of 4 100 acres.

From the testimony of Koo. Nehemaoa, and Mr. Ii, it appears, that the claimant was created Konohiki of this land in the time of Kamehamehal; and that he has exercised the Konohikiship of the same, without dispute ever since the year of our Lord 1822. It further appears, that the claimant obtained his Rights in this land in the same way that he obtained his Rights in the land comprised in the claim No. 801: namely, in remuneration for services rendered the King as Sea Captain or Sailing Master.

The Board are of the opinion, that the Claimants Rights in these lands are as large as those possessed by any Chief or other high Konohiki in lands possessed by them; namely a fee-hold title less than allodial, subject to the Rights of Tenants.

We do therefore award to Alexander Adams, the Claimant; a fee-hold title less than allodial, in the land of "Niu"; and in the Kalo land of "Kawaiaala" according to the metes and bounds of the annexed Surveys, made by T. Metcalf Esq. on 14th day of February A.D. 1848. The Claimant is to respect the Rights of all Tenants of these lands; and may commute this Title for a fee-simple, as prescribed by law.

"Notes of Survey of "Niu", in Waikiki."

"Commencing at Rock marked + at makai S.W. corner of this land by spring of water joining Wailupe at Sea and Running N. 29° 30' W. 52 Ch. 39 7/12 Lk. up Pali and along middle of Ridge seperating Niu from Wailupe Valley to large Rock at angle. Thence N. 14½° W. 14 Ch. 46 Lk. along Wailupe on top of Ridge to a tree on last bare peak at foot of woods. Thence N. 15° E. 26 Ch.

438

along Wailupe to mauka N.W. peak of this land on top of Mountain next to Koolau. Then following along on top of Mountain Ridge, the mauka side of this land and Koolau to Mountain peak at mauka E. peak of this, to land called "Kuli'ouou" in Koolau. Then following along down Ridge separating this from Koolau to Rock on top of Sea Pali little above Sea - thence S. 33° 30' E. 6 Ch. 39 ½ ft. down Pali along Kuli'ouou to Rock near Corner of Kalo patch little above Sea; at the Makai S.E. Corner of this land; then along Sea to place of Commencement This land has a Sea to it as marked on Map. and contains an area of

Feb. 14. 1848 Acres 244.2

See Page 490 for diagram

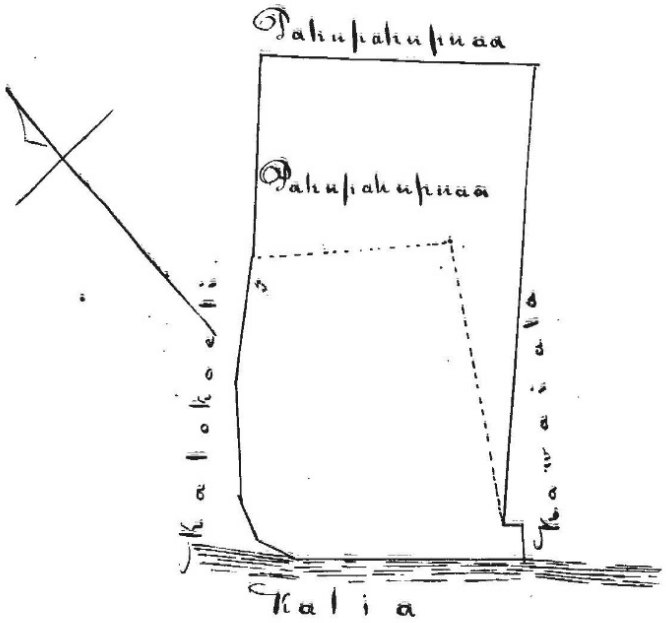
"Notes of Survey of Kalo Land in Waikiki called Kawaiaala alua in Niu"

"Commencing at Makai S. Corner of this land on Mauka side of stream called Kalia, and running N. 44° W. 3 Ch. 63 ½ ft. along Kalia stream to slight angle - thence N. 19° W. 58 ft. to Makai W. Corner of this land - thence N. 24° ¾ E. 46 ½ ft. along Kalokoali to slight angle - thence N. 43° 45' E. 2 Ch. to slight angle - thence N. 55° E. 2 Ch. 11 ½ ft. along Kalokoali to slight angle - thence N. 48° 30' E. 3 Ch. 33 8/12 ft. to Mauka N. Corner of this land - thence S. 42° E. 1 Ch. 63 ½ ft. along Pahupahu apuaa to mauka E. Corner of this land - thence S. 51° W. 8 Ch. along Kawaiaala 182 to Corner - then offset 21 10/12 ft. to left to Corner - thence S. 42° 30' W. 38 ½ ft. to place of Commencement. including an area of

Feb. 14. 1848 Acres 1 13/100

J. Metcalf Sur.

489



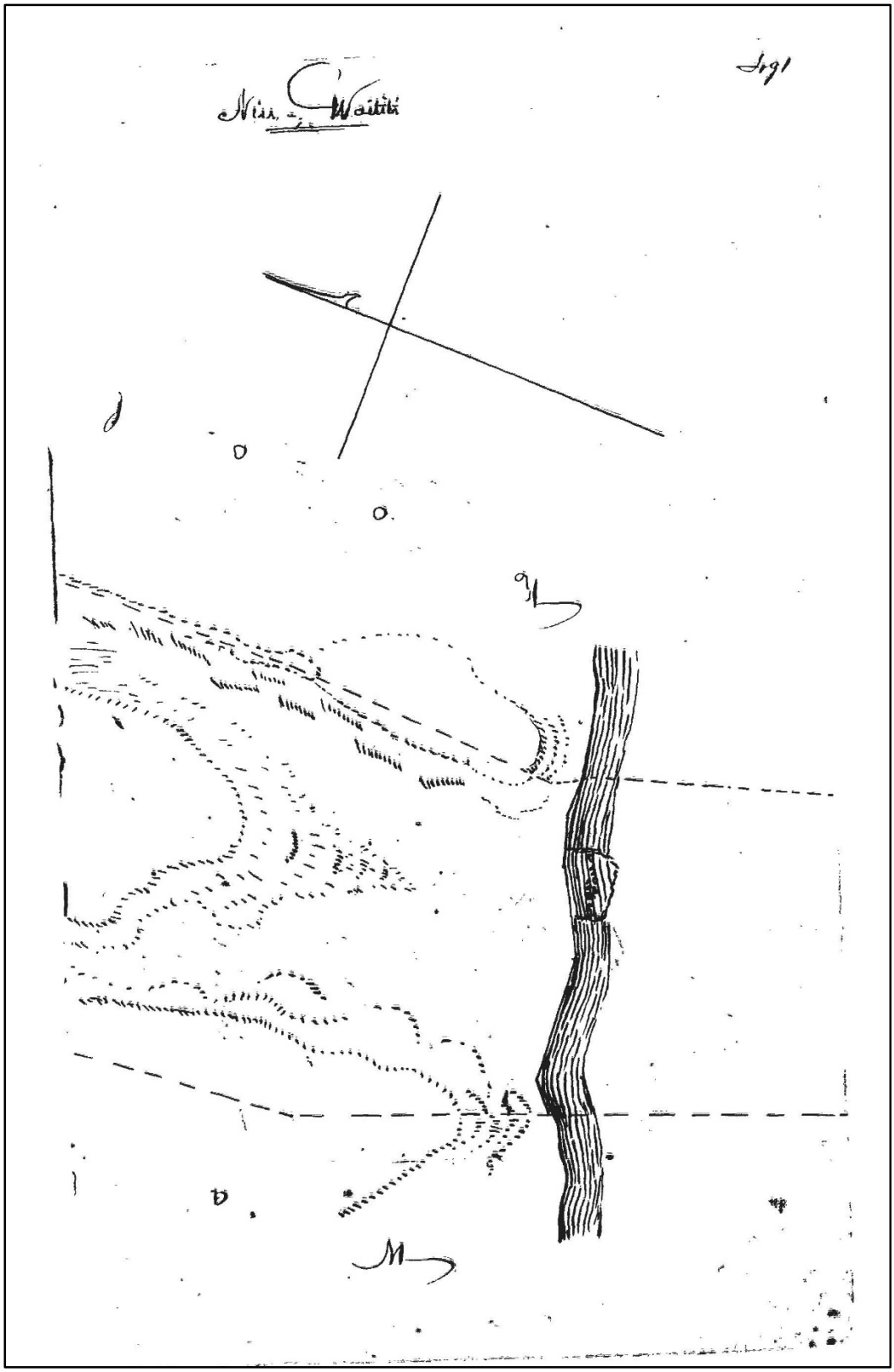
Costs. Adjudication of C. N. 802. Alex. Adams Dr.

To Incidental Expenses &		1	
action of Commiss.rs in this Cl. 19 January 1848		1	
draft deposition of Cl. reduced		1	
Citation			50
draft testimony Reduced & Eng.d on 19 Jan.y	$1		75
Survey of R. Matcalf for two lands		20	
Engrossed Copy of do	$12	6	
Report this day rendered by Commissioners on the above claim		5	
		35	25

Hale Naauao
29 January 1849

W. L. Lee
J. G. Smith
G. M. Ka[illegible]
Z. Kaauwai
Commrs.

190
Page 187 - Cl. 802 -


Niu, Waitiki
Fig 1

Appendix B Affidavit from Laura Lucas Thompson

GENERAL AFFIDAVIT

STATE OF Hawaii
COUNTY OF Honolulu

PERSONALLY came and appeared before me, the undersigned Notary, the within named Laura Lucas Thompson, who is a resident of Honolulu County, State of Hawaii, and makes this his/her statement and General Affidavit upon oath and affirmation of belief and personal knowledge that the following matters, facts and things set forth are true and correct to the best of his/her knowledge:

The purpose of this affidavit is to encourage action to improve the health of Maunalua Bay by allowing ground water to once again flow from the mountains to the sea with particular attention to Lucas Spring/Kalaha'iha'i fish pond on Kalanianaole Highway at Niu.

My family has owned the Ahupuaa of Niu since it was conveyed by King Kamehameha I to our ancestor, Alexander Adams. I am the fifth generation since that time and lived as a child on Niu beach on a large property that included the Pond. I remember how cold the water was, how clouds of opae would cluster near the rocks and how the pungent strings of limu eleele could be rolled into a ball. At high tide salt water would wash into the pond, at low tide, fresh water would flow out. There were lots and lots of baby fish, and sometimes bigger ones -- but not the size of those raised in Kuapa Pond at Koko Head.

My father owned Niu Dairy. The milk barn, cattle pens and grass fields encompassed what is now Niu Estates. The pasture across the street on the makai side allowed the cows and horses to wander down a slope to drink fresh water from the pond. Bishop Museum has a photo of horses standing in the ocean makai of Kalauhai'hai, with water up to their bellies, drinking fresh water. I have old photos of horses standing in the Pond drinking water.

My father's dairy cattle were fed grain when being milked but their main food was napier grass, cultivated, then chopped and fed to them. Niu is a dry area (a lot drier now than then). Those grass fields were irrigated by flume and ditch. The irrigation water was pumped out of a deep well located at the bottom of Kulepeamoa. We were not allowed to go into the well but I remember watching two young guys from the dairy swimming and saying that two "tunnels" (lava tubes) were the water source.

Water is precious, needs to be honored and protected -- nobody denies that. I would very much like to be on a team to have that happen.

DATED this the 31st day of August, 2012

Laura Lucas Thompson
Signature of Affiant

SWORN to subscribed before me, this 31 day August, 2012

NOTARY PUBLIC MARIE UEHARA
My Commission Expires: 6/25/2016

MARIE UEHARA NOTARY PUBLIC No. 2000-309 STATE OF HAWAII

Doc. Date: 8/31/12 # Pages: 1
Notary Name: MARIE UEHARA 1st Circuit
Doc. Description: General Affidavit
Notary Signature 8/31/12 Date
NOTARY CERTIFICATION

Appendix 9.3:

Botanical Inventory by Danielle Frohlich, M.S

BOTANICAL INVENTORY
Kalauhaʻihaʻi Fishpond

Prepared for:
Maunalua Fishpond Heritage Center
Honolulu, Hawaii

Prepared by:
Danielle Frohlich, M.S.
Date: April 1, 2016

INTRODUCTION

Kalauhaʻihaʻi Fishpond is a small pond located approximately 9 miles southeast of downtown Honolulu. It is on a rectangular shoreline parcel that is level and slightly above sea level. The soils of the mauka half of the parcel appear to be somewhat developed, and the soils in the makai half appear to be sand or derived from sand.

This is the second known inventory of plants at this site. The first was conducted in 2009 by Liloa Dunn. The present survey was conducted in one day during spring in February of 2016 during dry weather. The site is a small urban lot (approximately 1/4 acre) that extends to the sandy shoreline of Maunalua Bay. It has a fishpond which covers nearly 50% of the parcel. The survey included all terrestrial vegetated portions of the parcel, including the beach areas and the visible areas of the fishpond.

We did a walk-through survey of Kalauhaʻihaʻi Fishpond. Plants encountered were identified to species and frequency noted. Pictures were taken to visually document the current vegetative status of Kalauhaʻihaʻi Fishpond and to estimate abundance and/or cover as needed.

RESULTS

At Kalauhaʻihaʻi Fishpond we observed all the plant species found by Dunn plus several additional native species and non-native species. A total of 6 native species and 35 non-native species were observed. Table 1 summarizes observed plants and their status and relative abundance.

NATIVE SPECIES

The 6 native species that were encountered were *Bacopa monnieri* (‘ae‘ae), *Cocos nucifera* (niu)*, Ipomoea pes-caprae* (pohuehue), *Psilotum nudum*(moa), *Scaevola taccada* (naupaka kahakai), and *Thespesia populnea* (milo). None of these species is threatened or endangered.

No endemic species were found. All other species encountered and mentioned in this report are Polynesian introductions, cultivated species, or otherwise non-native.

CULTIVATED SPECIES

Two Polynesian introductions were seen:

- *Artocarpus atilis* (ulu). There is a single ulu, or breadfruit tree growing on the southeast boundary of the site.
- *Cordyline fruticosa* (ki). 8-10 variegated ki or ti plants are established at the southwestern edge of the fishpond.

Five other cultivated plants of other origins were noted:

- *Ficus carica* (fig) A single fig tree is located on the northeast property boundary approximately 18 meters from the highway.
- *Citrus reticulata* (tangerine). A large tangerine tree is located along the highway boundary.
- *Jatropha integerrima* (jatropa). Two large shrubs along the highway and a few small individuals throughout the site.
- *Sphagneticola trilobata* (wedeila). Wedelia is a widely cultivated, spreading, mat-forming herb that is is listed in the IUCN's “List of the world's 100 worst invasive

species". A patch approximately 2 m^2 in size is located at the front of the property.

- *Stenotaphrum secundatum* (St. Augustine grass). A small patch ($1m^2$) of this grass is established at the front of the property.

OTHER NON-NATIVE PLANTS

The remaining 28 species seen were non-native, non cultivated plants that are naturalized. Three of these tend to be more invasive than others, often altering the habitat and crowding out native plants and animals. They are:

- *Leucaena leucocephala* (koa haole), which dominates (70-80 % cover) over a quarter of the total site area. This species is listed as one of the '100 of the World's Worst Invasive Alien Species'.
- *Ficus microcarpa* (Chinese banyan)
- *Coccinia grandis* (ivy gourd)

Some other aggressive species found at Kalauhaʻihaʻi Fishpond include

- *Urochloa maxima* (Guinea grass)
- *Cynodon dactylon* (Bermuda grass)
- *Pluchea indica* (Indian Pluchea)
- *Schefflera actinophylla* (octopus tree)
- *Cyperus rotundus* (nut sedge)

BOTANICAL INVENTORY
Kalauhaihai Fishpond

Scientific Name	Common Name	Status	Est. # or % cover
Ageratum conyzoides	Chickweed, goat weed	N	few
Alysicarpus vaginalis	Alyce clover, white moneywort	N	few
Amaranthus spinosus	Amaranth, spiny	N	5
Amaranthus viridis	Amaranth, pigweed, `aheahea, pakai	N	20
Andropogon virginicus	Broomsedge bluestem	N	few
Artocarpus altilis	Breadfruit, ulu	C	1
Asystasia gangetica	Chinese violet	N	Hundreds
Bacopa monnieri	Aeae, dwarf bacopa, water hyssop	I	3puuohonua in pond
Bidens pilosa	Spanish needle	N	few
Brachiaria mutica	Para grass, buffalo grass	N	1m^2 patch
Cenchrus cilaris	Buffel grass	N	few
Citrus reticulata	Tangerine	C	1
Coccinia grandis	Ivy gourd	N	25
Cocos nucifera	Niu, coconut	I	15
Conyza bonariensis	Fleabane	N	few
Cordyline fruticosa	Ki, Ti, cordyline	C	4
Cynodon dactylon	Bermuda grass	N	few
Cyperus rotundus	Purple nut sedge	N	dozens
Desmanthus pernambucanus	Slender or virgate mimosa	N	few
Desmodium incanum	Spanish clover, ka'imi	N	few
Euphorbia hirta	Athsma plant	N	few
Ficus microcarpa	Chinese banyan	N (invasive)	10
Ficus carica	Common fig, fiku	C	1
Hyptis suaveoleus	Pignut, chan	N	
Ipomoea pes-caprae	Pohuehue	I	25
Jatropha integerrima	Jatropha	C	
Leucaena leucocephala	Koa haole, leucaena	N (Invasive)	Thousands
Oxalis corniculata	Creeping wood sorrel	N	few
Passiflora foetida	Passion flower	N	few
Pluchea indica	Indian pluchea, Indian fleabane	N	10
Portulaca oleracea	Common purslane	N	few
Psilotum nudum	Moa	I	few
Richardia scabra	Rough Mexican clover	N	
Scaevola taccada	Naupaka kahakai, beach naupaka	I	Dozens
Schefflera actinophylla	Octopus tree, schefflera	N	Few
Solanum americanum	Glossy/American nightshade	N	12

Sphagneticola trilobata	Wedelia	C	dozens
Stenotaphrum secundatum	St Augustine grass	C	$1m^2$ patch
Thespesia populnea	Milo, portia tree	I	6
Urochloa maxima	Guinea grass	N	few
Youngia japonica	Japanese hawkweed	N	few

(C) = Cultivated -- Non-native.
(N) = Naturalized -- Non-native.
(I) = Indigenous -- Native.
(E) = Endemic -- Native.

CONCLUSION

Kalauhaʻihaʻi Fishpond hosts a few robust natives including *Scaevola*, and *Ipomea but* clearly has been over-run with non-native species. In particular, *Leucaena leucephala* koa haole has proven to be a highly-successful invader illustrating the damage that invasive non-native plants can inflict. We understand that the site will be cleared of invasives, planted with natives and monitored, and we hope this report will assist in that endeavor.

REFERENCES

Dunn, L. 2009. Preliminary Report of the Vegetation at the Lucas Fishpond in Niu Valley, O`ahu along with a Native Plant Restoration and Landscaping Plans for the Area.

Global Invasive Species Database 2013. 100 of the "World's Worst" invaders. Accessed at: www.issg.org/database/species/search.asp?st=100ss

Appendix 9.4:
Hydrological Study by Joseph Kennedy

EVALUATION OF ANTHROPOGENIC IMPACTS ON THE FLOW OF TWO COASTAL SPRINGS IN MAUNALUA BAY, SOUTH SHORE, O`AHU

A THESIS SUBMITTED TO
THE GLOBAL ENVIRONMENTAL SCIENCE
UNDERGRADUATE DIVISION IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF

BACHELOR OF SCIENCE

IN

GLOBAL ENVIRONMENTAL SCIENCE

MAY 2011

By
Joseph J. Kennedy

Thesis Advisors

Craig R. Glenn
Henrieta Dulaiova

We certify that we have read this thesis and that, in our opinion, it is satisfactory in scope and quality as a thesis for the degree of Bachelor of Science in Global Environmental Science.

THESIS ADVISORS

Craig R. Glenn
Department of Geology & Geophysics

Henrieta Dulaiova
Department of Geology & Geophysics

Acknowledgements

I would first like to thank my two advisors, Craig R. Glenn and Henrieta Dulaiova for providing me with the opportunity to take on this project. They have given me invaluable help, resources, and their time to make this research project a success. Without their forethought and planning, this project would have passed by with no one taking advantage of the opportunity that the sewer line rehabilitation project provided for documenting the anthropogenic impact on the groundwater discharge into Lucas Spring. They were intimately involved in every aspect of this research and without their help and dedication to providing me with a superior level of hands on education, I would never have been able to arrive at the results presented herein.

I want to thank Chris Cramer of Maunalua Fishpond Heritage Center for his passion for saving Hawai`i's last few remaining fishponds. He provided a tremendous amount of knowledge regarding historical accounts of the research locations as well as obtaining critical documents that showed the accounts of the anthropogenic impact on Lucas Spring. He made known the issues at hand to the community and has fought for governmental protection that now prohibits the Department of Transportation under ACT 210 from auctioning these lands to private owners. His hard work and dedication has ensured their availability for educational purposes for generations to come.

I want to thank Lisa Pezzino for the groundwork she laid that allowed this project to take shape. By providing personal contacts with government officials and people within the community, this research project went through without any issues or hindrances. I also appreciate Dennis Yeoman for being extremely gracious and allowing

me to use his home for accessing one of the research locations. Without his help and interest in the subject matter, this project would not be what it is.

I want to thank Lau ohana for giving back to the educational system and providing funding for the L. Stephen Lau Water Research Endowed Scholarship and everyone at the Water Resources Research Center who decided that this project was worthy of receiving that scholarship. I also wish to thank the NSF/EPSCoR and University of Hawaii Sea Grant College Programs for providing support to work on research projects similar to the one here, during which I acquired valuable training and hands on experience that greatly facilitated the undertaking of the present study.

I want to thank the following graduate students for their help and wisdom. First, I want to thank Jacque Kelly for taking me under her wing and providing a challenging yet enjoyable learning experience as I pursued this project. She was always more than happy to answer questions and help me with any issues I came across when preparing for field deployment, data processing, and writing this thesis. Her brilliance, humility, and intriguing research provided me with a wonderful learning environment that I hope to be able to carry on. I want to thank Kayla Holleman for her hard work out in the field when it came time for deployment of research equipment. Two hands are always better than one. I also want to thank Christine Waters for her quick grasp of the subject and eagerness to master new research equipment and explain how to use it as well as help with field deployment.

Lastly I want to thank the following UH faculty for their dedication to providing the best education they could possibly provide. First, I want to thank Eric DeCarlo for taking the time to meet with me when I was questioning a degree in Civil Engineering.

With his wisdom, and straightforward approach, I was able to make one of the best decisions of my educational career and switch into the GES department. I want to thank Kathleen Ruttenberg for the tremendous effort she put forth in her detailed comments and grading of all of my writing assignments for OCN 401. It has definitely made me a better writer. And last but not least, I want to thank Jane Schoonmaker for her tremendous heart and dedication to all the GES students here at the University of Hawai`i at Manoa. Without her help, guidance, direction, and wisdom, the GES program would only be a shadow of what it currently is.

Abstract

Groundwater discharge has long been known to fringe O`ahu's south shores as springs and beach seeps, with many examples sporadically described since the early works of Stearns and Vaksvik (1935). Hawaiians have used these freshwater resources for centuries, primarily for creating brackish water environments that formed the setting for many of the fishponds that were found throughout the islands. Coastal development over the years has impacted these unique aquaculture practices and left most in ruin. The road widening project of Kalanianaole Highway in 1993 effectively severed all flow of water from the freshwater conduit that fed one of the last remaining fishponds on O`ahu, Lucas Spring, and allowed an estimated 1 million gallons of groundwater per day to infiltrate into an adjacent sewer line damaged during the construction. The proposed rehabilitation project of the sewer line in 2010 created a unique opportunity to study the possible restoration of groundwater flow to Lucas Spring. Continuous radon measurements combined with a salt mass-balance approach was used to determine groundwater flow rates into the impacted Lucas Spring, as well as in Kanewai Spring, which was selected as a comparison site. Over the course of this study, groundwater discharge to Lucas Spring increased from less than 1 m^3 day^{-1} to ~140 m^3 day^{-1} and the volume of water increased from ~8 m^3 to ~190 m^3 with no effective change in the nearby comparison spring. Although a spring discharge of 140 m^3 day^{-1} only represents ~20% of the historic flow, it is still a significant improvement over the prior decades' average flow when the pond was almost completely dry.

Table of Contents

Acknowledgements iii

Abstract vi

Table of Contents vii

List of Tables ix

List of Figures x

1 Introduction 1

2 Background 3

2.1 Hawaiian fishponds 3

2.2 Kalanianaole Highway widening and sewer line rehabilitation 6

2.3 Geologic pathway for groundwater flow 12

2.4 Groundwater quantification techniques 13

3 Methods 16

3.1 Study site description 16

3.2 Sampling methods 19

3.2.1 Radon time series monitoring 20

3.2.2 Salinity and water level analysis for tidal influence on spring discharge 21

3.3 Radon model description 22

3.3.1 Radon losses by evasion to the atmosphere 23

3.3.2 Radon decay 24

3.3.3 Groundwater flux calculation 25

3.4 Salinity mass balance model 25

4 Results 27

4.1 Lucas Spring 27

4.1.1 Lucas Spring 7-10 Apr, 2010 deployment 27

4.1.2 Lucas Spring 12-27 August, 2010 deployment 30

4.1.3 Lucas Spring CTD-Diver time series 31

4.2 Kanewai Spring 35

4.2.1 Kanewai 2 – 4 April, 2010 deployment 35

4.2.2 Kanewai 14 – 17 July, 2010 deployment 36

4.2.3 Kanewai 12 – 26 August, 2010 deployment 38

4.3 CTD-Diver time series: Kanewai Spring, Kanewai Fishpond, Paiko Lagoon 39

5 Discussion and Conclusions 45

5.1 Lucas Spring 45

5.2 Precipitation events 47

5.3 Kanewai Spring 50

5.4 Overall trends in groundwater fluxes 51

5.5 Conclusions 52

References 56

List of Tables

Table 1. Groundwater discharge rates (m^3 day^{-1}) and monthly average rainfall (mm) at the two spring sites..... 44

List of Figures

Figure 1. Historic locations of known fishponds and springs within Maunalua Bay 2

Figure 2. Parcel map of Niu Beach lots around former Niu fishpond 4

Figure 3. Aerial view of the remnants of Niu fishpond 4

Figure 4. Lucas Spring, 1980's and in April 2010..... 6

Figure 5. Water flowing out of probable broken lava tube conduit during the Kalanianaole Highway widening project..... 7

Figure 6. Water being pumped from flooded construction site landward of the Lucas Spring study site..... 7

Figure 7. Water being pumped from flooded utility corridor during the Kalanianaole Highway widening project. 8

Figure 8. View of Lucas Spring after the freshwater conduit was severed and beginning to deteriorate 9

Figure 9. View of desiccated Lucas Spring after the freshwater conduit was disrupted 9

Figure 10. Kanewai Fishpond 10

Figure 11. Idealized geologic representation of groundwater flow allowing for SGD 13

Figure 12. TIR image showing an overview of the research location 14

Figure 13. Lucas Spring, April 2011 16

Figure 14. Overview of Kanewai Spring, Kanewai Fishpond, and Paiko lagoon 18

Figure 15. Kanewai Spring, April 2010 18

Figure 16. Plywood barrier separating Kanewai Fishpond from Paiko Lagoon..... 19

Figure 17. Box model diagram of radon sources and sinks in the coastal environment... 23

Figure 18. Lucas Spring April 2010 deployment radon activity and salinity 28

Figure 19. Lucas Spring April 2010 deployment water level and salinity 28

Figure 20. Lucas Spring August 2010 deployment, water level and salinity 31

Figure 21. Lucas Spring August 2010 deployment, radon activity and salinity..... 31

Figure 22. Lucas Spring CTD-Diver time series data from November 11, 2010 to February 10, 2011. 33

Figure 23. Lucas Spring CTD-Diver time series data from February 10, 2011 to April 2, 2011 34

Figure 24. Kanewai Spring April deployment, salinity and water level..... 35

Figure 25. Kanewai Spring April deployment, salinity and radon activity 36

Figure 26. Kanewai Spring July deployment, salinity and water level 37

Figure 27. Kanewai Spring July deployment, salinity and radon activity. 38

Figure 28. Kanewai Spring August deployment, salinity and water level..... 39

Figure 29. Kanewai Spring August deployment, radon activity and salinity 39

Figure 30. CTD-Diver time series data showing water level fluctuations of Paiko Lagoon, Kanewai Fishpond, and Kanewai Spring 41

Figure 31. CTD-Diver time series data showing salinities of Kanewai Spring and Kanewai Fishpond 42

Figure 32. CTD-Diver time series data of Kanewai Spring showing salinity and water level 43

Figure 33. Lucas Spring, April 2010 46

Figure 34. Lucas Spring *`auwai* after being dug out 46

Figure 35. Niu Valley rain gauge 6-hour rainfall plot for December 2010 48

Figure 36. Niu Valley rain gauge 6-hour rainfall plot for January 2011 49

Figure 37. Dry-weather flow rates from the Niu Valley Wastewater Pump Station 54

1 Introduction

Submarine groundwater discharge (SGD) has received a tremendous amount of attention in recent years, principally for two reasons. The first is because of the realization that SGD can, in many instances, rival the total amount of fresh water exchanged from the land to the sea surface interface via surface water runoff (Moore et al., 2008). Second, extensive urbanization and agricultural development of coastal areas have vastly increased the amount of nutrients and other dissolved components that can then be transported to the ocean via subterranean coastal aquifers which line and feed coastal zones (e.g. see reviews in Slomp and Van Cappellen, 2004, and Burnett et al., 2006). Thus, most studies of SGD have concentrated largely on the current status of existing SGD systems from the viewpoint of how each system is perturbed by variations in naturally occurring SGD fluid driver phenomena, such as seasonal tides, variations in rainfall, or hydraulic head, and/or how SGD systems influence nutrient or other dissolved flow to the ocean. In contrast, to the author's knowledge, the study presented here is the first of its kind to apply SGD quantifications methods to monitor changes in groundwater discharge as a function of a major municipal groundwater diversion project.

Groundwater discharge has long been known to fringe O`ahu's south shores, with many examples described since the early works of Stearns and Vaksvik (1935). Historically, the most obvious of these south shore discharges have been manifested as natural springs that tap the Ko`olau basal aquifer (e.g. Kawaikui, Lucas, and Kanewai Springs), providing the brackish waters that formed many of the region's early Hawaiian fishponds (Figure 1). Very few of these fishponds remain today and are threatened by continued urbanization of Hawai`i's coastal areas.

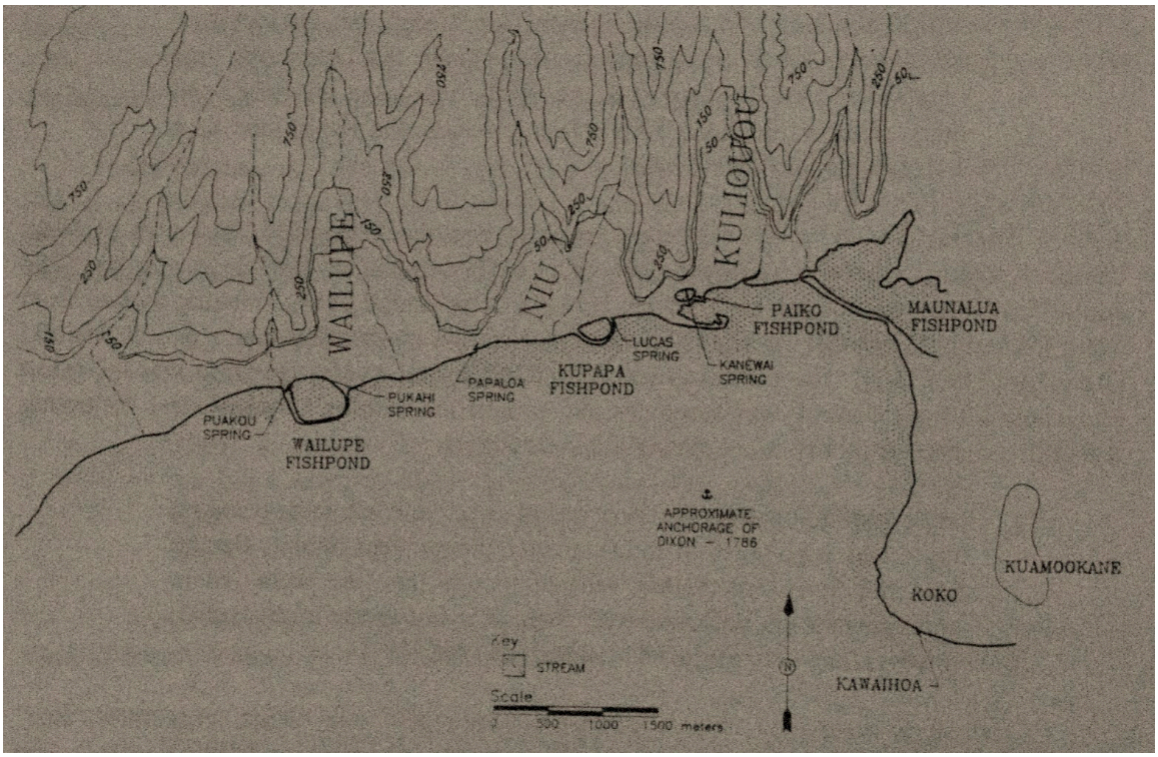


Figure 1. Historic locations of known fishponds and springs within Maunalua Bay (Erlens and Athens, 1994).

In 1993, the Department of Transportation (DOT) completed a road-widening project of Kalanianaole Highway, between East Honolulu and Hawai`i Kai. During that construction, the aquifer conduits that fed Lucas Spring, also known as Kalauha`iha`i fishpond, were diverted, resulting in dramatic reduction of the groundwater discharge that fed that site. A city-contracted study in 1997 found that sections of the sewer line in the vicinity of Lucas Spring were broken by the construction, allowing direct infiltration of the ground water into the sewer lines at an estimated rate of one million gallons per day (Fukunaga and Associates, 2005). This research capitalized on the opportunity to monitor changes in groundwater exit locations and flux rates that occurred due to the sewer line rehabilitation construction project that took place in 2010.

2 Background

2.1 Hawaiian fishponds

Hawaiians have known about the importance of groundwater springs in coastal ecosystems for centuries, and water resources throughout the Hawaiian Islands have played a pivotal role in the development of pre-contact Hawaiian society (Kikuchi, 1976). Historically, fishponds provided a constant source of easily accessible food, though both Kikuchi (1976) and Wyban and Wyban (1989) state that the fishponds were not run to maximize production but to serve as a food source for the *ali`i* or chiefs who ruled the *ahupua`a* or land division in which they resided. The fishponds also served as status symbols for the *ali`i* of the *ahupua`a* and maintained a key role in Hawaiian culture (Kikuchi, 1976).

The discovery of Hawai`i in 1778 by Captain James Cook led to the downfall of Hawaiian society, including the fishponds. When Cook first arrived in the Hawaiian Islands, it has been estimated that over 350 fishponds were in use (Wyban and Wyban, 1989). The destruction of the *kapu* system (traditional Hawaiian codes of ethics) in 1819 took all power away from ruling chiefs, paving the way for private land ownership (Kikuchi, 1976). Without the protection of the chiefly rule, fishponds were left unprotected from western influences and ways of life (Kikuchi, 1976). The influx of various cultures and western influences brought about a change of thought regarding fishpond use. Chinese immigrants turned some fishponds into fish farms with the intent to sell the fish to the local markets (Wyban and Wyban, 1989). Others, like Wailupe and

Niu fishponds, were filled in for coastal development (Figure 2 and Figure 3) or underutilized and left to deteriorate over time (Kikuchi, 1976; Wyban and Wyban, 1989).

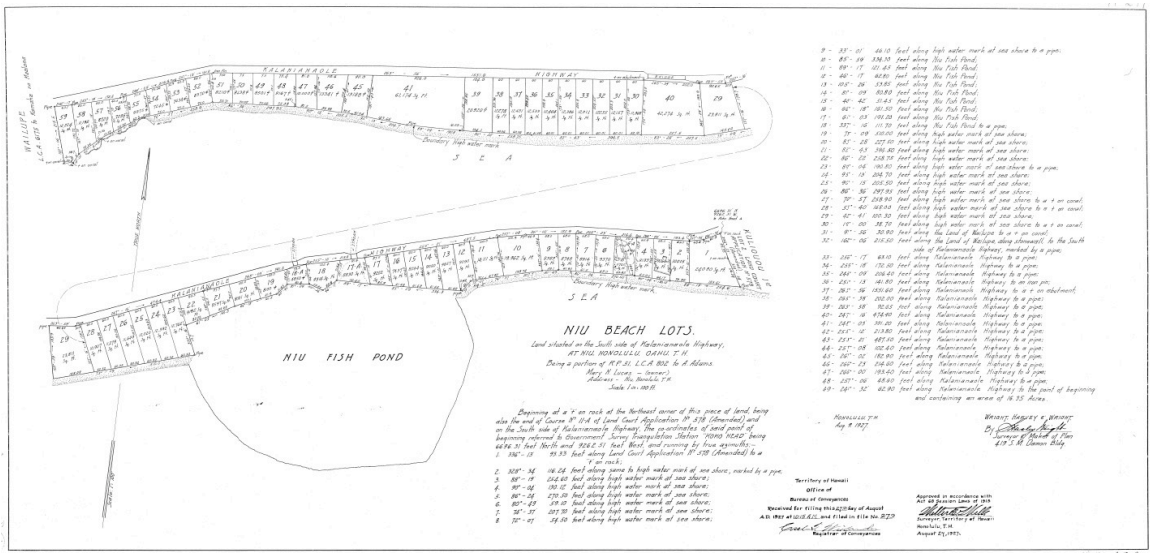


Figure 2. Parcel map of Niu Beach lots around former Niu fishpond, 1927 (Courtesy of MFHC).

Figure 3. Aerial view of the remnants of Niu fishpond, filled in today and turned into a housing development known as Niuiki Peninsula. Extracted from Google Earth, 2010.

Today, most Hawaiian fishponds are merely relics that are only visible in some locations throughout the island chain. Very few fishponds are actually in working order,

and most are on the verge of being taken away from the community due to private land ownership or continued development. This paper will show the impact modern day society has had on the flow rates of groundwater springs that currently feed water to two specific Hawaiian fishponds, Lucas Spring, also known as Kalauha`iha`i Fishpond and Kanewai Spring. Also, despite the continued urbanization, the paper will show evidence that there still exists the possibility of restoration of the few that remain.

The nonprofit organization, Maunalua Fishpond Heritage Center (MFHC), was founded in 2006 to raise awareness about the current state of Hawaiian fishponds, with its mission to restore fishponds on the verge of being lost forever, most notably Lucas Spring, Kanewai Spring and the adjoining fishpond known as Kanewai Fishpond. The goal was in conjunction with the University of Hawai`i's Hawaiian Studies Malama `Aina Program to create a place that would allow for cultural education for the benefit of Native Hawaiians and the community. The primary endeavor for MFHC was Lucas Spring (Figure 4).

Figure 4. Lucas Spring, 1980's (Photo: T. Hara, courtesy MFHC) and in April 2010. Photo: J. Kennedy.

2.2 Kalanianaole Highway widening and sewer line rehabilitation

Lucas Spring was owned and maintained by Mr. Tad Hara from the early 1970's to mid-1990's. Historical records show that an estimated 200,000 gallons (~750 m^3) of water a day flowed from Lucas Spring (Stearns and Vaksvik, 1935). With this much freshwater constantly flowing into the fishpond, the water in the pond was always clear. In 1993, construction during the road-widening project of Kalanianaole Highway disrupted the freshwater conduit that fed the spring, flooding the utility corridors that ran alongside the highway (Figure 5, Figure 6, Figure 7). For years, speculation surrounded where the groundwater went that once flowed into Lucas Spring.

Figure 5. Water flowing out of probable broken lava tube conduit during the Kalanianaole Highway widening project, ca. 1993. Photo: T. Hara, courtesy MFHC.

Figure 6. Water being pumped from flooded construction site landward of the Lucas Spring Study Site, ca. 1993. Photo: T. Hara, courtesy MFHC.

Figure 7. Water being pumped from flooded utility corridor during the Kalanianaole Highway widening project, ca. 1993. Photo: T. Hara, courtesy MFHC.

Throughout the widening project Mr. Hara photographically documented the impact the construction had on the area. His house was eventually condemned by the Hawai`i Department of Transportation due to the disrupted water supply and the proximity of the newly widened road to the house. With no one to take care of the fishpond and no freshwater flowing into it, Lucas Spring quickly deteriorated (Figure 8, Figure 9).

Figure 8. View of Lucas Spring after the freshwater conduit was severed and beginning to deteriorate, ca. 1993. Photo: T. Hara courtesy of MFHC.

Figure 9. View of desiccated Lucas Spring after the freshwater conduit was disrupted, ca.1993. The T. Hara property was noted for its "house with the glass floor" which looked down into the spring-fed fishpond over which it stood. Photo: T. Hara, courtesy MFHC.

The nearby Kanewai Fishpond (Figure 10) is listed on the State of Hawai`i Historic Register as one the last functioning shoreline fishponds in Honolulu. The fishpond's history dates back over 1000 years based on artifacts that were found in the area and it is listed as one of a few remaining royal fishponds (www.maunalua.net). The fishpond is fed by a freshwater spring known as Kanewai Spring (one of our research locations), which is located on private property. Historic records estimate 200,000 gallons (~750 m^3) of water a day once flowed from the spring (Stearns and Vaksvik, 1935).

Figure 10. Kanewai Fishpond, one of the few remaining fishponds on O`ahu, April 2010. Photo: J. Kennedy

The widening of Kalanianaole Highway in 1993 not only disrupted water flow to Lucas Spring, but it was also suspected to have damaged the sewer lines running parallel to the highway, possibly allowing infiltration of the groundwater directly into the sewer

lines themselves. In January 1997, the Wastewater Division of the City and County of Honolulu had the sewer line investigated by MGD Technologies, Inc and Geltech Contractors, Inc. Manhole flow depth and velocity calculations determined that 1 million gallons per day (mgd) of groundwater during dry-weather conditions was infiltrating into the broken sewer line (Fukunaga and Associates, 2005). These flow volume calculations were then followed by video camera assessment of the broken sewer line (Fukunaga and Associates, 2005). The Wastewater Division then created a project based on the findings, though further investigation during dry-weather conditions of the sewer line infiltration continued through January 2003 (Fukunaga and Associates, 2005). The goal of the project was to eliminate the 1 mgd (3,780 m^3 day^{-1}) of dry-weather infiltration, reducing the costs associated with pumping and treatment of the extraneous wastewater (Fukunaga and Associates, 2005). The project, and thus the initiation of this thesis research, began in the middle of 2010.

Both research locations, Lucas Spring and Kanewai Spring, were on the verge of being auctioned off by the DOT when the rehabilitation project brought the possibility of restoring Lucas Spring to the community's attention. The sewer line rehabilitation project brought hope that the once diverted freshwater could be directed back to the conduit that fed Lucas Spring. The DOT allowed access to both sites for scientific research while MFHC attempted to obtain legal protection of the fishponds (presently Act 210), and it was with this restoration attempt in mind that the present research was initiated and conducted. The major goal was to provide scientific evidence of Lucas Spring's groundwater state and document the possible changes that might occur after the sewer line rehabilitation project was completed. Kanewai Spring was chosen as a control site

for flow rate comparison that should otherwise mimic changes that may occur as a result of rainfall and infiltration variability of the area. The portion of the Sewer line rehabilitation project fronting Lucas Spring was completed at the end of October 2010.

2.3 Geologic pathway for groundwater flow

Groundwater discharge has the potential to occur anywhere there is an aquifer that is connected with the ocean by way of permeable rock or sediments (Burnett et al., 2006). As seen in Figure 11, groundwater moves from areas of higher hydraulic head toward the ocean where it discharges into the ocean as well as mixing with saltwater in an area known as the zone of diffusion (Johannes, 1980). The mixing zone generally intersects at the land ocean interface where some mixture of saltwater and freshwater discharge into the coastal environment as SGD. SGD is temporally variable, diffuse and patchy, making it difficult to quantify (Burnett et al., 2006). Unlike rivers and streams, there are generally no specific boundaries that contain its flow path. The term SGD can refer to any aspect of groundwater that discharges into the ocean, though it is usually described as all fresh and brackish water that flows from an aquifer into the ocean at the land-ocean interface that is below the mean high tide level (Burnett et al., 2006). Since Lucas Spring and Kanewai Spring do not necessarily fall below the mean high tide line but are at the land-ocean interface, this paper will refer to the spring flow as groundwater discharge.

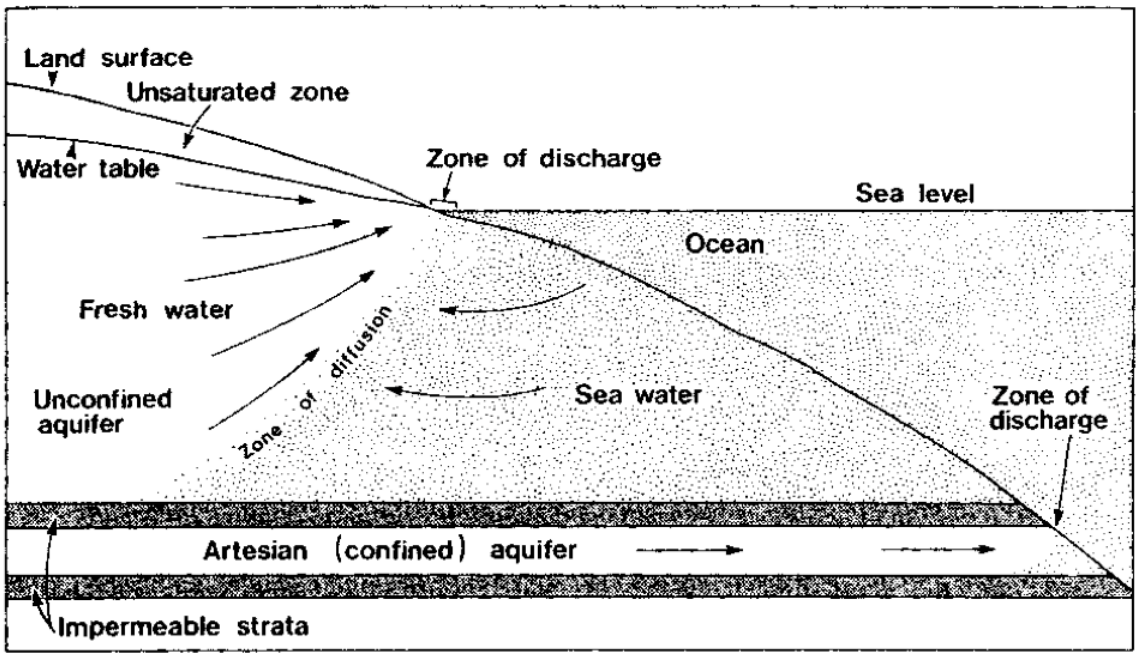


Figure 11. Idealized geologic representation of groundwater flow allowing for SGD (Johannes, 1980).

2.4 Groundwater quantification techniques

Determining locations and quantifying flow rates of groundwater discharge is difficult because it cannot easily be observed, and neither the flow patterns nor the flow rates can be precisely predicted (Hwang et al., 2005). Heterogeneity of sediments makes it extremely difficult to predict where the conduits are and where springs or slowly seeping groundwater can be expected to occur. Recently, however, the use of aerial thermal infrared (TIR) imaging technology has changed how researchers locate both coastal freshwater plumes and non-point source diffuse flow of groundwater (Johnson et al., 2008). The use of TIR imaging has enabled the collection of high-resolution sea-surface temperature data for identifying groundwater discharge over large areas and pinpointing key locations for further analysis. TIR imaging was collected and processed along the South Shore of O`ahu (Kelly et al., in prep) and Figure 12 shows the present research area imaged with this technique. The TIR method produces sea surface

temperature maps with blue and green colors representing colder water temperatures indicative of groundwater seepage, while the warmer red and orange colors represent ambient ocean temperature. The leakage of colder groundwater in immediate proximity to the Lucas Spring site is notably lacking.

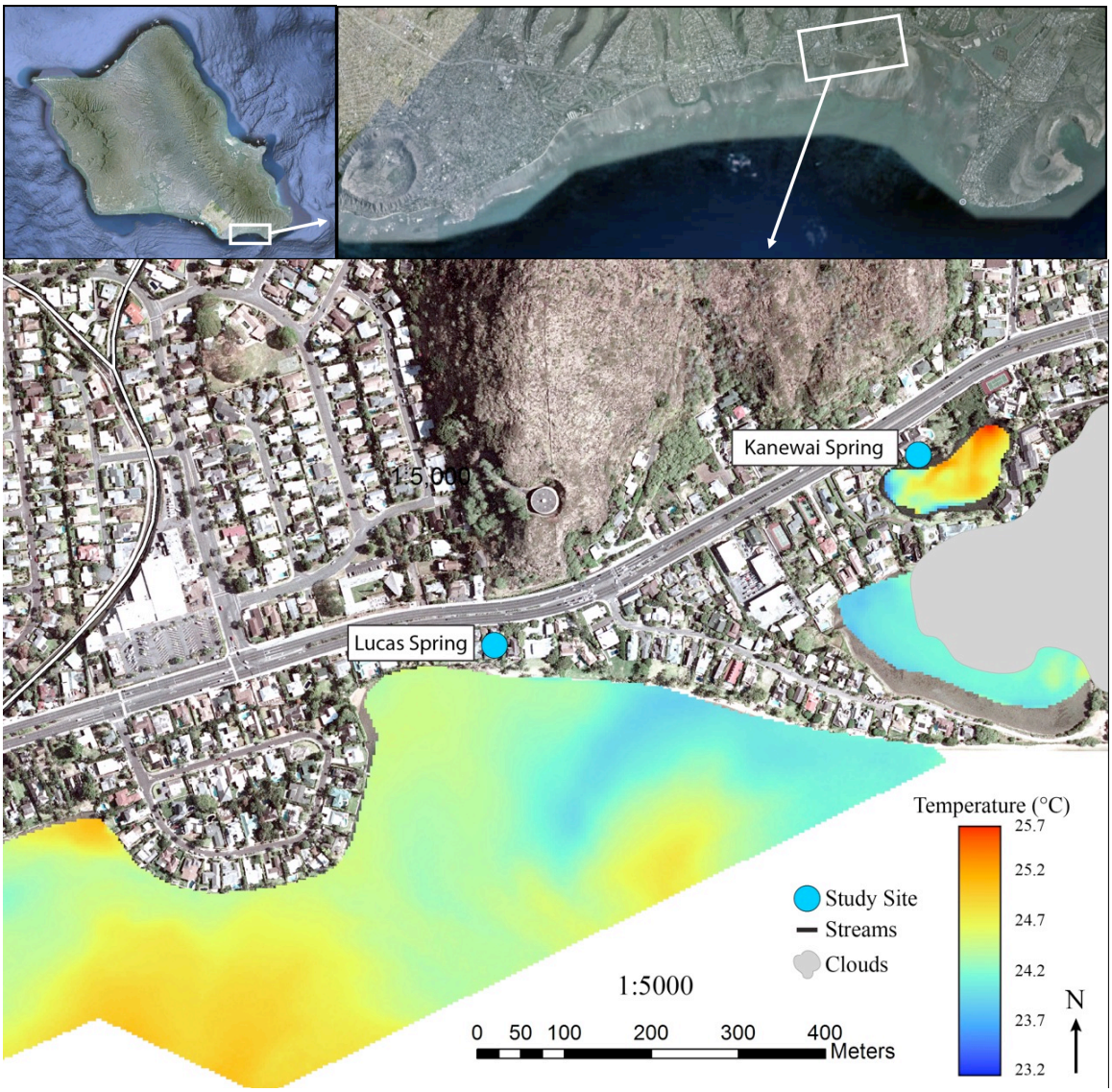


Figure 12. TIR image showing an overview of the research location. Flight occurred on July 6, 2009 at 2:09 am. Tide: +0.067 m, Altitude: 2133 m, Spatial resolution: 3.24 m, Temperature resolution: 0.5 degree C. Image: J. Kelly.

Among all the direct and indirect techniques of groundwater discharge assessment, the use of conservative geochemical tracers has been the most widely applied

in various environments and geological settings. Radium and radon isotopes, along with salinity, are used to determine flow rates of water using a mass balance approach that accounts for all sources and sinks of these isotopes in the coastal zone (Charette et al., 2008). Groundwater discharge is thus determined by a flux-by-difference approach. For example, the use of continuous radon measurements in the coastal zone over periods of hours to days allows for temporal fluctuations and spatial variability when calculating groundwater discharge rates (Burnett and Dulaiova, 2003).

Radon is a naturally occurring radioactive gas that is non-reactive and has a short half-life of 3.8 days (Burnett and Dulaiova, 2003). The concentration of radon in groundwater is up to three orders of magnitude greater than ocean or surface water, making it a perfect geochemical tracer for groundwater that has been in contact with radon emitting aquifer materials (Burnett and Dulaiova, 2003). Any water within the aquifer, independent of its salinity, becomes enriched in radon, so the estimated flux rates represent the discharge of both fresh and brackish groundwater. These fluxes are calculated from the radon inventory in the surface water that is corrected for losses from atmospheric evasion and losses due to tidal flushing (Burnett and Dulaiova, 2003). The excess radon in the system is then used to determine a groundwater flow rate (Burnett and Dulaiova, 2003).

3 Methods

3.1 Study site description

Two springs with fishponds were selected for the study of groundwater discharge. Both sites are located on the South Shore of O`ahu, Hawai`i at the terminus of the ridge that separates Niu and Kuli`ou`ou Valleys (Figure 12). Lucas Spring is located between the ocean and Kalanianaole Highway. The man made basalt rock walled fishpond has a surface area of 368 m^2. It is connected to the sea by a 0.5 m wide channel or *`auwai* 10 m long and is inundated by ocean water only during extreme spring tide events and intense storm swells. The *`auwai* was filled with sand during the entire research period. There is a house built on the property with a large corner overhanging the fishpond, which shelters Lucas Spring from the strong trade winds common to the area (Figure 13).

Figure 13. Lucas Spring, April 2011. Photo: J. Kennedy.

Kanewai Spring is located half a kilometer to the east-northeast of Lucas Spring. The spring is also located between Kalanianaole Highway and the ocean, though there are two larger bodies of water separating it from the ocean. Kanewai Spring flows into Kanewai Fishpond which then flows into Paiko Lagoon (see Figure 14). Kanewai spring is lined with a basalt rock wall and is slightly oval in shape. The spring is overgrown with various trees sheltering it from strong winds (Figure 15). It has a surface area of 48 m^2 and an average depth of 0.9 m. There is a small channel that connects Kanewai Spring to Kanewai Fishpond. The channel is blocked by a narrow permeable basalt rock wall structure about 0.2 m wide, restricting the flow of water between the fishpond and the spring. Kanewai Fishpond is connected to Paiko Lagoon by a 2 m wide *`auwai*. At the connecting point of Kanewai Fishpond and the *`auwai*, a sheet of plywood blocks the interchange of water between Paiko Lagoon and Kanewai Fishpond (Figure 16). At high tide, saltwater from Paiko lagoon spills over the top of the plywood sheet providing an influx of saltwater to Kanewai Fishpond. As the tide drops, the water in Kanewai Fishpond slowly drains out between the spaces where the plywood sheet and the walls of the *`auwai* meet. This setting creates a fast influx of saltwater with a slower out flux of water from Kanewai Fishpond before the next high tide introduces more saltwater. Paiko Lagoon is connected directly to the ocean by way of a natural shallow channel about 15 m wide.

Figure 14. Overview of Kanewai Spring, Kanewai Fishpond, and Paiko lagoon with CTD-Diver locations shown with an X, Google Earth, 2010.

Figure 15. Kanewai Spring, April 2010. Photo: J. Kennedy.

Figure 16. Plywood barrier separating Kanewai Fishpond (bottom) from Paiko Lagoon (top). Photo: J Kennedy.

3.2 Sampling methods

Sampling of both locations took place between April 2010 and April 2011. Two radon time series deployments (section 3.2.1) took place at Lucas Spring, while three radon time series deployments took place at Kanewai Spring. Rainfall records from the Niu Valley rain gauge were retrieved from the National Weather Service (www.weather.gov/hawaii) for the period listed. The initial research plan was to use radon measurements to determine groundwater discharge rates at Lucas Spring and Kanewai Spring both before and after the sewer line rehabilitation project took place. The rehabilitation project was repeatedly delayed, so within our project time frame, radon measurements only occurred in the spring and summer of 2010, both of which were before the rehabilitation project. The use of compact (22 mm x 135 mm), conductivity,

temperature, and depth (water level) data loggers (Schlumberger Water Services Inc. CTD-Diver, DI 271) provided the opportunity to monitor post-work changes in water flux variations at both locations using conventional salt balance modeling (section 3.4) based on observed salinity fluctuations from the pre-rehabilitation radon deployments. The CTD-Divers also provided important information on the effect tidal fluctuations had on each location.

3.2.1 Radon time series monitoring

In order to derive groundwater discharge rates to the fishponds over time, time-series measurements of radon, water level and salinity were performed. The first radon time series deployment at Lucas Spring occurred from April 7 – 10, 2010, while the second time series was deployed August 12 – 26, 2010. The radon time series deployments for Kanewai Spring were conducted April 2 – 4, July 14 – 17, and August 12 – 26, 2010. The method used for each continuous radon analysis was based on previous work done by Burnett and Dulaiova (2003) and Dimova and Burnett (2011).

Radon in the surface water was analyzed by a commercially available radon monitor (RAD-7, manufactured by Durridge, Inc). Water from mid water column at Kanewai Spring and bottom depth at Lucas Spring was pumped into an air-water exchanger via a small bilge pump. The purpose of the air-water gas exchanger is to release radon into a closed air loop that is then fed into the radon-in-air monitor. The RAD-7 analyzes the radon activity at pre-set intervals and is able to perform automated repeated measurements. The radon in the closed air loop reaches equilibrium with the radon in the water depending on the water temperature. The radon water activity can then be derived from the measured radon in air value. Since the radon activity ratio of water to

air is determined by water temperature, a multi-parameter sonde was used in conjunction with the RAD-7. A YSI multi-parameter sonde (model 6920V2-2, YSI Inc.) was used for all radon time series setups and placed at the same depth and location as the bilge pump. The YSI sonde measured temperature (^{o}C), specific conductivity (mS/cm), salinity, depth (m), pH, chlorophyll-a, and dissolved oxygen (% saturation and mg/L) every 5 minutes. The data from the RAD7 and the YSI was retrieved upon completion of each time series analysis.

3.2.2 Salinity and water level analysis for tidal influence on spring discharge

Changes in salinity and water level were monitored in both Lucas Spring and Kanewai Spring in order to study the influence of the tidal cycle on groundwater discharge. We deployed four CTD-Divers for an extended period of time at four locations (Figure 14): Lucas Spring – 5 months, Kanewai Spring – 3 months, Kanewai Fishpond – 3 months, and the mouth of Paiko Lagoon – 2 months. The Paiko Lagoon diver captured the uninhibited ocean tidal fluctuation. Each diver was secured to a brick and set to record conductivity (mS/cm), temperature (^{o}C), and water depth (m) every 30 minutes. Conductivity was later converted to salinity using the following equation, where C is conductivity (Williams, 1986):

$$\text{Salinity} = (C^{1.0878})*(0.4665) \qquad (1)$$

The divers for Paiko Lagoon and Lucas Spring were deployed on November 11, 2010. The divers for Kanewai Fishpond and Kanewai Spring were deployed one day later on November 12, 2010. Due to a protective equipment failure, the diver located at Paiko Lagoon was permanently removed on December 31, 2010 with valid data collected intact.

The divers Kanewai Spring and Kanewai Fishpond were removed on February 10, 2011 while the diver located at Lucas Spring remained in place until April 2, 2011.

3.3 Radon model description

The use of continuous radon measurements for quantifying groundwater discharge stems from the basic idea that groundwater is highly enriched in radon while surface waters have no sources of radon other than groundwater and diffusion from the bottom substrate. By accounting for the radon inventory in the surface water one can calculate the radon-enriched groundwater flux required to sustain the measured surface water inventory. The major losses of radon from these spring systems are radioactive decay (half-life 3.8 days) and evasion to the atmosphere. Sources would be diffusion and groundwater discharge. Groundwater discharge rates can be determined by a flux-by-difference approach using a mass balance equation that accounts for all these sources and sinks of radon in the springs (Charette et al., 2008). Figure 17 illustrates a simple box model diagram depicting the conceptual model that the following calculations are based on.

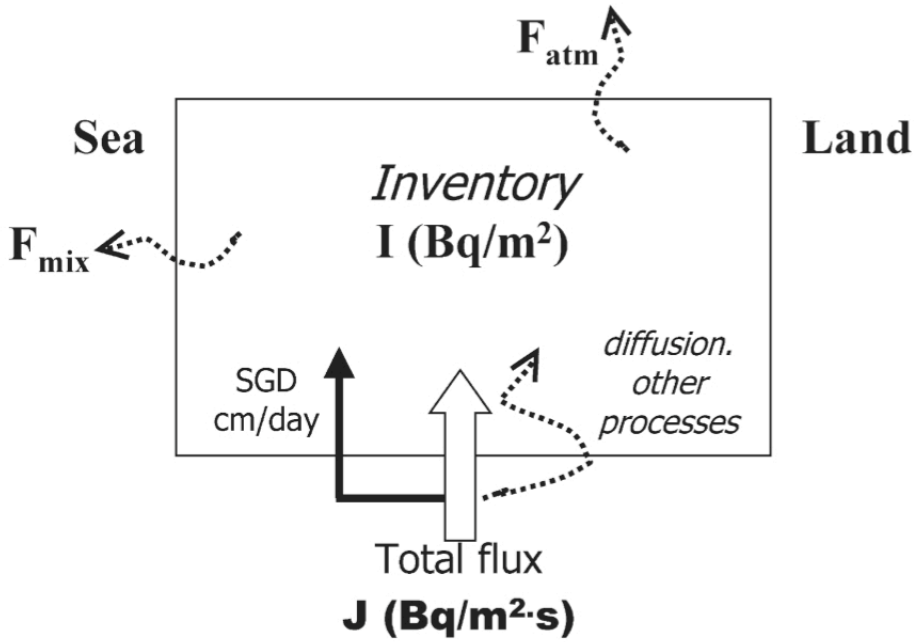


Figure 17. Box model diagram of radon sources and sinks in the coastal environment (from Burnett and Dulaiova, 2003). All the same source and sink terms were applied except losses to the ocean by mixing as our springs are not directly connected to the ocean.

3.3.1 Radon losses by evasion to the atmosphere

Radon losses to the atmosphere are fluxes driven by the air-water radon activity gradient and the gas transfer coefficient in the water. To calculate evasion rates we used radon activity measured by the RAD-7 and temperature and salinity measured by the multi-parameter sonde. The diffusive flux of radon gas across the air-water boundary was calculated using the following equation from Macintyre et al., (1995):

$$F_{atm} = k(C_w - \alpha C_a) \quad (2)$$

where F_{atm} (dpm/m^2*min) is the diffusive flux based on the activity gradient between the water and air, k (m/min) is the gas transfer coefficient, C_w (dpm/m^3) is the activity of radon in the water, C_a (dpm/m^3) is the activity of radon in the air and α is the temperature (T) dependent equilibrium activity ratio, also known as the Ostwald solubility coefficient, which is calculated using the following equation (Burnett and Dulaiova, 2003):

$$\alpha = 0.105+0.405e^{-0.0502T} \quad (3)$$

The gas transfer coefficient for radon, k, was determined based on the gas transfer velocity dependence on the Schmidt number of other known gases (Macintyre et al., 1995). The Schmidt number (Sc) for radon was calculated as the ratio of the kinematic viscosity of water, v (cm^2/sec), and the molecular diffusion coefficient, D (cm^2/sec), of the radon gas (Macintyre et al., 1995):

$$Sc = v/D \quad (4)$$

The kinematic viscosity of water is the absolute or dynamic viscosity (μ_{sw} (kg/m*sec)) divided by seawater density (ρ_{sw} (kg/m^3)) and was determined using work done by Isdale et al. (1972):

$$v = \mu_{sw}/\rho_{sw} \quad (5)$$

The diffusion coefficient, D, was calculated based on work done by Peng et al. (1974) Once the Schmidt number for radon was determined, the following formula was used to find k.

$$k_{Rn}/k_{CO2} = (Sc_{Rn}/Sc_{CO2})^{-0.5} \quad (6)$$

Since both study sites were sheltered from strong winds a k_{CO2} value of 0.8 cm/hour was used in determining the k value for radon since Macintyre et al. (1995) state that k is independent of wind speeds below 3 m/s.

3.3.2 Radon decay

A radon inventory was calculated by multiplying the water depth with the average radon activity during each deployment period. Time periods over which the average radon inventory was constant were selected. To sustain this constant inventory, the flux of radon rich groundwater must be equal to radon losses by radioactive decay.

$$I = F_I * (1-e^{-\lambda t})/\lambda \quad (7)$$

where I (dpm/m^2) is radon inventory, F_I (dpm/m^2 day^{-1}) is the radon flux that is required to sustain the measured radon inventory, λ (0.182 day^{-1}) is the radon decay constant, and t is time.

3.3.3 Groundwater flux calculation

By summing radon losses by evasion (F_{atm}) and radioactive decay (F_I) the total radon flux that has to be balanced by groundwater discharge is found.

$$F_{Rn\ total} = F_{atm} + F_I \quad (8)$$

Inputs by diffusion and from ^{226}Ra dissolved in the water are negligible (Dimova and Burnett, 2011). Finally, groundwater flux (m^3/m^2/day) was determined by dividing the total radon flux by the groundwater radon activity (dpm/m^3). The groundwater flux rate is then multiplied by the surface area of the basin giving a groundwater discharge rate (m^3/day) into the fishpond. This calculation assumes that the water in the pond is well mixed and the radon measurement is a good representative of activities across the whole pond. Due to the shallow depth, small water volume and long residence time, this is a valid assumption

3.4 Salinity mass balance model

Due to observed changes in the salinity of both locations, a salt mass-balance approach was also used to calculate discharge rates. We took advantage of the fact that at peak spring high tide, Kanewai Spring was inundated by seawater in one individual spike. The salinity of the spring was then assumed to decrease at a rate equivalent to the groundwater discharge rate. We calculated the groundwater discharge based on the time

required to achieve a minimum salinity in the pond. The following equation was used to calculate the amount of groundwater needed (V_{GW}) to account for the change in the observed drop in salinity after seawater inundation due to spring tides or the tsunami of March 11, 2010 at Lucas Spring (Dulaiova et al., 2010).

$$V_{GW} = (S_F V_S - S_I V_S) / (S_{GW} - S_F) \quad (9)$$

S_I represents the initial salinity, S_F is the final salinity, S_{GW} is the salinity of the groundwater discharging into the fishpond, and V_S is the volume of the fishpond. Flux rate, Q (m^3/day), was then calculated based on the amount of time (t) during which salinity values dropped from maximum to minimum.

$$Q = V_{GW}/t \quad (10)$$

4 Results

4.1 Lucas Spring

4.1.1 Lucas Spring 7-10 April, 2010 deployment

The Lucas Spring deployment in April 2010 lasted a total of 3 days during which only one fourth of the surface area was filled with water. Our objective was to monitor salinity, water level, and radon activities in Lucas Spring over time to discern any fluctuations due to tidal or meteorological forcing. Due to the low water level in Lucas Spring, we deployed the YSI multi-parameter sonde and the radon intake pump at the deepest location (0.17 m) to provide adequate water coverage. This location was about 25 m inland from the *`auwai* and located underneath the overhang of the house. Due to the irregularity of the bottom, an estimated average water depth of half of the deepest location was used for water volume calculations. For these calculations we used exact measurements of the dimensions of Lucas Spring and estimated a volume of 7.7 m^3.

Over the 3-day deployment the salinity ranged between 19.9 and 20.4. During this deployment, radon activity ranged from a low of 340 decays per minute per cubic meter of water (dpm/m^3) to a high of 3590 dpm/m^3, both the radon and salinity were tidally modulated though they cycled on a 24-hour period (Figure 18). However, water level in Lucas Spring cycled on a 12 hour period, with the water level only changing ~2-3 cm during each semidiurnal tidal induced fluctuation (Figure 19). Because there was no observable surface water flux between Lucas Spring and the ocean, tidal fluctuations in Lucas Spring were likely due to the underground hydrological connection of Lucas

Spring to the coastal aquifer. Figure 18 shows the regularity of both the change in salinity and the corresponding peak of radon activity whenever the salinity dropped. This is an indication of radon-rich and lower salinity groundwater discharge.

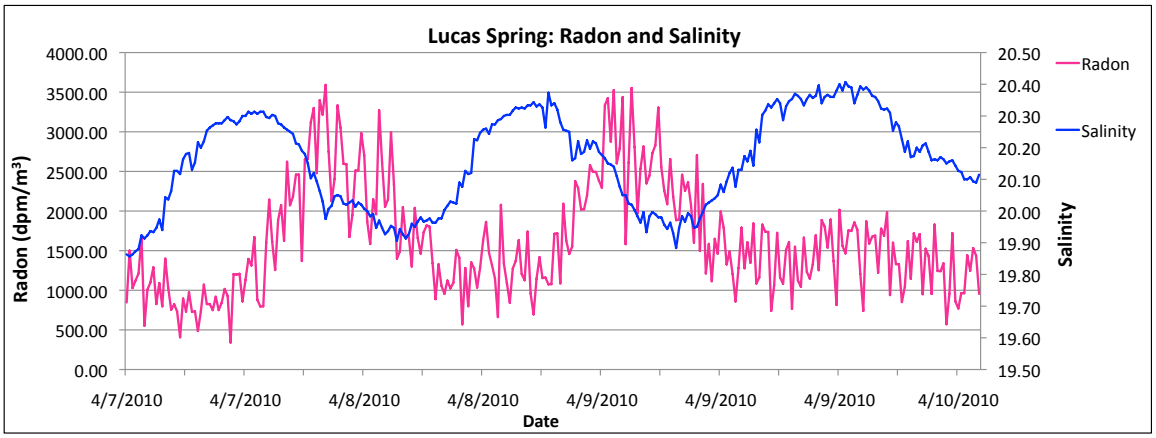


Figure 18. Lucas Spring April 2010 deployment radon activity and salinity.

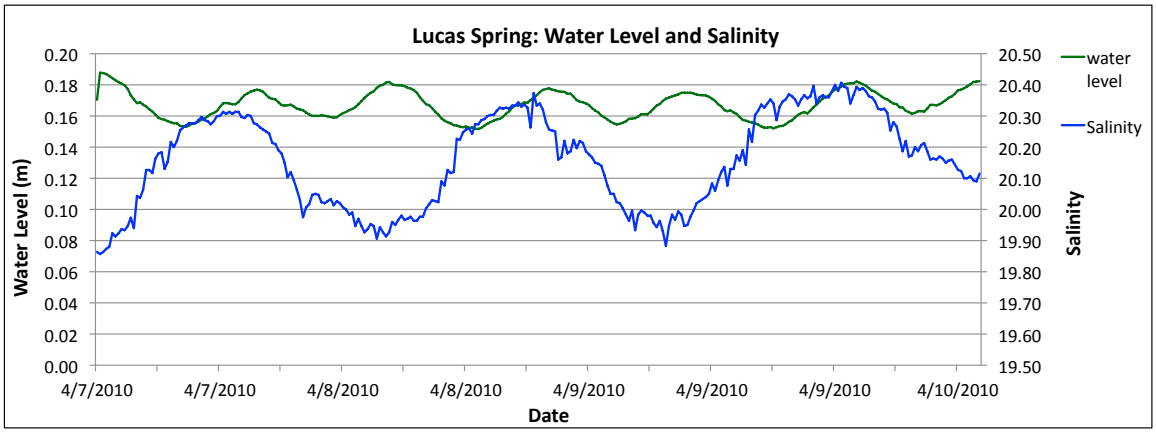


Figure 19. Lucas Spring April 2010 deployment water level and salinity.

These measurements recorded a decrease in average radon starting late April 9, indicating a slight shift in groundwater discharge. The radon balance (Eq (8)) was used to derive water flux into Lucas Spring. With an average radon activity for the period of April 7 – 9 of 1740 dpm/m^3 and a depth of 0.08 m, a radon inventory of 145 dpm/m^2 was calculated, and for the same time period the calculated losses to the atmosphere using Eq (2) were 417 dpm/m^2 day^{-1}. Radon loss due to radioactive decay was calculated using Eq

(7). These two terms represent radon losses, which have to be compensated for by radon flux into Lucas Spring by groundwater discharge. To compensate for radon losses by radioactive decay and atmospheric evasion a flux of 1290 dpm/m^2 day^{-1} of radon is required to sustain the calculated inventory. With a groundwater radon end-member of 168000 dpm/m^3, a water discharge of 0.71 m^3 day^{-1} is required in the period of April 7 – 9. However, at the end of the deployment period April 9 – 10 the radon inventory drops to 116 dpm/m^3 with losses to the atmosphere at 333 dpm/m^2 day^{-1}, leaving 1026 dpm/m^2 day^{-1} of radon to be compensated by groundwater giving a discharge rate of 0.56 m^3 day^{-1}.

The groundwater radon end-member activity was based on groundwater well measurements that were completed in the area (Holleman, in prep). From the time series record it is obvious that the total water level in Lucas Spring fluctuates only by 2-3 cm due to ocean tides. It is assumed that at lower low tide the hydraulic pressure allows the pond to fill with lower salinity high radon groundwater. Conversely, it is also assumed that at higher high tide, higher salinity low radon water is pushed into Lucas Spring from the ocean side of the coastal aquifer. One has to therefore distinguish between diurnal groundwater fluxes vs. long-term net groundwater discharge into the pond. Radon was used to calculate the average net fluxes and the salinity record was used to obtain groundwater discharge rates on a diurnal time scale due to tidal fluctuation. From the three observed drops in salinity, three groundwater discharge rates were calculated, 0.73 m^3 day^{-1}, 1.10 m^3 day^{-1}, and 0.64 m^3 day^{-1} for an average groundwater discharge rate of 0.82m^3 day^{-1} during dropping tide. Some of this water recharges back to the aquifer at

each higher high tide to sustain a constant average water level. No significant precipitation events occurred prior to or during this deployment.

4.1.2 Lucas Spring 12-27 August, 2010 deployment

During this 15-day deployment, the entire area of the Lucas Spring was filled and had an average water depth of 0.18 m. Salinity started out at 25.7 and showed an increasing trend with a peak salinity of 27.0 four days later. The overall trend then leveled off until August 21, when the salinity record began a decreasing trend with a low of 24.9 at the end of the deployment (Figure 20). Water level showed similar semidiurnal fluctuations to the April 2010 deployment with changes of ~2-3 cm that tracked the local ocean tidal frequency. Radon activity also showed similar diurnal fluctuations as were observed in April 2010 (Figure 21). Radon activity started at an initial minimum value of 580 dpm/m^3 on August 12 and reached a maximum value of 4470 dpm/m^3 on August 22, 2010. The largest increase in radon was by 3500 dpm/m^3 that occurred within a 3-hour time span on August 22. Radon activity was averaged over two separate periods (Aug 12 – 17 and Aug 18 – 27) due to a distinct increase in activity on August 17. Average radon activity for the period of August 12 – 17 was 1680 dpm/m^3, an inventory of 294 dpm/m^2, and losses due to atmospheric evasion at 368 dpm/m^2 day^{-1}, giving a groundwater discharge rate of 4.7 m^3 day^{-1}. The average radon activity for the period of August 18 – 26 was 2280 dpm/m^3, an inventory of 397 dpm/m^2 and losses due to atmospheric evasion at 492 dpm/m^2 day^{-1}, giving a groundwater discharge rate of 6.3 m^3 day^{-1}. Two specific salinity drops on August 24 and August 26 were used to calculate a groundwater discharge rate of 12.2 m^3 day^{-1} and 7.3 m^3 day^{-1}. No significant precipitation events occurred prior to or during this deployment.

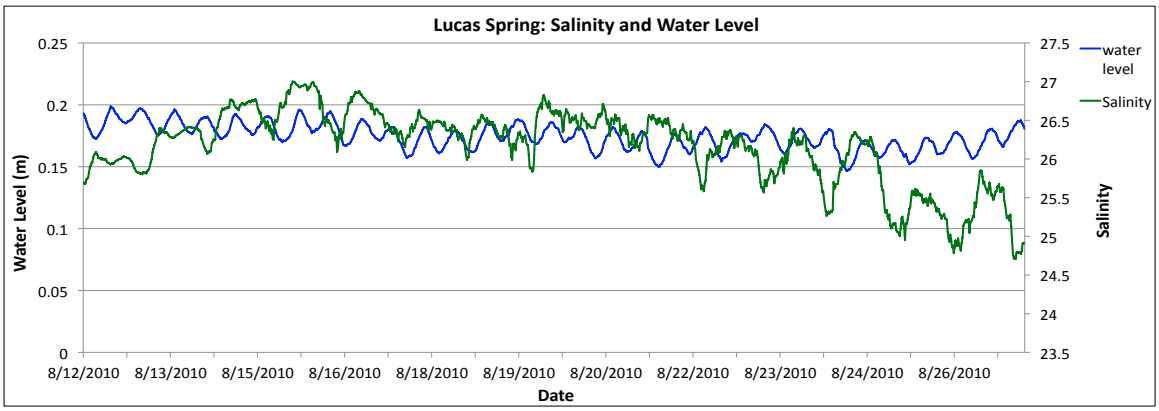


Figure 20. Lucas Spring August 2010 deployment, water level and salinity.

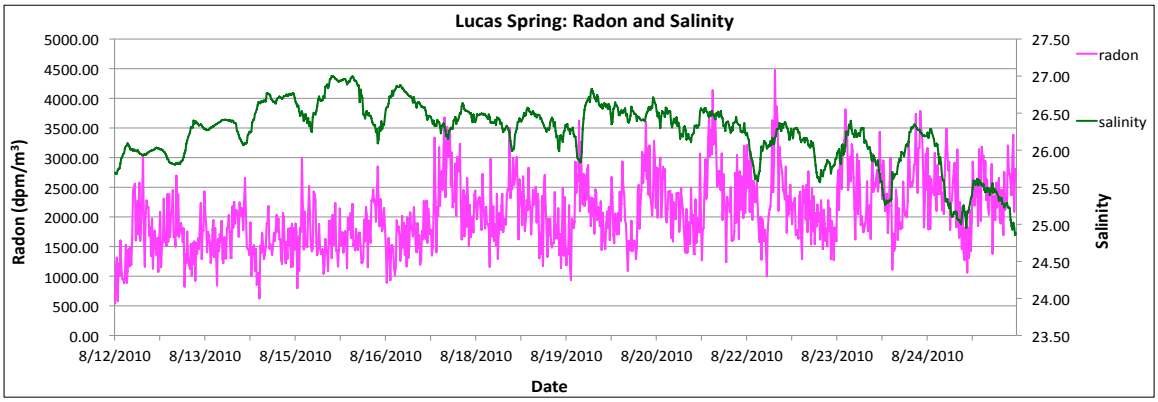


Figure 21. Lucas Spring August 2010 deployment, radon activity and salinity.

4.1.3 Lucas Spring CTD-Diver time series

The final measurements at Lucas Spring were restricted to the use of a CTD-Diver and spanned a period of nearly 5 months, between November 2010 and April 2011. The CTD-Diver was deployed 2 weeks after the sewer line rehabilitation project was completed. Throughout this period, the salinity in Lucas Spring showed an overall decreasing trend from an already low initial value of 9.1 on November 11, 2010, to a sustained baseline salinity approaching ~ 2 by mid-December. Two major anomalies in salinity punctuate that record, one due to a significant rainfall event on December 19, 2010 that coincided with spring tide inundation, and the other due to a tsunami which struck Hawai`i on March 11, 2011 (Figure 22 and Figure 23). Due to both salinity

anomalies as well as the completion of the sewer line rehabilitation project at the end of October 2010, the data from this diver will be discussed further in section 5 below.

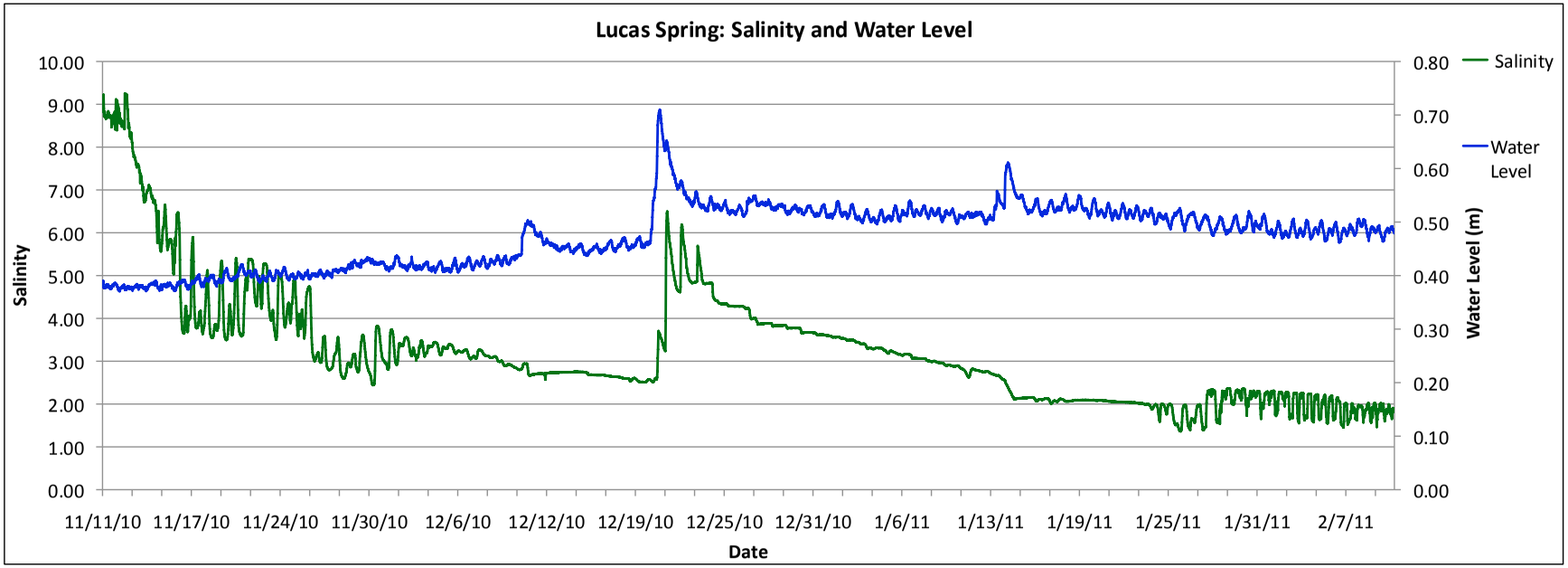


Figure 22. CTD-Diver time series data of Lucas spring from November 11, 2010 to February 10, 2011 showing changes in salinity and water level after the sewer line rehabilitation project was completed at the end of October 2010.

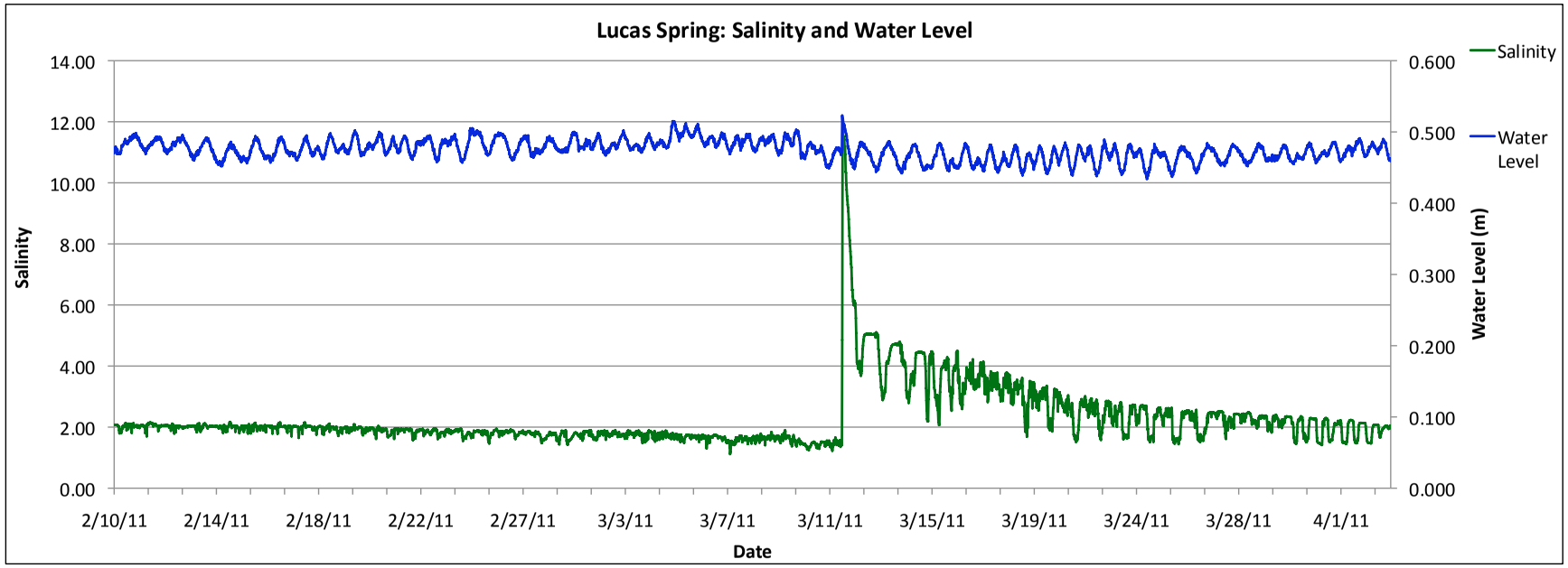


Figure 23. CTD-Diver time series data from February 10, 2011 to April 2, 2011 showing changes in salinity and water level with the impact from the March 11 tsunami that hit Hawai`i clearly seen in the salinity spike.

4.2 Kanewai Spring

4.2.1 Kanewai Spring 2-4 April, 2010 deployment

The initial deployment at Kanewai Spring took place over a period of 2 days. During this period the salinity of Kanewai Spring fluctuated slightly between 2.8-2.9 (Figure 24). Water depth averaged 0.9 m and the water level fluctuated ~4-5 cm on a 12-hour period, coinciding with the semidiurnal tidal cycle. Radon activity ranged between 36000 - 64000 dpm/m^3. The lowest radon activity was observed shortly after the initial deployment while the peak activity was observed 12.5 hours later (Figure 25). With an average radon activity of 51080 dpm/m^3, a radon inventory of 45970 dpm/m^2, and losses to the atmosphere at 11960 dpm/m^2 day^{-1}, a groundwater discharge rate of 82 m^3 day^{-1} was calculated. No significant changes in salinity occurred during the April 2010 deployment at Kanewai Spring, so no salinity mass balance calculations were completed for comparison to the radon model calculation. No significant precipitation events occurred prior to or during this deployment.

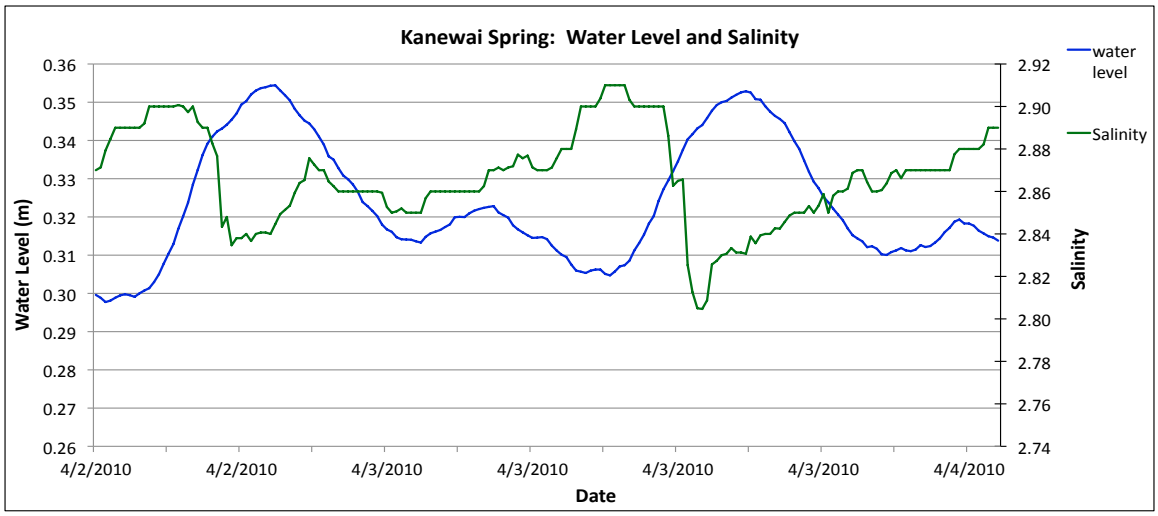


Figure 24. Kanewai Spring April deployment, salinity and water level.

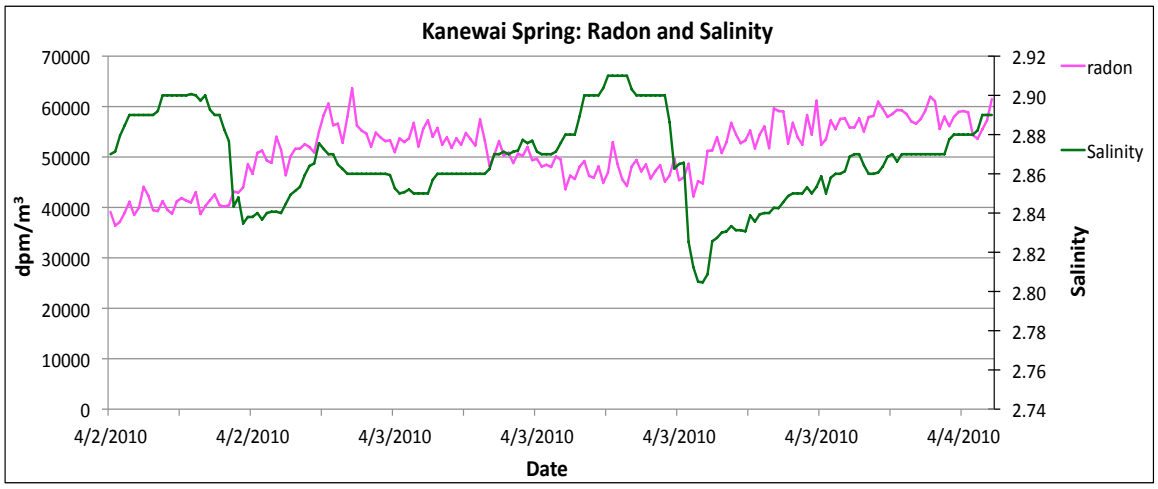


Figure 25. Kanewai Spring April deployment, salinity and radon activity.

4.2.2 Kanewai 14-17 July, 2010 deployment

The July deployment at Kanewai Spring took place over a period of ~3 days. The initial salinity of the spring was an extremely high 31 and increased to 33.5 the first night. Water level and temperature also peaked at the same time as the peak in salinity, indicative of an influx of seawater. After the initial peak, the salinity gradually dropped to 20 by the end of the time series analysis (Figure 26). The water level of Kanewai Spring fluctuated with a 12 hour period coinciding with the ocean tide and an amplitude of ~4-5 cm. Radon levels in Kanewai Spring started off low, 21000 dpm/m^3 and initially dropped to 11800 dpm/m^3, coinciding with the peak in salinity. This may have been due to flooding of Kanewai Spring with ocean water from Kanewai Fishpond. After this relatively low initial radon activity, radon levels consistently increased and leveled off around 95000 dpm/m^3 for about the last 12 hours of the time series deployment (Figure 27). The radon activity averaged over the entire period gave a groundwater discharge rate of 70.1 m^3, slightly lower than the first time series analysis. However due to the dramatic increase in radon activity, three separate groundwater discharge rates were also

calculated based on the change in radon activity: July 14-15, 15-16, and 16-17 resulting in discharge rates of 30.4 m^3 day^{-1}, 68.2 m^3 day^{-1}, and 151.4 m^3 day^{-1} respectively. Using the drop in salinity from its peak of 33.5 to the final minimum salinity of 20, 56 hours later, a groundwater discharge rate of 16.0 m^3 day^{-1} was calculated using an end member salinity of 2.8 (based on the April deployment). This estimate is significantly lower than the one obtained from the radon mass balance. This may be due to the uncertainty in our groundwater end-member salinity and radon activity. Salinity seemed to be leveling out at about 6.5 during the later August deployment so the same calculation was also done using an end member salinity of 6.5 resulting in a groundwater discharge rate 20.5 m^3 day^{-1}. This estimate was still much lower than the radon derived discharge and we can conclude that in this setting for this short time period salinity is not the best tracer because there might be some interaction between Kanewai Spring and the high salinity water of Kanewai Fishpond that we cannot account for. No significant precipitation events occurred prior to or during this deployment.

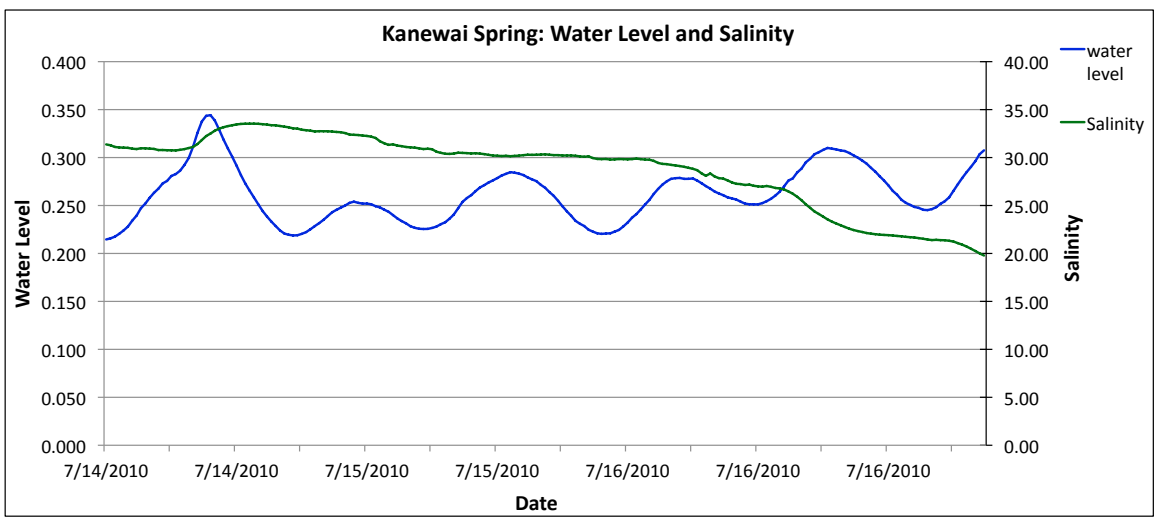


Figure 26. Kanewai Spring July deployment, salinity and water level.

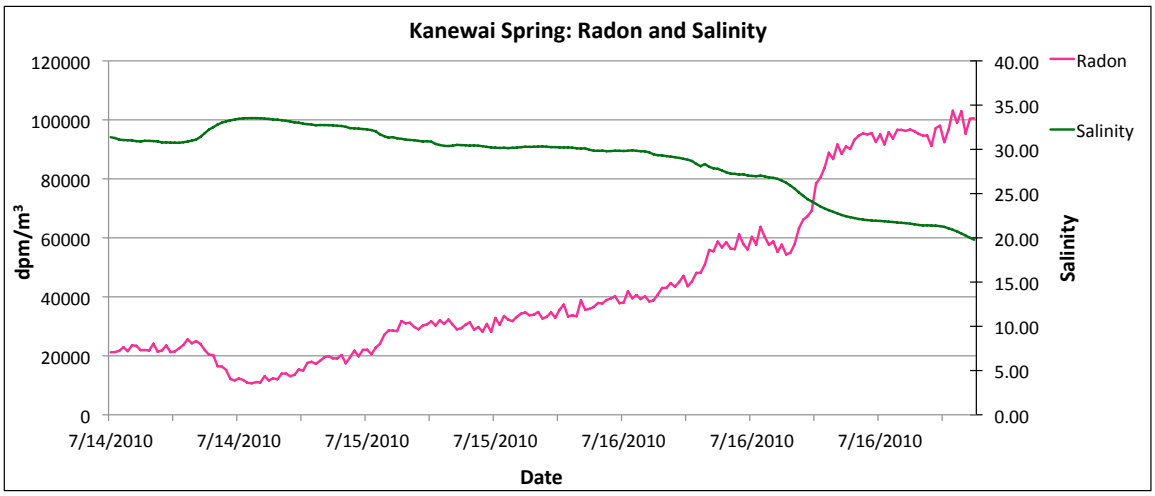


Figure 27. Kanewai Spring July deployment, salinity and radon activity.

4.2.3 Kanewai 12-26 August, 2010 deployment

The August deployment at Kanewai Spring lasted 14 days. The initial salinity of Kanewai Spring was 25.3 and peaked 4 hours later at 25.9. From this point, the salinity dropped for the next 8 days, leveling off at 6.5 before a fluctuating increase to 22.1 and subsequent decline that occurred over the last 6 days, with a salinity of 9.5 upon completion of the time series deployment (Figure 28). Figure 28 also shows how the water level of Kanewai Spring fluctuated with the semidiurnal ocean tide about 4-5 cm in a 12-hour period. Radon levels of Kanewai Spring started off low but quickly increased over the first day as the salinity dropped. Radon activity leveled off on the second day and then fluctuated between 100000 – 125000 dpm/m^3 for the next 4 days (Figure 29). A peak radon activity level of 157000 dpm/m^3 was observed on August 17, 2010. During the next four days, radon levels fluctuated more drastically with a net decrease to ~100000 dpm/m^3 when a blockage to the airline occurred on August 21 at 11:50 am invalidating the rest of the time series radon data. Radon levels were averaged from August 13 – 21, with an average radon activity of 117740 dpm/m^3 resulting in an average

groundwater discharge rate of ~188 m^3 day^{-1}. In addition, a salinity mass balance calculation was done for the drop in salinity from the initial deployment salinity of 25. A groundwater discharge rate was calculated from the initial salinity peak to when it leveled off 5 days later to ~ 6.50, providing a discharge rate of ~158 m^3 day^{-1}. No significant precipitation events occurred prior to or during this deployment.

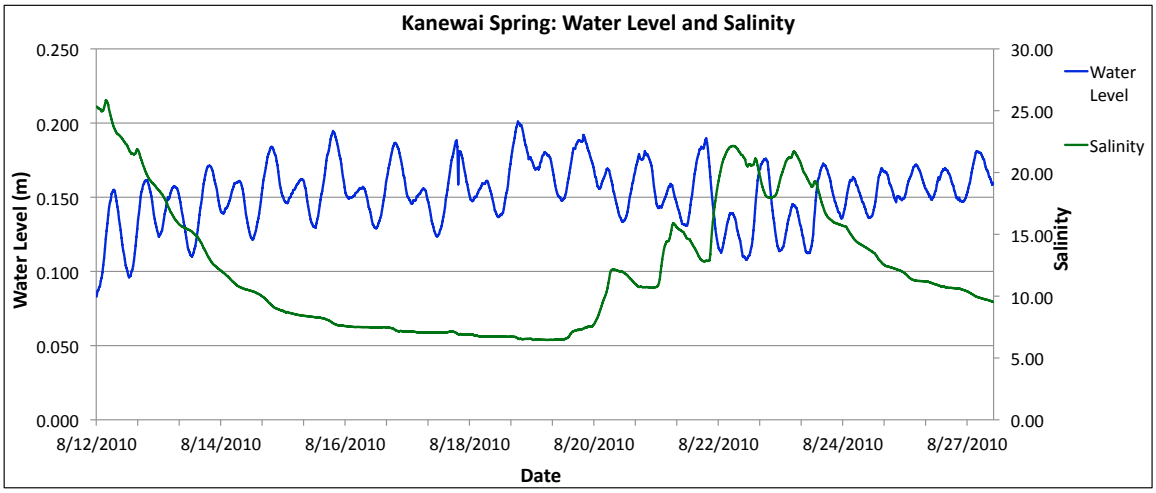


Figure 28. Kanewai Spring August deployment, salinity and water level.

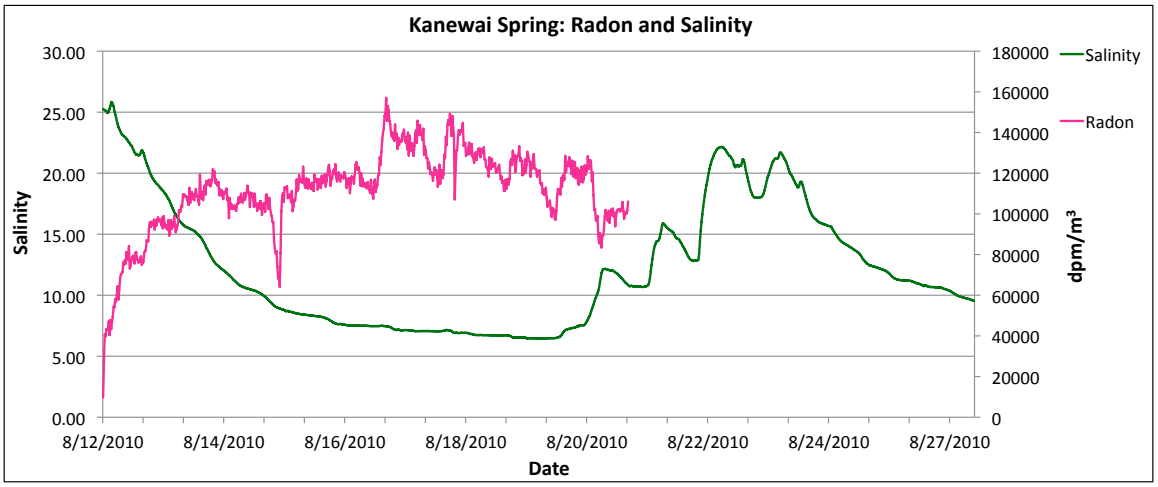


Figure 29. Kanewai Spring August deployment, radon activity and salinity.

4.3 CTD-Diver time series: Kanewai Spring, Kanewai Fishpond, Paiko Lagoon

CTD-Diver deployment for Kanewai Spring, Kanewai Fishpond, and Paiko Lagoon revealed some key coastal dynamics of the research area. The Paiko Lagoon

diver recorded open ocean tide for comparison to what was occurring at the two research locations. A clear increase in tidal amplitude was recorded at the Paiko Lagoon site every two weeks, consistent with spring and neap tide fluctuations. The same increase in tidal amplitude could be seen in the Kanewai Fishpond and Kanewai Spring water level data (Figure 30). The data revealed that only during peak spring high tide does the water level of Kanewai Fishpond increase enough to flood Kanewai Spring with a subsequent increase in salinity of Kanewai Spring (Figure 31). The change in water level would also increase from an amplitude of ~ 4-5 cm to ~10-15 cm during the spring tide flooding of Kanewai Spring (Figure 32). The salinity of Kanewai Spring fluctuated between a high of 34 and a low of ~7. The salinity of Kanewai Spring did drop to a low of ~6 at the beginning of February at the end of the deployment. The 3 month long CTD-Diver time series revealed the consistency with which Kanewai Spring was flooded by high saline ocean water, allowing for the salinity mass-balance calculations to be completed. Table 1 shows all calculated flow rates based on both radon and salinity, which will be discussed in more detail in section 5.

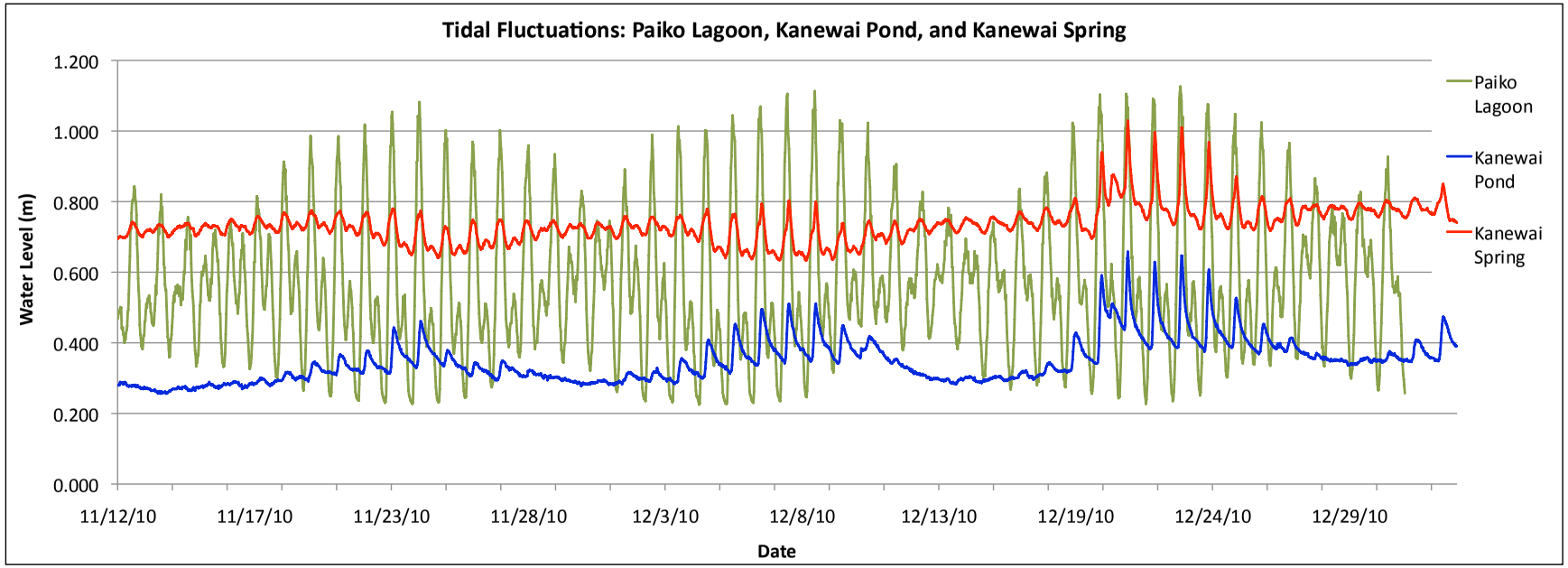


Figure 30. CTD-Diver time series data showing water level fluctuations due to spring tide events of Paiko Lagoon, Kanewai Fishpond, and Kanewai Spring

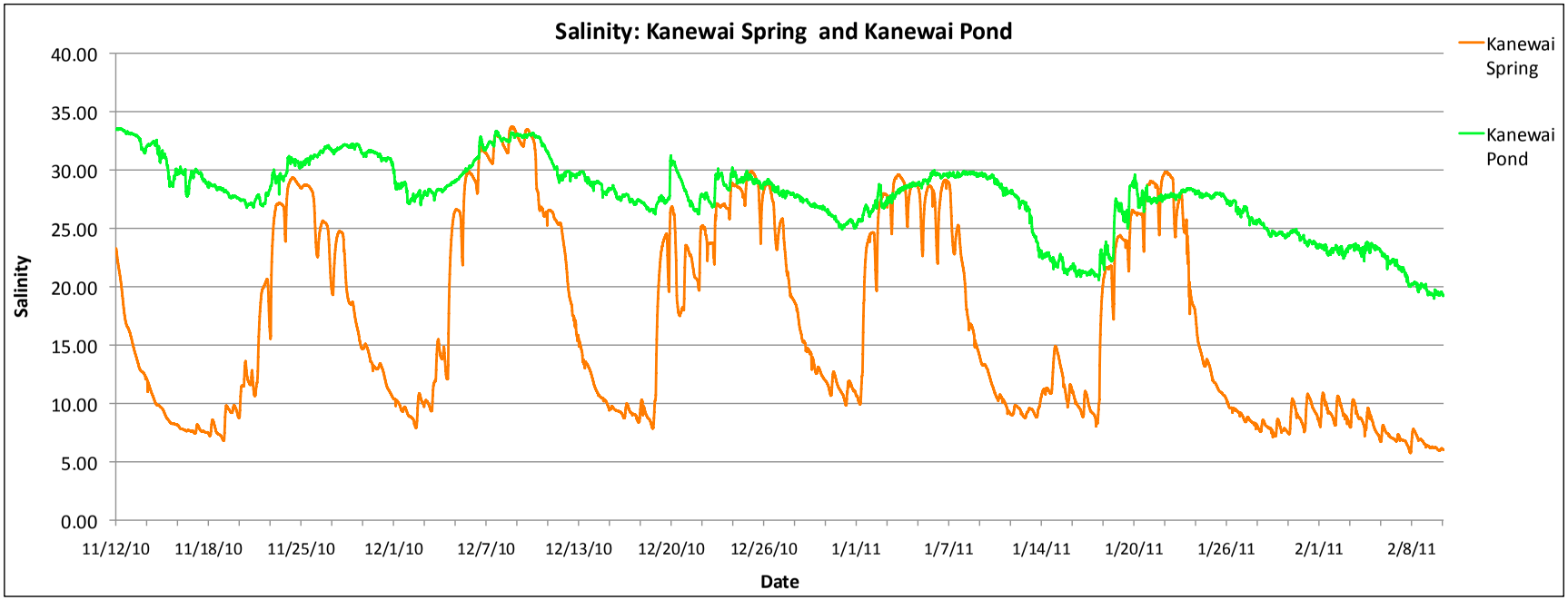


Figure 31. CTD-Diver time series data showing that the salinities of Kanewai Spring would match those of Kanewai Fishpond during peak spring high tides when Kanewai Fishpond would flood Kanewai Spring.

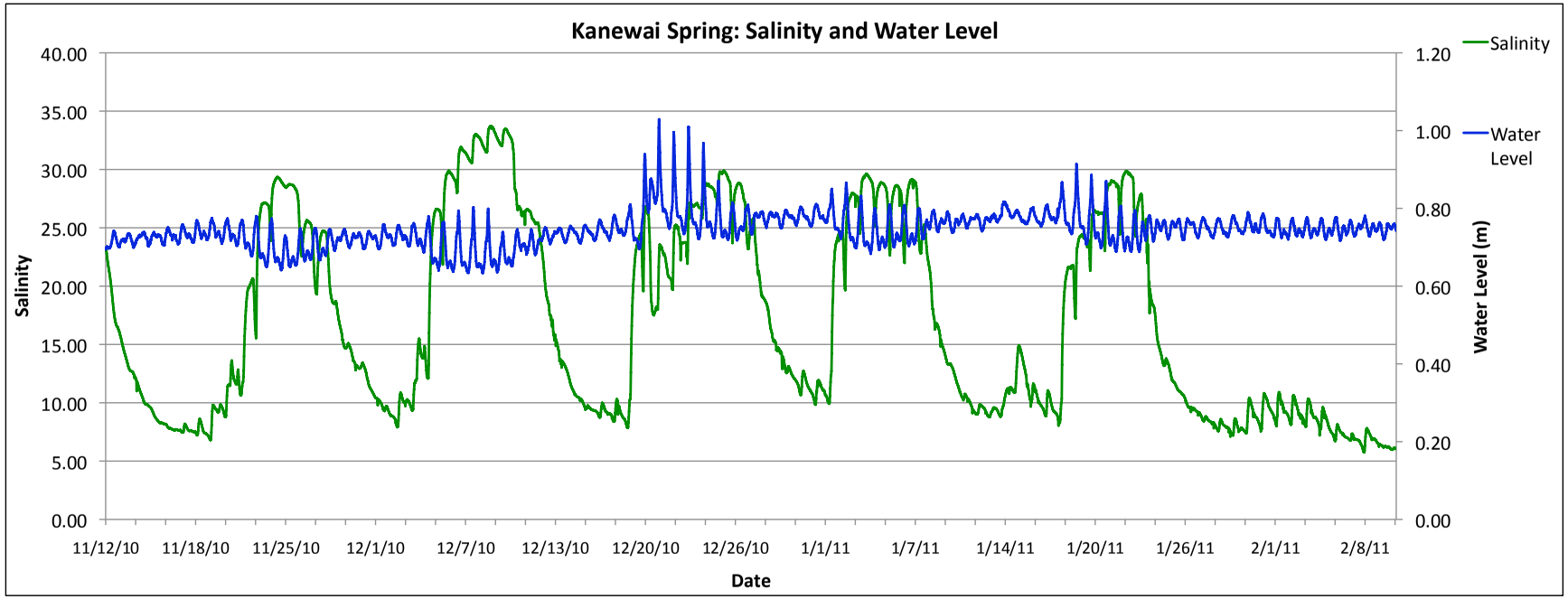


Figure 32. CTD-Diver time series data of Kanewai Spring showing the increase in salinity in conjunction with the increased water level amplitudes that coincide with peak spring high tides.

Table 1. Groundwater discharge rates (m^3 day^{-1}) and monthly average rainfall (mm) at the two spring sites. Post-sewer line rehabilitation values are shaded.

		Radon mass-balance		Salinity mass-balance		Rainfall
	Date	Low	High	Low	High	Monthly Avg
Lucas Spring	Apr '10	0.6	0.7	0.6	1.1	26.7
	Aug '10	4.7	6.3	7.3	12.2	35.3
	Nov '10	-	-	35.8	114.5	95.5
	Mar '11	-	-	139.3	-	75.9
Kanewai Spring	Apr '10	-	82.0	-	-	26.7
	July '10	30.4	151.4	16.1	20.5	36.8
	Aug '10	-	188.3	36.1	157.8	35.3
	Nov '10	-	-	18.1	27.3	95.5
	Dec '10	-	-	22.9	33.1	272.5
	Jan '11	-	-	26.3	41.3	104.9

5 Discussion and Conclusion

The primary objective of this research was to determine before and after groundwater discharge rates to Lucas Spring, a spring clearly impacted by the road widening and sewer line rehabilitation projects, and Kanewai Spring, as a comparison site, which did not appear to be impacted by the construction. Although technical limitations allowed the collection of radon measurements to only take place before the rehabilitation project. The use of the Schlumberger CTD-Divers provided the opportunity to monitor post-work changes in water flux variations at both locations as a function of conventional salt balance modeling. In addition, the availability and thus longer-term deployment of the CTD-Divers also proved advantageous in providing a better overall grasp of the important impact of tides on the hydrology at both research locations.

5.1 Lucas Spring

The water volume of Lucas Spring changed dramatically throughout the entire research period of April 2010 to April 2011. Lucas Spring had an initial water volume of 7.7 m^3 during the April 2010 deployment, with only one fourth of the surface area covered with water, the remainder being desiccated to mud (Figure 33). Prior to the August deployment at Lucas Spring, the *`auwai* leading to the ocean had been partially dug out, allowing ocean water into Lucas Spring during some high tide events (Figure 34). The August deployment thus showed a dramatic change in water level with an estimated water volume of 64 m^3, covering all previous muddy areas of Lucas Spring. The increased salinity of the August deployment (~26 vs. ~20 in April, see Figure 19 and Figure 20), the visual observation of the *`auwai*, and the fact that the August radon inventories were of the same order of magnitude as those in April (150 and 350 dpm/m^2,

respectively) all suggest strongly that this increase in water volume was mostly a result of increased surface flooding from the ocean.

Figure 33. Lucas Spring, April 2010. Photo: J. Kennedy.

Figure 34. Lucas Spring *`auwai* after being dug out (Photo: C. Cramer) and Lucas Spring July deployment Photo: J. Kennedy.

As noted above, this study's final deployment using CTD-Divers at Lucas Spring took place after the sewer line rehabilitation project was finished. The sealing of the sewer line took about 2 weeks to complete and began October 12, 2010. Due to the accessibility of the research locations, The CTD-Diver was deployed on November 11, 2010, approximately 2 weeks after the rehabilitation work was completed. The initial salinity reading on November 11 of 9.1 at Lucas Spring revealed a dramatic drop in salinity when compared to the April and August deployments (~20 and ~26 respectively), and the water level of Lucas Spring also increased from 0.08 m to an average depth of 0.4 m, giving an estimated volume of ~140 m^3. Although precipitation events must also be taken into account (see below), these values suggested that the sealing of the sewer line had indeed restored some flow of groundwater to Lucas Spring.

5.2 Precipitation events

The Niu Valley rain gauge showed a cumulative precipitation of 46.0 mm for the month of September 2010, slightly above the 30.0 mm average of the previous six months. The month of October 2010 had a cumulative precipitation of 10.2 mm. The salinity of Lucas Spring showed a dramatic drop over the month of November and into December (Figure 22). The month of November did have an increase in precipitation, although the salinity of Lucas Spring had already been fluctuating at remarkably low salinities of 4-5 even before the first significant precipitation event occurred, which was a 6-hour cumulative rainfall total on Nov 25, 2010 of almost 15.2 mm. A week after this precipitation event, the salinity fluctuations began to diminish and eventually leveled off below 3 about two weeks later when the next precipitation event occurred.

The next precipitation event took place on December 10, with a 12-hour rainfall total of ~50 mm (Figure 35); one day later a small spike in water level was observed at Lucas Spring. The one-day lag suggested that it was increased hydraulic head and not surface water runoff that impacted Lucas Spring. Interestingly, only a very small drop in salinity (0.3) was observed with the December 10 precipitation event, though the small salinity fluctuations prior to this event diminished greatly, suggesting that the precipitation and corresponding increase in hydraulic head overrode any tidally induced impacts of ocean water on the coastal aquifer at Lucas Spring.

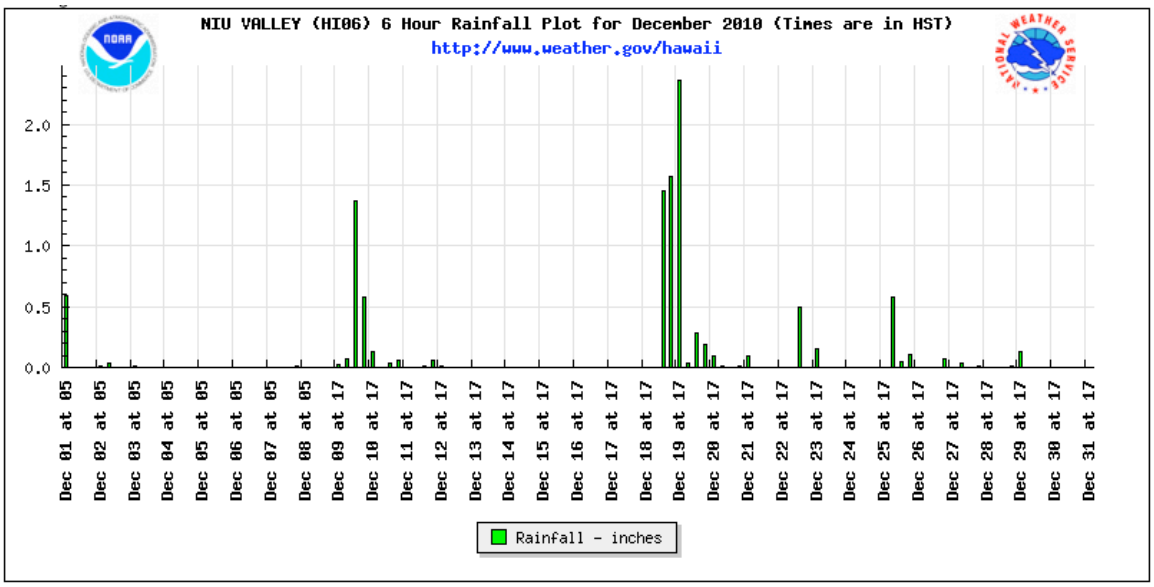


Figure 35. Niu Valley rain gauge 6-hour rainfall plot for December 2010 (www.weather.gov/hawaii).

The most notable precipitation event was a storm that occurred on December 19, 2010. The rain gauge in Niu Valley recorded two consecutive 6-hour rainfall totals ~40 mm, with a third 6-hour rainfall total immediately following totaling ~65 mm (Figure 35). The next day, a spike in water level at Lucas Spring was observed, followed by an increase in salinity. One might assume that the salinity of Lucas Spring would drop due to the amount of freshwater from the storm; however, the opposite occurred and the

salinity increased, consistent with an influx of ocean water through the *`auwai*. CTD-Diver data from Paiko Lagoon, Kanewai Fishpond and Kanewai Spring revealed peak spring high tides at the same time period as the storm event. These combined events complicate differentiation between how much the rise in water level is due to increased hydraulic head from the storm and how much is from ocean water coming through the *`auwai*.

After the late December spring high tides, the salinity of Lucas Spring dropped consistently to just under 3 before a third precipitation event occurred with rainfall amounts of ~35 mm on January 12, 2011, and just over 50 mm on January 13, 2011 (Figure 36). A slight salinity drop to ~2 was observed at Lucas Spring one day later, which was accompanied by about a 0.1 m increase in water level that lasted for about 2 days. The salinity then leveled off at ~2 for the next 2 months until the tsunami of March 11, 2011.

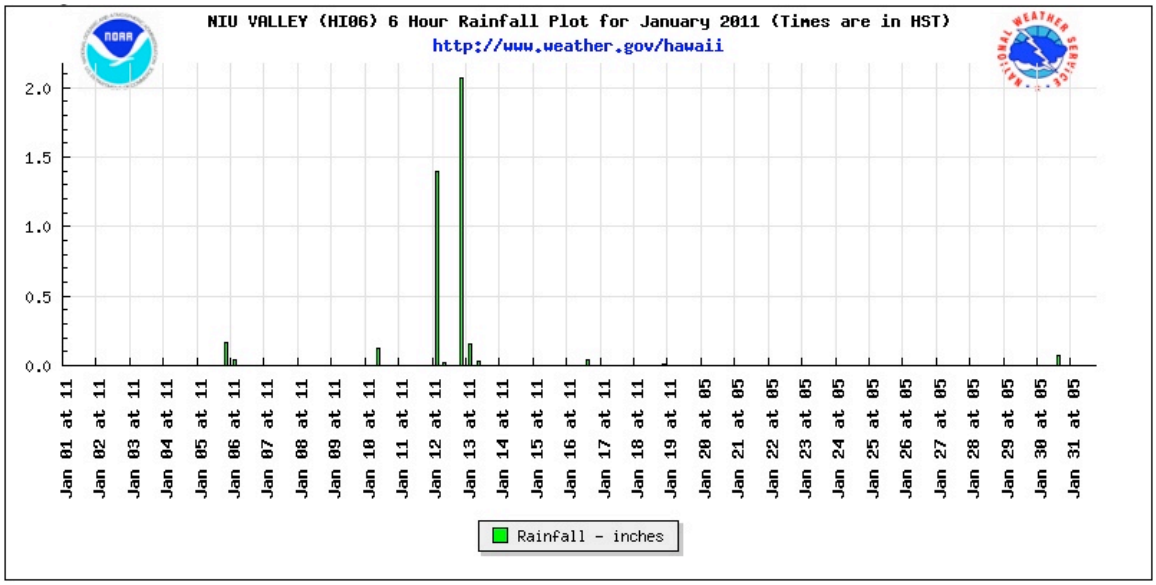


Figure 36. Niu Valley rain gauge 6-hour rainfall plot for January 2011 (www.weather.gov/Hawai`i).

Due to salinity changes during the 5-month deployment, the salt mass-balance approach (see Methods) was used to calculate a final groundwater discharge rate into Lucas Spring. In order to use this approach one must first determine the end-member salinity of the water that was discharging into the spring. During the first two deployments in April and August 2010, no clear salinity minimum was detected; this was expected due to the assumption that barely any water was flowing into the spring. The CTD-Diver provided a salinity minimum of 1.2 before the tsunami of March 11, 2011 hit Hawai`i. This provided the only clear representation of end member salinity for Lucas Spring that could be used when calculating the discharge rate using equation (9). During the tsunami, the water level of the pond rose 4.6 cm and the salinity increased from 1.3 to 11.8 in a span of 40 minutes (Figure 23). The sudden one time spike in salinity from the tsunami provided the perfect opportunity to then calculate a groundwater flux using the salinity mass-balance approach. Using this approach, the calculated groundwater discharge into the pond was a high 139 m^3 day^{-1}, which represents two orders of magnitude increase in groundwater discharge in comparison to April and August 2010 (both <1 m^3 day^{-1}).

5.3 Kanewai Spring

The April 2010 deployment at Kanewai spring showed salinities fluctuating in a narrow range between 2.8-2.9. The July deployment showed a vast difference from the April deployment with salinity reaching as high as 33.5 and only a low of 19.8 at the end of the deployment. The third deployment in August showed an even greater range with values ranging from a high of 25.8 and leveling off at a low of 6.5 before increasing again. Even the 3 month CTD-Diver deployment revealed that most salinity minimums

never dropped below 6.5 with a few sporadic values dropping down to ~6 at the end of the deployment period. This shows that the salinity in Kanewai Spring is greatly influenced by the salinity of groundwater and water infiltrating from the fishpond. Since it is hard to determine exact groundwater salinity end-members for our salinity mass balance, we assumed a possible range of salinities based on the lowest salinities observed throughout our study period as a lower limit and where the salinity leveled out during the diver deployment as a higher limit. The two end member values of 2.8 and 6.5 were used to calculate a discharge rate providing a high and low range of groundwater discharge into the spring.

5.4 Overall trends in groundwater fluxes

Table 1 (Results section) shows the values of all SGD fluxes calculated using both radon and salinity. The groundwater flux rates into Lucas Spring show a clear increase when a pre- and post-rehabilitation project fluxes are compared. Both the April 2010 radon and salinity mass balance calculations reveal similar values. The Salinity mass-balance calculations for August are slightly higher than the radon mass-balance calculations. The November 2010 flux rates show a definite increase in groundwater discharge into Lucas Spring, in line with the assumption that the sewer line rehabilitation project did return some flow of groundwater to the conduit that feeds Lucas Spring. The nearly constant low salinity values for a two-month stretch in conjunction with the salinity mass-balance calculation from the tsunami salinity spike and subsequent drop back to extremely low levels further suggest that the sewer line rehabilitation project diverted water back to Lucas Spring. Our estimates show an increase of ~130 m^3 day^{-1}

which is 4% of the estimated 3,780 m^3 day^{-1} that was previously calculated to leak into the sewer lines before the rehabilitation project took place.

The calculated groundwater fluxes for Kanewai Spring do not show the same increase as in Lucas Spring. The Kanewai Spring radon mass-balance calculations show doubling of groundwater discharge from April to August 2010, before the sewer line rehabilitation project started. The salinity mass-balance calculations for August are much higher than the values calculated for July, November, December, and January. The August salinity mass-balance discharge rates are the only flow rates at Kanewai Spring that correspond with the radon mass-balance discharge rates for the same time period. This could be due to the fact that the salinity of the August deployment leveled out at 6.5, revealing the clearest end member salinity of the research period. The November, December and January flux rates, though much less than the August flow rate, show a progressive increase that is in line with the increased precipitation for that period. However, the salinity mass-balance flow rate calculations do not provide enough evidence to show that the sewer line rehabilitation project had any positive impact on the groundwater discharge at Kanewai Spring.

5.5 Conclusions

The results indicate that groundwater discharge to Lucas Spring increased after the sewer rehabilitation project by about two orders of magnitude, while discharge to Kanewai Spring over the same time period did not increase at the same magnitude. This may indicate that the rehabilitation project restored some groundwater conduits that are feeding Lucas Spring. To further test this theory we looked at sewer flow data obtained from HDR Inc., showing before and after sewer line rehabilitation dry-weather flow rates

for the Niu Valley wastewater pump station. Figure 37 shows two dry-weather flow rates within the sewer system, with the January 2005 representative of the pre-rehabilitation scenario and the December 2010 flow rate showing the flow rate after the rehabilitation project was complete. The data reveals about a 2650 m^3 day^{-1} decrease in the flow rate after the sewer line rehabilitation project was completed. This data reveals that about 70% of the estimated 3,780 m^3 day^{-1} of groundwater is no longer infiltrating into the sewer line. All of the data suggests that the sewer line rehabilitation project did indeed restore some groundwater flow to the subterranean aquifer conduits, some of which feed Lucas Spring. Because only 4% of the restored flow of 2650 m^3 day^{-1}in Lucas Spring was accounted for, the rehabilitation project probably also enhanced groundwater discharge to the coastline or other nearby springs.

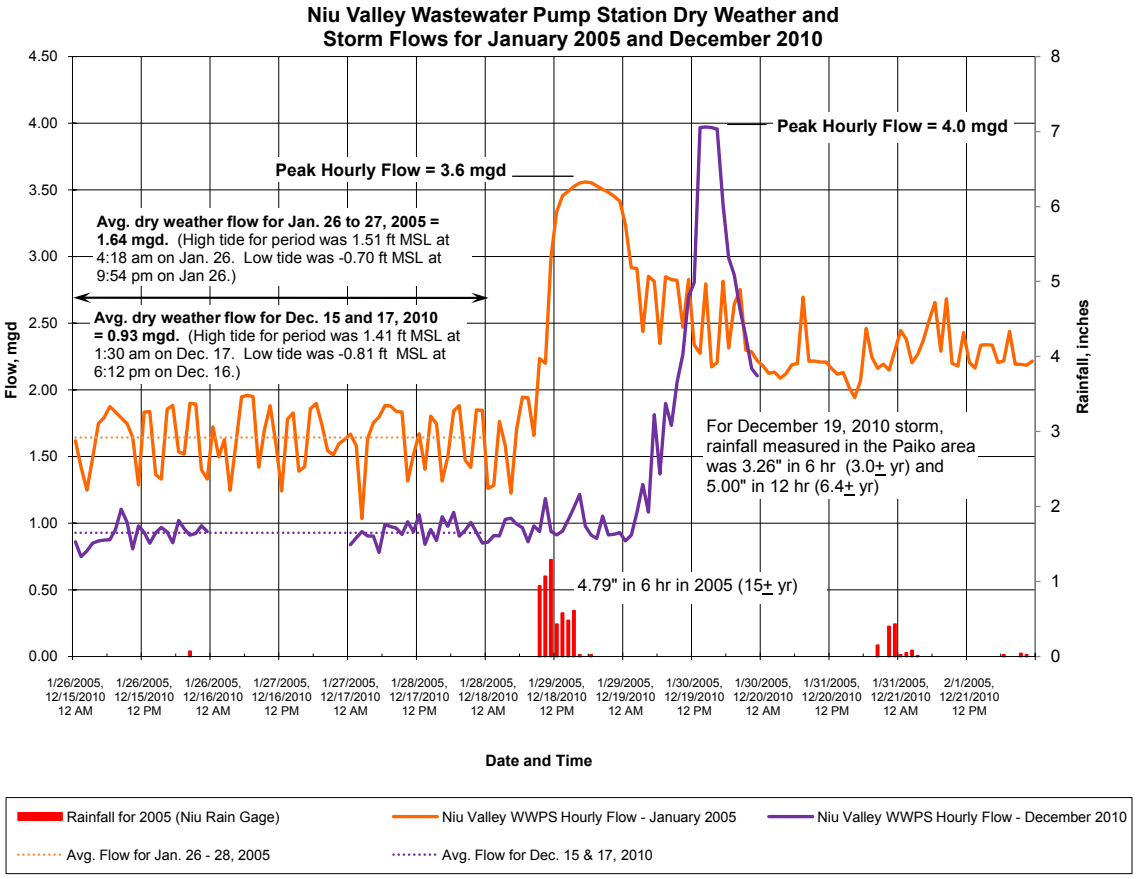


Figure 37. Dry-weather flow rates from the Niu Valley Wastewater Pump Station, showing flow rates from January 2005 and December 2010 (Abe, HDR Inc.).

Historically, both Lucas Spring and Kanewai Spring had an estimated 750 m^3 day^{-1} flux of groundwater. Fluxes observed at Kanewai Spring were on the order of 150 m^3 day^{-1} and the groundwater discharge in Lucas Spring after the restoration project was ~140 m^3 day^{-1}. Both these fluxes are significantly lower than the historic spring flow, representing only 18% of the 750 m^3 day^{-1}. This means that either not all water has been redirected back to Lucas Spring or that there is much less groundwater available as the aquifer has been stressed over the past few decades because of groundwater withdrawal for the public. Nevertheless, we can conclude that the sewer line rehabilitation project improved the flux into Lucas Spring and that the road-widening project on Kalanianaole Highway did indeed have an immediate and lasting effect on the groundwater discharge

of the area. Lucas Spring has sat abandoned since 1994, but with the data suggesting that ~18% of the original flow of groundwater has been returned to the fishpond, and with the volume of water in the fishpond increasing from ~8 m^3 in April 2010 to ~190 m^3 in January 2011, there is now the chance that this location will once again be able to benefit the community through the continued preservation and restoration efforts of Maunalua Fishpond Heritage Center.

References

Abe, R.K., HDR Inc., Data from personal communication, 2011. HDR Inc. Hawai`i Pacific Engineers 1132 Bishop Street, Suite 1003, Honolulu, HI, 96813-2830

Burnett, W.C., and H. Dulaiova, 2003. Estimating the dynamics of groundwater input into the coastal zone via continuous radon-222 measurements. Journal of Environmental Radioactivity. Vol. 69, pp. 21-35

Burnett, W.C., P.K. Aggarwal, A. Aureli, H. Bokuniewicz, J.E. Cable, M.A. Charette, E. Kontar, S. Krupa, K.M. Kulkarni, A. Loveless, W.S. Moore, J.A. Oberdorfer, J. Oliveira, N. Ozyurt, P. Povinec, A.M.G. Privitera, R. Rajar, R.T. Ramessur, J. Scholten, T. Stieglitz, M. Taniguchi, and J.V. Turner, 2006. Quantifying submarine groundwater discharge in the coastal zone via multiple methods. Science of the Total Environment. Vol. 367, pp. 498-543.

Charette, M.A., W.S. Moore and W.C. Burnett, 2008. Uranium- and thorium-series nuclides as tracers of submarine groundwater discharge. Radioactivity in the Environment, ed. S. Krishnaswami, J.K. Cochran, vol: "U-Th Series Nuclides in Aquatic Systems", 13, 155-191.

Dimova, N.T. and W.C. Burnett, 2011. Evaluations of groundwater discharge into small lakes based on the temporal distribution of radon-222. Limnol. Ocenaogr., 56(2), pp. 486-494. Doi:10.4319/lo.2011.56.2.0486

Dulaiova, H., Camilli, R., P. B. Henderson, and M. A. Charette, 2010. Coupled radon, methane and nitrate sensors for large-scale assessment of groundwater discharge and non-point source pollution to coastal waters, Journal of Environmental Radioactivity, 101(7), pp. 553-563, doi:10.1016/j.jenvrad.2009.12.004.

Erlens, C. and J.S. Athens, 1994, Burials, highways and history: archaeology along Kalaniana'ole Highway, East Honolulu, O'ahu. Prepared for Hawai'i State Department of Transportation, Honolulu, Hawai'i. International Archaeology Research Institute, Inc. Honolulu, Hawaii.

Fukunaga and Associates, Inc., 2005, "Final Design Alternatives Report, Elelupe Road and Kalanianaole Highway Sewer Rehabilitation SMPR No. 36," prepared for City & County of Honolulu, Department of Environmental Services, March 2005.

Hwang, D.W., Y.W. Lee, and G. Kim, 2005. Large submarine groundwater discharge and benthic eutrophication in Bangdu Bay on volcanic Jeju Island, Korea. Limnology and Oceanography Vol. 50, No. 5 pp. 1393-1403.

Holleman, K., in prep. Impact of submarine groundwater discharge on leeward Hawai`i and leeward O`ahu. University of Hawai`i at Manoa MS Thesis. University of Hawai`i, Honolulu, HI.

Johannes, R.E., 1980. The ecological significance of the submarine discharge of groundwater. Marine Ecology. Vol. 3, pp. 365-373.

Johnson, A.G., C.R. Glenn, W.C. Burnett, R.N. Peterson, and P.G. Lucey, 2008. Aerial infrared imagery reveals large nutrient-rich groundwater inputs to the ocean. Geophys. Res. Letters, 35, L15696. doi:10.1029/2008GL034574.

Kelly, J.L., C.R. Glenn, and P.G. Lucey, in prep. Aerial thermal infrared remote sensing of submarine groundwater discharge. Intended for Remote Sensing of the Environment.

Kikuchi, W.K., 1976. Prehistoric Hawaiian Fishponds: indigenous aquaculture influenced the development of social stratifications in Hawaii. Science, New Series, Vol. 193, No. 4250, pp. 295-299.

MacIntyre, S., R. Wanninkhof, and J. P. Chanton. 1995. Trace gas exchange across the air-sea interface in freshwater and coastal marine environments. In: P. A. Matson and R. C. Harris (Ed.), Biogenic Trace Gases: Measuring Emissions from Soil and Water. Blackwell Science Ltd, Boston, 52-97.

Moore, W. S., J. L. Sarmiento, and R. M. Key. 2008. Submarine groundwater discharge revealed by ^{228}Ra distribution in the upper Atlantic Ocean. *Nature Geoscience* 1: 309-311. doi:310.1038/ngeo1183.

Slomp, C.P., and P. Van Cappellen, 2004. Nutrient inputs to the coastal ocean through submarine groundwater discharge: controls and potential impact. Journal of Hydrology. Vol. 295, pp. 64-86.

Stearns, H.T., and K.N. Vaksvik, 1935, Geology and ground-water resources of the Island of O`ahu, Hawai`i. Territory of Hawai`i, Division of Hydrography Bulletin 1 (Prepared in cooperation with the U.S. Geological survey). Maui Publishing Co. Maui.

Williams, W.D., 1986, Conductivity and salinity of Australian salt lakes. Australian Journal of Marine and Freshwater Research 37 (2) 177-182.

Wyban, J.A., and C.A.Wyban, 1989. Aquaculture in Hawai`i: past, present and future. Advances in Tropical Aquaculture, Tahiti (French Polynesia), 20 Feb – 4 Mar 1989.