DEPARTMENT OF PLANNING AND PERMITTING
CITY AND COUNTY OF HONOLULU
650 SOUTH KING STREET, 7TH FLOOR • HONOLULU, HAWAII 96813
PHONE: (808) 768-8000 • FAX: (808) 768-6041
DEPT. WEB SITE: www.honoluludpp.org • CITY WEB SITE: www.honolulu.gov

FILE COPY
JUL 23 2015

KIRK CALDWELL
MAYOR

GEORGE I. ATTA, FAICP
DIRECTOR

ARTHUR D. CHALLACOMBE
DEPUTY DIRECTOR

2015/ED-5 (EK)

July 13, 2015

RECEIVED
'15 JUL 13 A11:36
OFC. OF ENVIRONMENTAL QUALITY CONTROL

Ms. Jessica Wooley, Director
Office of Environmental Quality Control
Department of Health, State of Hawaii
235 South Beretania Street, Room 702
Honolulu, Hawaii 96813

Dear Ms. Wooley:

SUBJECT:	Chapter 25, Revised Ordinances of Honolulu Draft Environmental Assessment
Project:	Punaluu Stream Restoration Project
Applicant:	Kamehameha Schools
Agent:	ICF International
Location:	Punaluu Watershed – Koolauloa
Tax Map Keys:	5-3-1: 41 and 52, and 5-3-3: 1

With this letter, the Department of Planning and Permitting hereby transmits the draft environmental assessment and anticipated finding of no significant impact (DEA-AFONSI) for the Punaluu Stream Restoration Project situated at TMKs 5-3-1: 41 and 52, and 5-3-3: 1, in the Punaluu District on the island of Oahu, for publication in the July 23, 2015, edition of "*The Environmental Notice.*"

Enclosed, please find a completed OEQC Publication Form and a disk with a copy of the DEA-AFONSI. We have also emailed an electronic copy of the publication form in MS Word.

If there are any questions, please contact Elizabeth Krueger at 768-8017.

Very truly yours,

for George I. Atta, FAICP
Director

NEPA Action EA/EIS
Publication Form

Project Name: Punalu‘u Stream Restoration Project, EA

Island: O‘ahu

District: Ko‘olauloa District

TMK: 5-3-003:001, 5-3-001:052, 5-3-001:041

Permits: Special Management Area Permit Major, Grading/Grubbing/ Stock Piling Permit, Flood Hazard District Variance, National Pollution Discharge Elimination System Permit, Noise Permit, Stream Channel Alteration Permit, Safe Harbor Agreement, Water Quality Certification, Nationwide Permit 27 Aquatic Habitat Restoration, Section 10 permit

Applicant or Proposing Agency:

Kamehameha Schools, 567 South King Street Suite 200, Honolulu, Hawaii 96813. Contact: Joey Char, jochar@ksbe.edu, 808-534-8189

Approving Agency:

Department of Planning and Permitting, City and County of Honolulu, 650 South King Street, 7th Floor, Honolulu, Hawaii 96813. Contact: Elizabeth Krueger, 808-768-8017

Consultant:

ICF International, 630 K Street Suite 400, Sacramento, CA 95814. Contact: Brendan Belby, PH, Brendan.belby@icfi.com, 916-231-7611

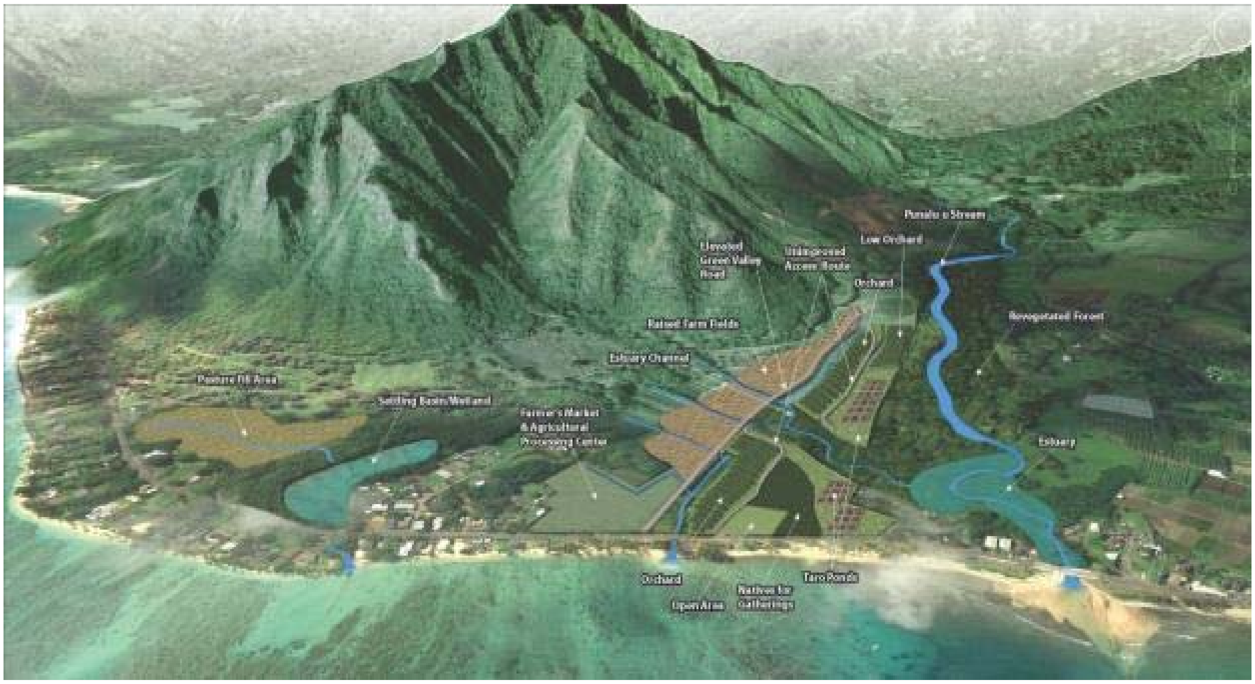
Status:

30 day comment period. Please send comments to the applicant, approving agencying and consultant.

Summary: Kamehameha Schools proposes to restore the Punalu‘u Stream and its immediate surroundings by restoring the ecosystem health, developing sustainable flood protection, improving agricultural sustainability, and creating new environmental educational opportunities. All work will occur on land owned by Kamehameha Schools. Punalu‘u Stream is constrained by a very un-natural straight and narrow channel requiring constant maintenance when annual flood events break through portions of the artificial berms that generally confine the flow of water within the channelized stream. Flood water spills out onto the floodplain at unpredictable locations and causes damage to farmers and residents occupying the floodplain that is otherwise hydrologically disconnected from the channel. The proposed design will 1) restore a natural valley floodplain and terraced landscape, 2) re-designate land uses so that farmers on chronically flooded agricultural lands are relocated to elevated terraces, and 3) create a new stream corridor that restores a floodplain connection with Punalu‘u Stream. Restoration work will include cutting, grading and fill operations to lower elevations on the floodplain and create new setback berms that will allow the stream to naturally meander, while high flows to spill out of the stream channel and spread out in a designated floodway.

Draft Environmental Assessment

Punaluʻu Stream Restoration Project



PREPARED FOR:

Kamehameha Schools
567 South King Street, Suite 200
Honolulu, HI 96813

PREPARED BY:

ICF International
630 K Street, Suite 400
Sacramento, CA 95814

July 2015

ICF International. 2015. Draft Environmental Assessment, Punalu‘u Stream Restoration Project. July (ICF 00640.12.) [Fairfax, VA]. Prepared for
Kamehameha Schools, 567 South King Street, Suite 200, Honolulu, HI.

Contents

Exhibits

Appendices

Acronyms and Abbreviations

BMPs	Best Management Practices
BWS	Board of Water Supply
CFR	Code of Federal Regulations
cfs	cubic feet per second
CWA	Clean Water Act
CZM	Coastal Zone Management
dB	decibel
dBA	A-weighted
DPP	Department of Planning and Permitting
EA	Environmental Assessment
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
HAR	Hawaiʻi Administrative Rule
HDOH	Hawaiʻi Department of Health
HRS	Hawaiʻi Revised Statutes
km	kilometers
KS	Kamehameha Schools
LAD	Land Assets Division
LUC	Land Use Commission
mgd	million gallons per day
MLRA	Major Land Resource Area
NAAQS	National Ambient Air Quality Standards
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NRCS	Natural Resources Conservation Service
NWI	National Wetlands Inventory
ROH	Revised Ordinances of Honolulu
SHPD	State Historic Preservation Division
SMA	Special Management area Use Permit
SMA	Special Management Area
U.S.C.	United States Code
USACE	Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
USGS	United States Geological Survey

Chapter 1
Project Overview

1.1 Project Information Summary

Type of Application:	Environmental Assessment, Special Management area Use Permit (SMA)
Project Name:	Kamehameha Schools Punaluʻu Stream Restoration Project
EA Trigger:	Project located in SMA (see Section 1.4)
Applicant/Recorded Fee Owner:	Kamehameha Schools 567 South King Street Suite 200 Honolulu, Hawaii 96813 Contact: Joey Char, Land Asset Manager Endowment Group, Land Assets Division Email: jochar@ksbe.edu Telephone: 808.534.8189
Planning Consultant:	ICF International 630 K Street, Suite 400 Sacramento, CA 95814 Contact: Leo Lentsch Email: Leo.Lentsch@icfi.com Telephone: 843.693.8264
Approving Agency:	Department of Planning and Permitting City and County of Honolulu 650 South King Street, 7th Floor Honolulu, Hawaii 96813
Project Location:	Punaluʻu Watershed, Punaluʻu Ahupuaʻa, Koʻolauloa District, Island of Oʻahu (see Exhibit 1-1)
Tax Map Keys:	5-3-003:001, 5-3-001:052, 5-3-001:041 (see Exhibit 4-10)
Landowner:	Kamehameha Schools
Project Area:	140 acres
Existing Zoning (LUO):	Within Project Area: Ag-2 General Agriculture District; Country District (see Exhibit 4-10) Within Tax Map Keys: Ag-2 General Agriculture District; Country District; P-1 Restricted Preservation District (see Exhibit 4-10)
Existing Use:	Property is currently used for agricultural and education activities.
Proposed Use:	The Punaluʻu Stream Restoration Project will develop sustainable flood protection and restore hydrologic processes in the Punaluʻu watershed. Stream restoration work will enable traditional agricultural activities in the area to continue with a reduced risk of chronic flooding.
State Land Use District:	Within Project Area: Agricultural; Urban (see Exhibit 4-10) Within Tax Map Keys: Agricultural; Urban; Conservation (see

	Exhibit 4-10)
Sustainable Communities Plan (SCP):	Koʻolau Loa
SCP Land Use Designation:	Rural Residential, Agricultural, and Preservation
SCP Public Facilities Map Designation:	Rural Community, Agricultural, and Preservation
Special Management Area:	Yes
Flood Zone Designation:	FEMA Zone AEF, AE, VE, XS, and X
Historic Register:	No
Required Applications/Approvals:	See Exhibit 7-2

1.2 Introduction

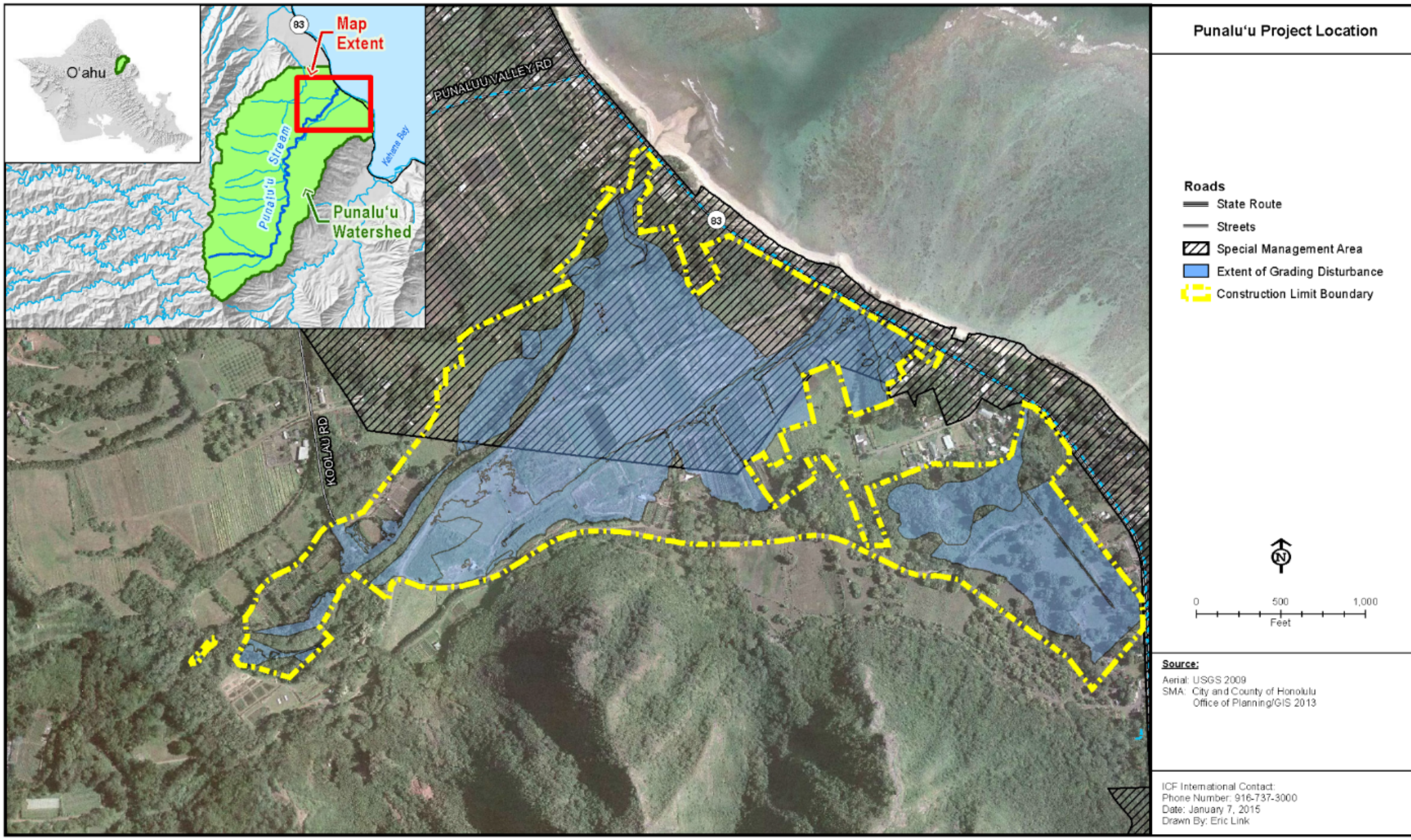
Kamehameha Schools (KS) is a private landholder in Hawai‘i, with approximately 365,000 acres of land statewide. Of this land, 98 percent is used for agriculture and conservation. KS’ recent strategic plan for 181,373 acres of agricultural land on 5 islands focuses on establishing KS as an agricultural leader in active management and stewardship in Hawai‘i (Kamehameha Schools 2010).

The Punalu‘u Valley is on the windward coast of O‘ahu in the Ko‘olauloa District. The Punalu‘u watershed drains 6.7 square miles of largely forested terrain extending from sea level to the crest of the Ko‘olau Range at 2,600 feet. KS currently owns approximately 150 acres of the valley bottom (see Exhibit 1-1 for project location map).

A principal objective of KS is the appropriate stewardship of its lands and water resources (mālama ‘āina and mālama wai) through an ahupua‘a management strategy that takes a holistic approach to watershed resources to ensure that these natural resources are sustained in perpetuity (Kamehameha Schools 2011). The Land Assets Division of the Endowment Group of KS is specifically responsible for stewardship of agricultural and conservation lands and the implementation of eco-cultural programs. KS aims to have a firm understanding of stream and estuarine ecology, balancing agricultural and ecosystem services, applying wise conservation applications and sustainable strategies, and fostering community pride and responsibility over the long-term through eco-cultural opportunities for involvement and shared stewardship.

Under these broad guidelines, KS has proposed a project for the Punalu‘u watershed based on the ahupua‘a management strategy (Kamehameha Schools 2010). The primary objective of the project is to develop sustainable flood protection while restoring hydrologic processes in the watershed with a focus on the lower reach of Punalu‘u Stream, its floodplain, and estuary.

Exhibit 1-1. Punaluʻu Flood Mitigation and Stream Restoration Project Location



1.3 Kamehameha Schools Management Directives

KS was founded in 1887 by Bernice Pauahi Bishop, the great-granddaughter and last royal descent of Kamehameha the Great. Since its founding, KS has grown to be the largest independent school system in the U.S. and a symbol of educational excellence for Hawaiians. In addition to its campus-based educational programs, KS administers several outreach efforts, including ʻĀina based educational programs for eco-cultural and stewardship initiatives (Kamehameha Schools 2010).

Income from KS' real estate assets and financial investments fund KS' education services and operations. Management of KS' conservation and agricultural lands, including the lands at Punaluʻu, is conducted by the Land Assets Division (LAD). LAD's management strategy for these lands incorporates five components: environment, economic, education, culture, and Hawaiian community. In particular, the "environment" component of this strategy aims to "protect and restore native ecosystems and the services they provide including a resource base for traditional practices, and to function as a place to be well and be Hawaiian" (Kamehameha Schools 2010). Initiatives outlined in the May 2010 *Punaluʻu Ahupuaʻa Plan* for implementing this component include:

Mitigate flooding and storm water runoff and facilitate stream stewardship opportunities;

- Steward native ecosystems; and
- Control invasive plant species and feral animals.

In particular, the stream restoration work described in this EA was identified in KS' *Punaluʻu Ahupua'a Plan* as a priority project. As a result, completion of the restoration work would align closely with the strategic goals of KS' LAD as outlined in the *Punaluʻu Ahupua'a Plan* (Kamehameha Schools 2010).

1.4 Regulatory Provisions Governing this Environmental Assessment

Activities conducted in Hawaiian shorelines areas that have been designated as being within the "Special Management Area" are regulated through issuance of Special Management Area (SMA) permits under Chapter 205A of the Hawaiʻi Revised Statutes (HRS). SMA permits are issued at the county level; county authorities establish shoreline setback provisions and requirements for permit compliance.

In Oʻahu, the City and County of Honolulu has established environmental assessment requirements for issuance of SMA use permits in Chapter 25 of the Revised Ordinances of Honolulu (ROH). These requirements state that any proposed development within an SMA and requiring an SMA use permit shall be subject to an assessment by the agency in accordance with the procedural steps set forth in the State of Hawaiʻi's environmental review requirements in Chapter 343 of the HRS. A major SMA permit is required if a construction value of more than $500,000 will occur within the SMA. As the proposed stream restoration project would take place almost entirely within the SMA and the construction value would exceed this value, completion of the proposed project would require issuance of a major SMA permit by the City and County of Honolulu. Such approvals are in the form of a formal resolution adopted by the City and County of Honolulu County Council. Processing of the

SMA application and preparation of the draft resolution that is forwarded to the County Council for consideration is handled by the City and County's Department of Planning and Permitting (DPP). Because the request for approval stems from a request by the landowner (KS), the Chapter 343 document is treated as an "applicant action".

Chapter 2
Project Purpose and Need

The Punaluʻu ahupuaʻa has been subjected to a range of historic impacts that include water diversions; invasion by non-native stream, plant, and animal life; stream channelization; unprotected stream crossings; land grading and alteration of natural drainage patterns; tillage; livestock grazing; aquaculture; and residential development. Currently, over 50 acres of the lower Punaluʻu Valley are flooded annually. Flooding causes economic hardship and appears to be getting worse, possibly as a result of sedimentation within the stream. The most recent episode of flooding occurred on July 19, 2014, and damaged roads, properties, fields, and crops.

KS identified the lower Punaluʻu Stream Valley as an opportunity to implement a project that incorporates its ahupuaʻa management strategy to provide flood mitigation and restore natural ecological form and process. Specific objectives of the project include, but are not limited to the:

1. Ecological restoration of native flora and fauna to a Hawaiian lowland stream;
2. Continuation of traditional Hawaiian land use compatible with periodic flood inundation;
3. Provision of improved flood protection and drainage for agricultural tenants and KS facilities;
4. Stabilization of eroding stream banks and a reduction in sediment discharge to the marine shoreline; and
5. Creation of eco-cultural educational opportunities to learn about sustainable agriculture and ecosystem function.

The primary restoration objective of this project is to develop sustainable flood protection and restore hydrologic processes in the Punaluʻu watershed altered by a previous lessees, with a focus on the lower reach of Punaluʻu Stream and its floodway. The comprehensive restoration design would reduce flooding along Punaluʻu Stream using natural materials and methods that augment natural physical processes, are aesthetically pleasing, are sustainable with little to no maintenance, are acceptable to the Punaluʻu community, all while enhancing aquatic and wetland habitats. Key components of the restoration design are to restore a natural valley floodplain and terrace landscape; re-designate land uses so that farmers on chronically flooded agricultural lands are relocated to the floodplain margins on elevated terraces; and create a new stream corridor with a new riparian forest that restores a floodplain connection with Punaluʻu Stream.

Chapter 3
Proposed Action and Alternatives

Proposed restoration work includes restoring the channel, estuary, and floodplain of the lower Punaluʻu Stream to alleviate chronic flooding and restore natural ecosystem processes. These actions have specific Federal, State and local permitting requirements, and are described in more detail below. Agricultural and educational uses will continue on the site after the project.

3.1 Proposed Action - Stream Restoration

The **project area** for the proposed action is defined as the approximately 140 acres of land along the lower reaches of the Punalu'u stream and its floodplain within the construction limit of the proposed restoration work (see Exhibit 3-1). The 140 acres includes approximately 90 acres where earthwork would occur to re-contour the topography, as well as acreage on the site designated for construction access, equipment staging, and land that would be revegetated without cutting or filling the ground surface. Restoration work includes cutting, grading and fill operations to lower elevations on the floodplain and create new setback berms that would allow the Punaluʻu stream to naturally re-meander, allow high flows to spill out of the Punaluʻu stream channel, and to spread out in a designated floodway. All work would contribute to a larger floodplain and stream corridor than currently exists to temporarily store floodwaters, trap sediment on the floodplain and estuary before it reaches Kamehameha Highway and nearshore environments, improve flood conveyance, and restore geomorphic and ecologic processes. Restoration work would occur within three sections of the Punaluʻu valley: the Upper Valley, the Lower Valley, and the Kahana (southern) side of the Valley (see Exhibit 3-1).

The 90% design level engineering drawings prepared for the project are presented in Appendix A.

3.1.1 General

Earthwork in the project area would involve clearing, grubbing, grading, excavation, dredging, and fill operations. All earthwork would occur in and along previously altered areas of the Punaluʻu stream channel on lands owned by KS. All earthwork would occur upstream of the Kamehameha Highway which is outside of the shoreline setback area established in Section 23-1.4 of the ROH.

Construction activities using heavy earthmoving equipment are expected to last six months; work hours will be restricted to weekdays between 7:00 AM and 6:30 PM. Staging areas for construction will be located on KS property. All materials and equipment will be stored in designated staging areas when not in use. As active farming will be occurring mauka of the project site, construction areas will be designed to provide continual access for farmers to access active farmlands.

Clearing and Grubbing

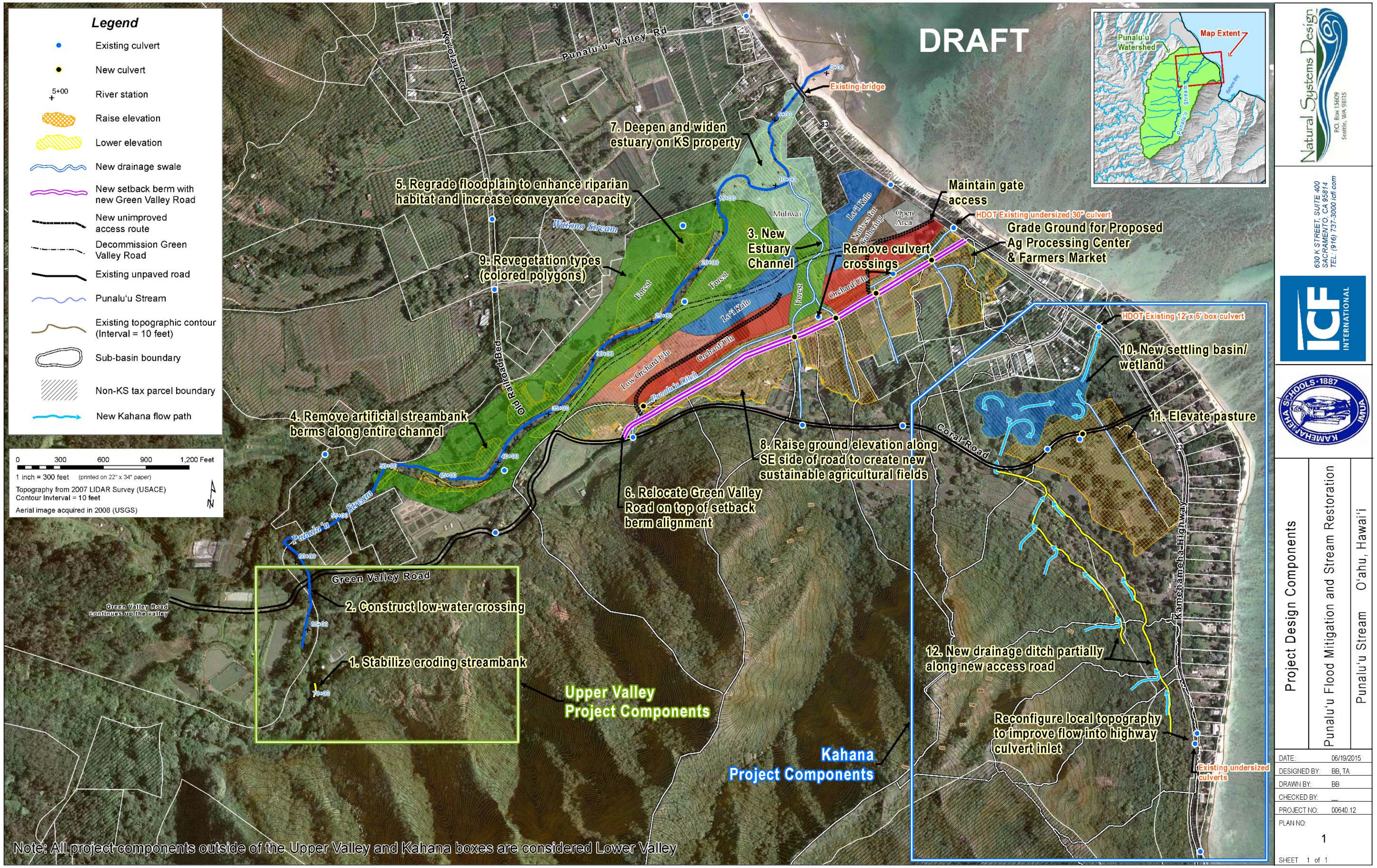
Prior to conducting any grading operations, land will be cleared and grubbed. Clearing will include removal and disposal of all unwanted surface material, such as non-native trees, brush, grass, weeds, downed trees, and other material. Some trees may be retained and protected during construction (e.g., Polynesian-introduced species, large trees important to the structural integrity of the stream bank). Prior to the start of construction, tree protection zones will be established around these trees so that they are retained and protected from injury or damage. Grubbing activities will include removal and disposal of all unwanted vegetative matter from underground, such as stumps, roots, buried logs, and other debris. Cleared debris, as well as non-native and invasive vegetation, will be disposed of at an authorized disposal site. Cleared native vegetation will be chipped into slash (6" maximum diameter and 12" maximum length) and stockpiled as mulch on cleared land.

Construction Best Management Practices

All construction activities will follow Best Management Practices (including all guidelines set forth in the "Best Management Practices Manual for Construction Sites in Honolulu" and the City and County of Honolulu's "Rules for Soil Erosion Standards and Guidelines") to minimize water pollution and soil erosion into State waters, drainage, and local sewer systems. Exposed or disturbed soil surfaces will be protected with mulches, grass seeds or hydromulch (a combination of wood fibers, paper, and an organic tackifier mixed with water). Mulches will be clean and free of noxious weeds and deleterious materials. Quick growing grass species (e.g., rye grass, Italian rye grass, or cereal grasses) will be used that will not compete with permanent cover. The total area of bare soils will be limited to five acres in dry months (April–October) and two acres in wet months (November–March). Chemicals may also be used as soil stabilizers for erosion and dust control.

To limit soil erosion, during the initial construction phase of the project, a 50-foot long vegetation buffer will be cordoned off on both sides of Punaluʻu stream where no clearing and grubbing will take place. After floodplain grading is complete, this buffer area will be cleared and grubbed, one acre at a time, leaving exposed soils bare for no more than seven days in dry months and two days in wet months before applying slash or mulch to bare soils.

Exhibit 3-1. Punalu'u Flood Mitigation and Stream Restoration Project Elements



Cut and Fill Areas

Cut and fill areas are depicted on Exhibit 3-2 below. Note the footprint of the proposed New Settling Basin/Wetland feature has been updated since the 90% grading plan and Exhibit 3-2 was developed (see Exhibit 3-1 for updated boundary). Cut and fill calculations for the revised boundary will be determined in the final design but are expected to be similar to the 90% design values since the areas of both footprints are the same. Cut areas are shown as warm colors (green, yellow, orange, and red); fill areas are shown as cool colors (blue and purple). In total, excavation as part of the proposed project will occur on approximately 46 acres of the project area. Fill areas will comprise approximately 41 acres. Fill will be composed of on-site native floodplain material, including granular fine-grained sand silt mix with periodic cobbles and boulders. Fill work would only occur in areas beyond the riparian zone. All floodplain cut and fill areas will be covered with mulch or slash as final grade is achieved to prevent erosion of exposed soil. Cut areas may need to be dewatered, as needed, to install culverts in dry conditions. Any needed dewatering operations will be conducted in accordance with applicable permit requirements to prevent discharge into State waters.

There will be no long-term stockpile areas; as areas are cut and excavated, temporary stockpiles may be created in the immediate vicinity of the excavation, but will be immediately hauled to permanent fill placement areas. When transporting excavated fill material, the exposed surface will be covered completely with a tarpaulin or similar device to prevent the fill from becoming a source of fugitive dust. Exposed soil in the project area will also be covered to prevent soil erosion during rain and flooding events.

3.1.2 Upper Valley Project Components

The major project components described below are mapped in Exhibit 3-1. The numbers assigned to the components in the text correlate with the numbers labeled on the map to aid in identifying their location.

1. Stabilize Section of Eroding Streambank

Approximately 160 feet of Punaluʻu Stream's south bank is eroding at river station[1] 70+00, threatening to undercut a resident's property and structure. The project would use a combination of natural materials, including large woody debris with attached rootwads, native alluvium, and large boulders to construct an immobile 160 foot long bench along the lower bank. The bench would provide bank stabilization by directing the erosive energy of flood events away from the eroding bank.

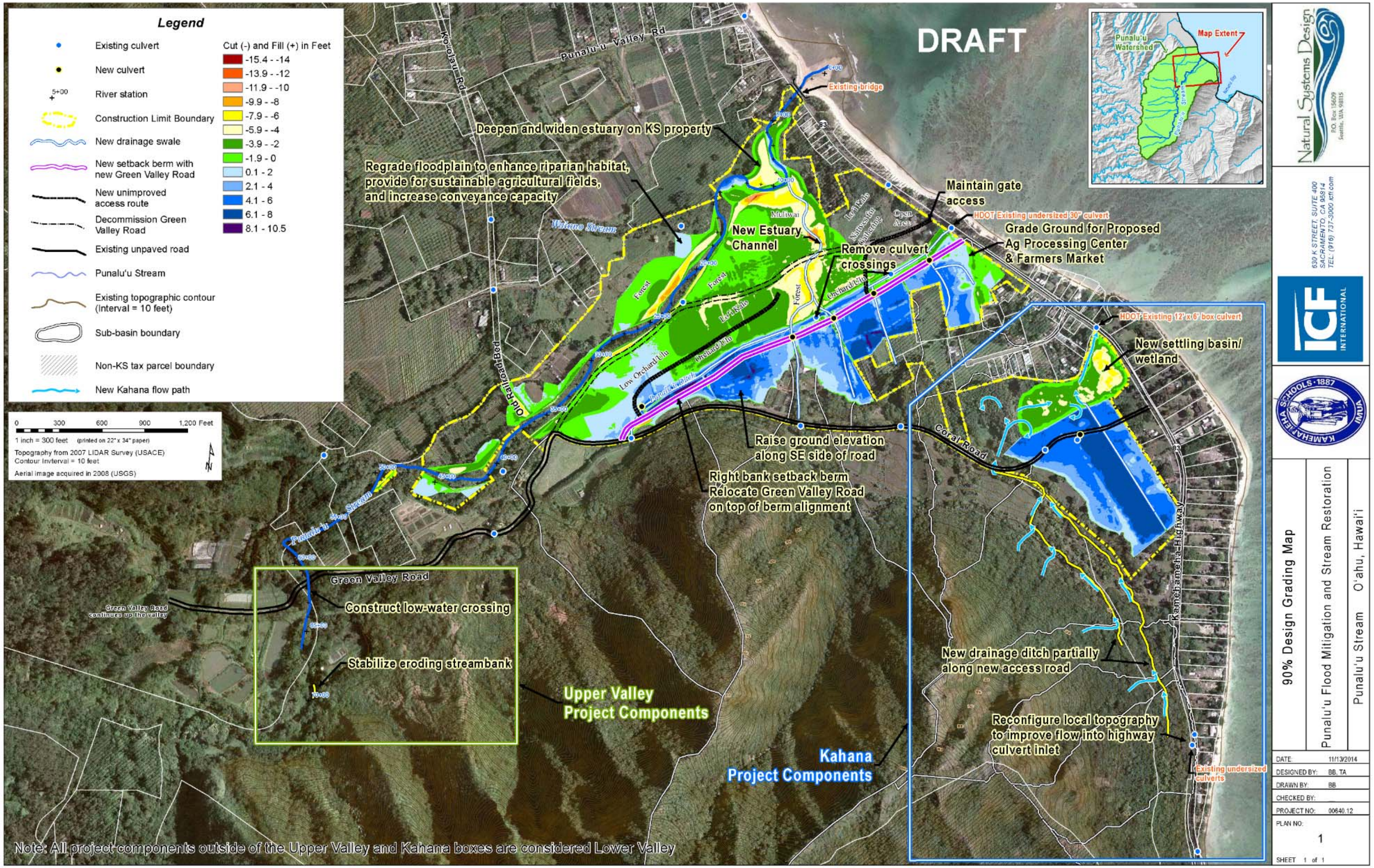
2. Construct Low-Water Crossing

Green Valley Road currently crosses Punaluʻu Stream at a low water crossing at river station 62+00. The crossing is made of local gravel and cobble bed sediment graded flat across the low flow channel. The crossing is typically washed out at least once a year, thus requiring heavy equipment to work in the channel to rebuild the crossing. The project would construct a rock grade control

[1] The river stations shown on the planview maps follow the centerline of the Punaluʻu Stream channel and mark the distance in feet along the channel upstream from its mouth in the ocean. Following standard practice, a + sign is used between the hundreds and tens digits (e.g., a river station of 5+00 indicates that location on the channel is 500 feet upstream from the ocean).

structure made of large boulders organized in the stream channel to prevent scouring at that location. The crossing would be capable of withstanding transport during large flood events, thereby holding grade at the low water crossing and preventing it from washing out and requiring repair. The constructed grade control would resemble a high-gradient riffle morphology with cobble and gravel material placed in the voids of the larger boulders. During construction, a temporary barrier will be constructed to divert stream flow around one side of the channel; an excavator will then be used to dig out the portion of existing channel on the other side of the barrier. Excavated materials will temporarily be stockpiled on the stream bank. Large boulders will be placed in the excavated area. Some of the excavated material will be used to fill in the void spaces between boulders; the rest will be distributed in the local channel and not permanently stockpiled. Once work is complete on one side of the stream channel, the same process will be used to construct the crossing on the other side of the channel. In total, less than an acre of material (approximately 293 cubic yards) will be excavated to construct this crossing.

Exhibit 3-2. Cut and Fill Areas for Punaluʻu Flood Mitigation and Stream Restoration. Note the Footprint of the Proposed New Settling Basin/Wetland Feature has been updated since the 90% Grading Plan was developed (see Exhibit 3-1 for Update). Cut and Fill Calculations for the Revised Boundary will be Determined in the Final Design.



3.1.3 Lower Valley Project Components

3. Create New Estuary Channel and Improve Kahana Drainage

An existing drainage ditch south of the stream (known as Punaluʻu Ditch) currently drains 194 acres from the sub-basins on the Kahana side of the valley into a HDOT undersized 30-inch culvert at Kamehameha Highway, which contributes to chronic flooding in the lower valley. The project would convert Punaluʻu Ditch into a new sinuous estuary channel with a riparian forest corridor that conveys the vast majority of Kahana runoff into the newly created corridor and estuary on Punaluʻu Stream, thus allowing sediment loads generated from the Kahana sub-basins to deposit in the estuary instead of direct transport into the coral reefs of the nearshore environment and dramatically reducing the amount of flow conveyed to the undersized highway culvert.

The new estuary channel will be created by excavating on approximately 0.5 acre of the floodplain along the Punaluʻu Stream (see Exhibit 3-1). During construction, the existing earthen berm along the Punaluʻu Stream will be retained between river stations 0+00 and 0+50 to isolate the channel excavation from the Punaluʻu Stream. In addition, 2,005 linear feet of turbidity curtains will be installed along the edge of the existing stream channel to further isolate the work area from active stream flow.

Excavation in the lower portion of the site may encounter groundwater; as a result, equipment mats, layers of vegetation, and/or low-ground pressure equipment will be used as needed to prevent equipment from becoming mired in saturated soils.

Once the floodplain excavation is complete, the berm will be removed to complete the channel excavation; the turbidity curtains will be removed when the turbidity has settled and the water has clarified in the estuary channel.

All earthwork in and along the channel would occur within the lower reach that is tidally controlled. No major diversions or discharge of water is proposed as part of the channel excavation.

4. Remove Artificial Streambank Berms

Historically unconsolidated alluvium has been used to form artificial push-up berms several feet high along lower Punaluʻu Stream's north and south banks over the past several decades. The berms channelize the stream and limit the existing stream floodway width to about 100-125 feet on average. The floodway widens near the Punaluʻu Stream's mouth upstream of Kamehameha Highway where tide levels create a backwater zone covered with dense hau bush (*Hibiscus tiliaceus*), an invasive species. The project would remove about 7,000 linear feet of berms along the channelized reach to restore natural channel bank heights. Elimination of the berms would remove an artificial constraint imposed on the stream's ability to naturally meander and would enable the channel to gradually regain a more natural channel sinuosity through natural channel migration into the new floodplain corridor (further discussed below). Sections of the stream banks would be lowered to reconnect the channel to the floodway. A section of fill at river station 36+00 would also be excavated to remove the high ground and improve floodplain connectivity (see Exhibit 3-1).

5. Excavate Historic Floodplain Fill and Create a Floodplain Corridor

Green Valley Road is a private agricultural access road that currently traverses from Kamehameha Highway into the upper watershed, providing access to farmers and other residents in the watershed. The road is elevated on fill, aligned close to Punaluʻu Stream's south bank in many locations, and contributes to the lack of connectivity between the stream and its floodplain by creating a barrier between the two. The loss of floodplain connectivity is exacerbated by several feet of fill that has been placed on the floodplain over the past 100 years or more.

This project element would excavate approximately 29 acres of floodplain fill between the Punaluʻu Stream and the proposed relocated Green Valley Road (see Exhibit 3-1) to restore natural floodplain elevations and contours. Punaluʻu Stream's floodplain corridor would be changed from the existing 100–125 feet width into a new corridor over 700 feet wide, on average.

The new corridor landscape created by the floodplain excavation and elevated road is based on a natural alluvial valley morphology in which the Kahana (southern) hillslope transitions into a terrace elevated above the floodplain that in turn transitions into a lower elevation floodplain and stream channel. The boundary of the corridor is within land owned by KS and is wide enough to encompass the floodplain area occupied at one time or another by historic channels as evidenced by the channel migration analysis dating back to the earliest available photo in 1928 (Exhibit 3-3). The upstream extent of the corridor roughly coincides with the start of historic channelization and the transition into a lower gradient alluvial reach. Areas outside the floodplain corridor where flood risks would be reduced would not be subjected to the chronic damages they have experienced under the site's current conditions.

6. Relocate Green Valley Road

The Green Valley Road currently aligned along the stream's south bank would be relocated away from the channel to the top of a new constructed berm that would elevate the road out of the floodplain. This berm would be approximately 20 feet wide and 2,800 feet long, extending from the Kamehameha Highway to a point just south of river station 30+00. The berm will be constructed of materials excavated from other areas, with the top one foot of material composed of gravel or sand wrapped with geotextile material. The relocated road would form the southern boundary of the new approximately 4,200 feet long, 70 acre floodplain corridor (measured within KS property). The road would be elevated about 3–5 feet, on average, to prevent floodwaters from entering the southern side of the valley where excavated fill would be placed on the upland side of the berm to create new productive agricultural lands. Five culverts would be constructed under the relocated road to route Kahana runoff into the new estuary channel and Punaluʻu Ditch.

7. Create a Punaluʻu Stream Estuary

Historic imagery shows Punaluʻu Stream used to have a larger and more open estuary than currently exists. Much of the estuary today is encroached upon by the invasive hau bush, which has become so prolific that it impedes water flow and prevents the estuary from trapping sediment. The project would excavate approximately 5 acres of land near river station 10+00 to a depth of 4-5 feet to create a new estuary. Existing hau bush would be removed to create an open estuary that would not only improve flood conveyance, but would also trap sediment before it can be delivered to coral reefs in the nearshore environment.

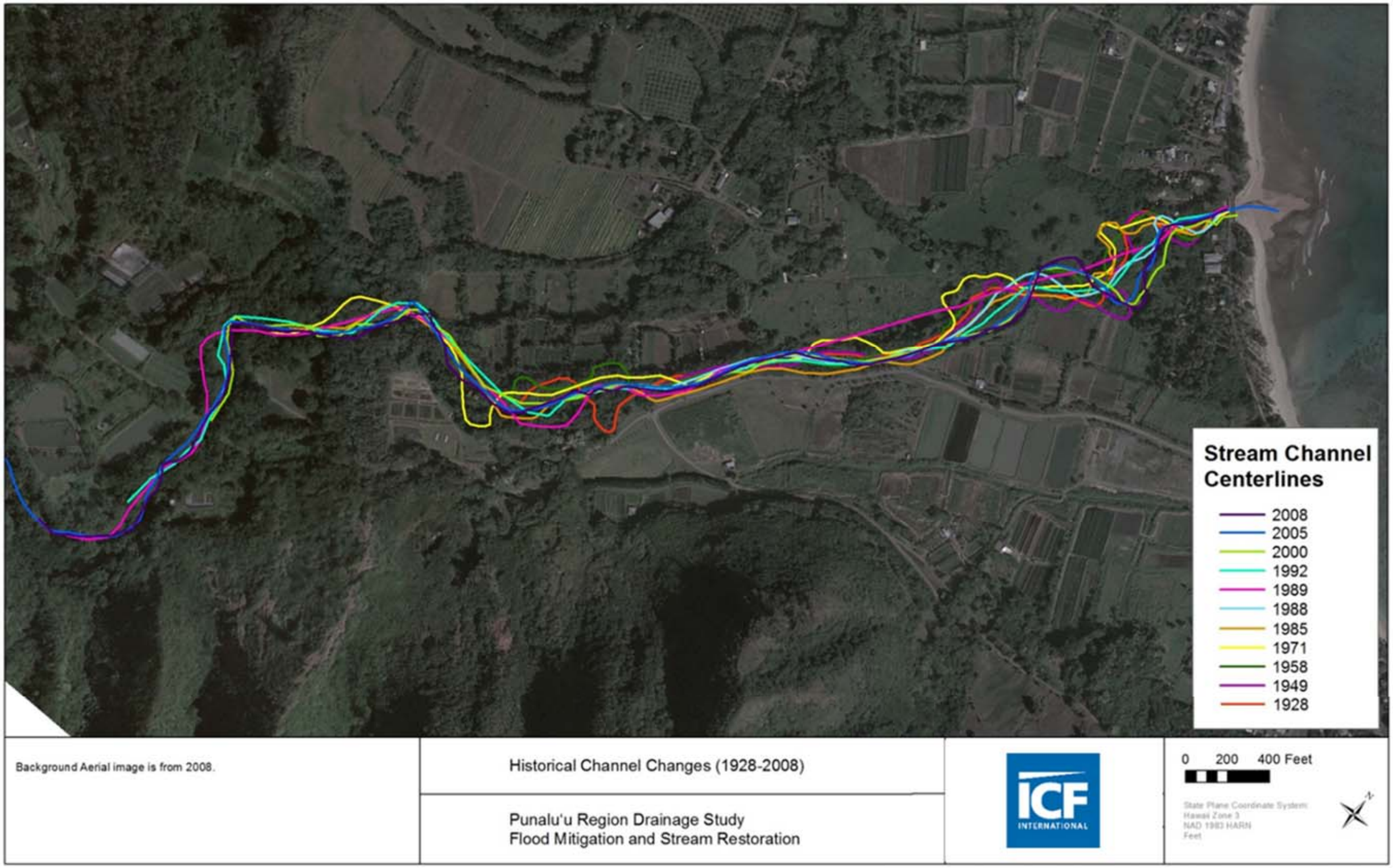
8. Create Ancillary Agricultural Use Area

This element of the proposed project would use excess material excavated from the Punaluʻu floodplain to construct an elevated pad of approximately 5 acres immediately south of where Punaluʻu Ditch intersects Kamehameha Highway. The site would be elevated 3-4 feet above the existing ground to keep it dry during low to moderate flood events and keep all existing soils on site and out of local landfills. Future proposals for this area include a future agriculture processing center and other agricultural ancillary use facilities.

9. Revegetation

The existing riparian corridor surrounding the Punaluʻu Stream is comprised almost entirely of non-native and invasive species such as California grass (*Brachiara mutica*), honohono grass (*Commelina diffusa*), cane grass (*Pennisetum purpureum*), hau (*Hibiscus tiliaceus*), gunpowder tree (*Trema orientalis*), octopus tree (*Schefflera actinophylla*), java plum (*Syzygium cumini*), guava (*Psidium guajava*), christmas-berry (*Schinus terebinthifolius*), koa haole (*Leucaena leucocephal*a), and wild ginger (*Zingiber* spp.) (Kamehameha Schools 2009, Kamehameha Schools 2010). A map of the site's existing vegetation is included in the wetland delineation presented in Appendix B. The non-native vegetation in the project area will be cleared and grubbed as part of the proposed project. After construction work is complete, native vegetation would be planted in a 50 feet wide corridor along both banks of Punaluʻu Stream and the Punaluʻu Estuary Channel. All other areas on the floodplain outside of areas not designated for loʻi kalo or orchards will be hydroseeded with a native grass mixture. More extensive revegetation could occur as part of a potential habitat bank described in Section 3.2 below. The colored polygons depicted on the floodplain in Exhibit 3-1 indicate the proposed land uses after construction.

Exhibit 3-3. Historical Change of Punalu‘u Stream’s Channel Centerline from 1928 to 2008



3.1.4 Kahana (Southern) Side Project Components

Improve Southeast Kahana Drainage

The low-lying area southeast of Punaluʻu Stream and the subdivision south of existing Punaluʻu Ditch historically has been used as a pasture and has very poor drainage. The natural drainage path of the area is north to a HDOT 12 x 6 foot box culvert under Kamehameha Highway just south of the road into the subdivision. Because of the area's low elevations and being separated from the downstream drainage by elevated Coral Road (the private agricultural access road that goes from Kamehameha Highway to the northwest at the base of the Kahana hillslope before joining Green Valley Road), water collecting in the site from Kahana hillslope floods local homes and can take weeks to drain under a small 18" and perched (elevated above the water surface) culvert under Coral Road.

10. Construct Wetland Settling Basin

The proposed project would cut approximately 5 acres (for a total of approximately 28,000 cubic yards of excavated material) to create the Kahana stormwater basin just north of the low-lying pasture area, currently identified in Exhibit 3-1 in the northern portion of the area proposed as the future settling basin/wetland. The cut material will be isolated from the existing Kamehameha Highway culvert by maintaining a plug of soil a minimum of 50 feet wide in the settling basin area until the basin grading is completed. The settling basin would be approximately four feet deep when full, and sized to attenuate the runoff from a 50-year, 1-hour rainfall intensity storm.

11. Elevate Pasture Area

All of the cut material generated from constructing the settling basin will be placed as fill to elevate the depressed pasture area relative to the surrounding land. In total, 103,000 cubic yards of fill will be placed on approximately 14 acres of the low-lying pasture to elevate the ground. The balance of the fill beyond the 28,000 cubic yards generated from the settling basin excavation will come from the Punaluʻu Stream floodplain excavation. Drainage swales and a larger capacity culvert under Coral Road would be constructed in the filled pasture area to route the water to the newly constructed settling basin upstream of the Kamehameha Highway culvert.

12. Construct New Drainage Paths to Reduce Flooding

Approximately 3,100 feet south of the existing HDOT culvert under Kamehameha Highway at the proposed settling basin, flooding is also problematic due to runoff from the Kahana hillslope draining into a pair of highly undersized culverts under Kamehameha Highway. Runoff from the hillslope is funneled into a small culvert through a berm along the west side of the highway. After the flow exits the culvert through the berm it is forced to make a 90 degree turn to the north where it flows along an undersized drainage ditch along the highway before entering another small and undersized culvert that routes the water under the highway and into a drainage ditch that flows between residential properties before entering the ocean. Since the culverts are severely undersized, much of the flood water cuts across the highway road surface and flows uncontrolled into residential properties on the east side of the highway. To improve stormwater drainage in this area, a drainage ditch will be constructed from a point on the hillslope approximately 170 feet west of the existing undersized culverts to divert hillslope runoff into the newly constructed settling basin where flood flows can be attenuated and sediment deposition can occur instead of being discharged directly into the ocean (see the yellow line on Exhibit 3-1). To take advantage of the existing drainage ditch network, roads, and topography, the drainage ditch will consist of upper ditch (2,000 feet in length) and lower ditch (1,800 feet in length) components. Excavation will take place on approximately 0.5 acre of land, creating upper and lower ditches of 5 feet and 4 feet in depth, and 7.5 feet and 6 feet in width, respectively. Cut material will be used to form the downslope side of the ditch.

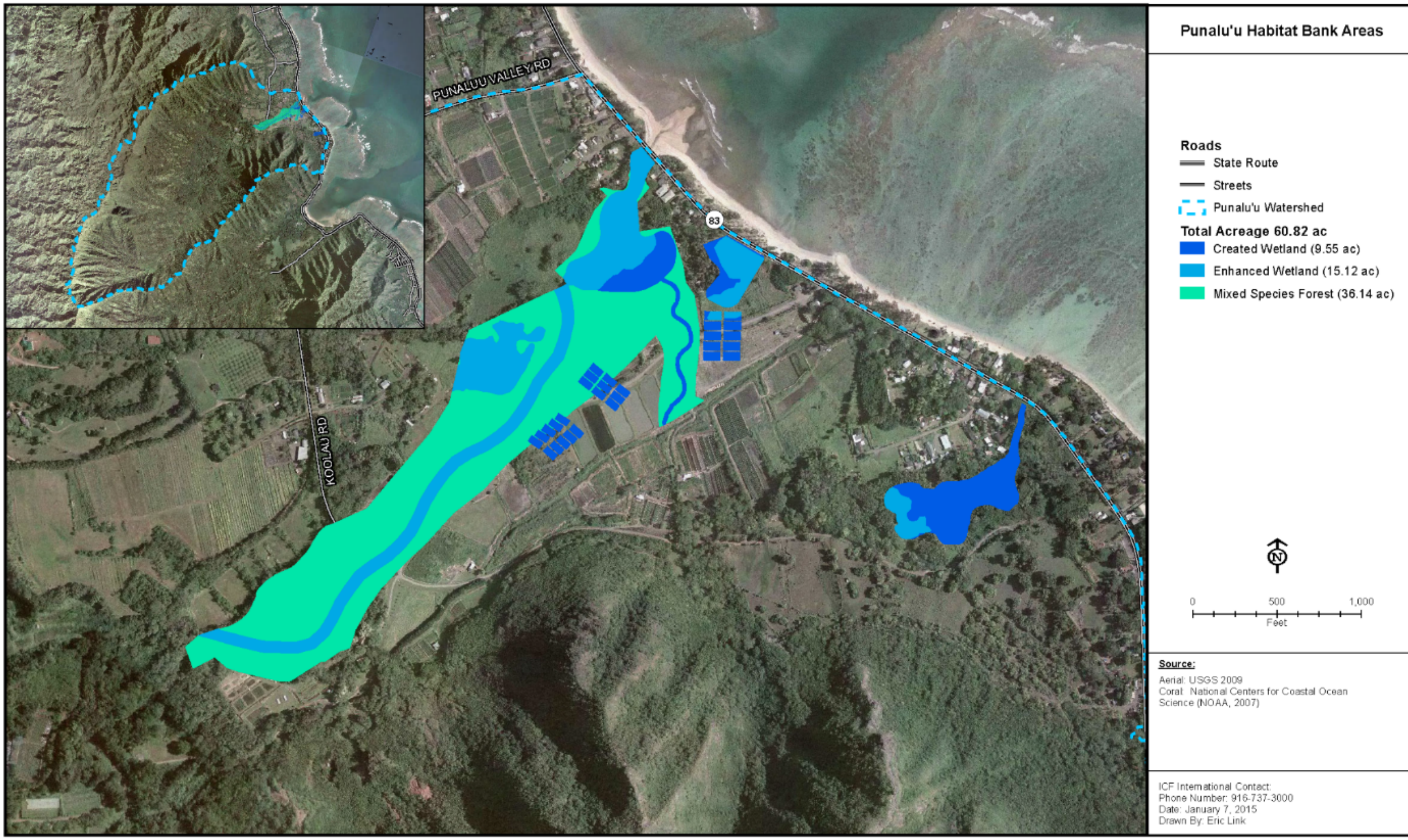
3.2 Restoration with Habitat Bank Option

In addition to the stream restoration work described in Section 3.1, KS is considering creation of a habitat bank to restore, enhance, and preserve wetlands and estuary habitats for the purpose of establishing a compensatory wetland mitigation (Wetland Credits) and species conservation (Conservation Credits) bank in the Punaluʻu Valley. The proposed name of this bank is the “Punaluʻu Habitat Bank”. The purpose of the Punaluʻu Habitat bank would be to develop off-site compensatory mitigation that could be used by individuals or organizations seeking permits that would require the permittee to offset project impacts. The permittee’s mitigation requirements would be satisfied by the bank. A Conservation Bank Agreement for the site would commit KS to recording a conservation easement on up to 60 acres of to protect it from development in perpetuity. The habitat bank would also include a more extensive revegetation plan than the Proposed Action. A riparian forest would be re-planted with native Hawaiian trees throughout the new floodplain rather than just a 50 foot wide buffer along the channels. These trees would provide the shading necessary to eliminate the invasive grasses that have severely encroached upon the channel in several reaches with full sun exposure. Additional planting of freshwater and estuarine wetland species would occur to create new wetland and enhance existing wetland. Outside of areas not designated for riparian forest, wetland, loʻi kalo, or orchards, cleared areas would be hydroseeded with a native grass mixture.

The potential Punaluʻu Habitat Bank would be located in the Punaluʻu Valley in the same area proposed for the restoration work described in Section 3.1 (Exhibit 3-4). Ecological components of the bank would include enhancement and creation of approximately 24.67 acres of freshwater wetland habitat and 36.14 acres of mixed species riparian forest. KS currently owns approximately 150 acres of the Punaluʻu valley bottom. Existing activities, including agricultural uses, would continue within KS lands outside of the Punaluʻu Habitat Bank.

In determining whether or not to pursue the Punaluʻu Habitat Bank, KS prepared a bank prospectus, with technical guidance and assistance from ICF Jones and Stokes Inc. (ICF), to comply with the informational requirements of a prospectus associated with establishing mitigation/conservation banks outlined by the Army Corps of Engineers (USACE) and

Exhibit 3-4. Optional Punalu'u Habitat Bank Areas



US Fish and Wildlife Service (USFWS). The bank was submitted to the USACE and USFWS in August 2014 and discussions continue between KS and the agencies. After further coordination with USACE and USFWS, if KS continues to pursue the Habitat Bank, the next steps in the process would be:

1. **Finalize the Bank Prospectus**
    - USACE and USFWS would determine if the Bank Prospectus is complete and communicate this to KS.
2. **Assembling the Interagency Review Team (IRT) and Bank Prospectus Review.**
    - An IRT would be invited to participate in review of the proposal. Members are invited from the state and federal natural resource agencies, as well as other appropriate state and local regulatory agencies and others with specific expertise as may be needed.
3. **Preparation of the Draft Bank Instrument (Future KS Decision Point)**
    - If KS decides to move forward, ICF would prepare the draft Bank Instrument addressing all items required in state and federal rule and issues brought up during the Bank Prospectus review and submits a draft Bank Instrument to the COE, USFWS and DFW for completeness check.
    - COE, USFWS and DFW determine whether the draft Bank Instrument is complete and communicate this to the KS.
4. **Final Bank Instrument (Future KS Decision Point)**
    - If KS decides to move forward with the Bank, ICF submits the final Bank Instrument to the agencies
    - The COE, USFWS and DFW notify the Sponsor and IRT whether each agency would approve the Bank Instrument.
    - The Bank Instrument is Approved, Not Approved, or the federal dispute resolution process is started.
5. **Public Notice of Approved Bank**
    - Upon approval of the Bank Instrument, Public Notice of Mitigation Bank Approval is issued by the COE and/or USFWS.
6. **Release of credits**
    - All legal documents such as recorded deed restrictions and financial sureties are completed and submitted to the COE, USFWS and DFW before the initial credit release.
    - As-built drawings or other documentation of the Bank establishment as provided in the Bank Instrument are submitted to the COE, USFWS and DFW.
    - KS may sell credits as soon as they have been formally released by the COE, USFWS and DFW.
    - Each sale must be documented with a receipt including the permit numbers, amount of credit, and a statement that KS is thereby assuming responsibility for completion of the mitigation obligation.
    - COE, USFWS and DFW will subtract these credit sales from their respective ledgers when the subject permit is issued.

7. **Monitoring**
    - KS submits **Annual monitoring reports**, due by date specified in the instrument, to the IRT. These reports include data to document whether the Bank performance standards have been met, a complete and cumulative credit ledger, and recommendations for any remedial actions as may be needed.

8. **Adaptive Management**
    - It's expected that site visits or monitoring reports may trigger review and amendment of the Bank Instrument to accommodate changes in expectations and results. Any amendments to the Instrument will be at the mutual agreement of the COE, USFWS, DFW, and KS.

9. **Transition to Long-Term Steward**
    - A portion of the expected credits are withheld until the KS submits, and the COE, USFWS, and DFW approve a long term plan, stewardship agreement, and ongoing funding mechanism to ensure the wetland functions are sustained in perpetuity.

3.2.1 Wetland Mitigation Component

The wetland mitigation bank component would include all wetland areas to be enhanced or created through the habitat restoration work and is depicted in blue in Exhibit 3-4. This includes approximately 24.67 acres of enhanced or created estuarine, riverine, and freshwater emergent wetlands (see Exhibit 3-5). Existing riverine and estuarine wetlands within the Punaluʻu stream and estuary channel would be enhanced by restoring natural flood flows, removing invasive species, and reducing sedimentation. Approximately 0.5 acres of new riverine wetland would be created by constructing a new estuary channel to deliver Kahana runoff to the estuary instead of diverting it through Punaluʻu Ditch and directly into the ocean, as is currently done. Enlarging the existing estuary that has nearly filled with sediment and diverting flows from the former Punaluʻu Ditch to the estuary channel would create 1.6 acres of estuarine wetland and enhance 4.2 acres. Approximately 7.5 acres of freshwater emergent wetland would be created, and 2.5 acres enhanced, through construction of a settling basin for runoff from the Kahana hillslope runoff and taro pond construction. Furthermore, 5.2 acres of riverine wetland within Punaluʻu Stream, and 3.2 acres of wetland at the confluence of Waiono Stream and Punaluʻu Stream, would be enhanced.

3.2.2 Mixed Species Riparian Forest Component

The mixed species riparian forest component is depicted in green in Exhibit 3-4 and would include approximately 36.1 acres of mixed species riparian forest (see Exhibit 3-5). Existing habitat within this area would be enhanced by restoring natural flood flows, removing invasive species, and reducing sedimentation. See Exhibit 3-6 for the full list of species that would be targeted by this component of the habitat bank.

Exhibit 3-5. Wetland & Riparian Habitat in the Punaluʻu Habitat Bank

Habitat Type	Enhanced (acres)	Created (acres)	Lost (acres)	Net Change in Habitat Area (acres)
Estuarine Wetland	4.2	1.6	0.0	+1.6
Riverine Wetland	5.2	0.5	0.0	+0.5
Freshwater Emergent Wetlands	5.8	7.5	-1.4	+6.1
Wetland Total	15.2	9.6	-1.4	+8.2
Mixed Species Riparian Forest	0.0	36.1	0.0	+36.1
Habitat Total	15.2	45.7	-1.4	+44.3

Exhibit 3-6. Federally Listed Species with Potential Habitat in the Stream and Riparian Corridor Component of the Punaluʻu Habitat Bank

Common Name	Scientific Name
Animals	
Hawaiian duck or Koloa maoli	*Anas wyvilliana*
Hawaiian coot, ʻalae keʻokeʻo	*Fulica alai*
Hawaiian moorhen or ʻalae ʻula	*Gallinula chloropus sandvicensis*
Hawaiian Stilt or Aeʻo	*Himantopus mexicanus knudseni*
Hawaiian Hoary Bat or ʻopeʻapeʻaa	*Lasirus cinereus semotus*
n/a (damselfly)	*Megalagrion leptodemas*
Flying earwig Hawaiian damselfly, pinapinao	*Megalagrion nesiotes*
Black line Hawaiian damselfly, pinapinao	*M. nigrohamatum nigrolineatum*
Oceanic Hawaiian damselfly, pinapinao	*M. oceanicum*
Pacific Hawaiian damselfly, pinapinao	*M. pacificum*
Plants	
n/a	*Achyranthes splendens*
Kāmanomano	*Cenchrus agrimonioides*
ʻAkoko	*Chamaesyce celastroides*
n/a	*Cyperus pennatiformis*
Hilo ischaemum	*Ischaemum byrone*
Nehe	*Lipochaeta lobata*
Palapalai	*Microlepia strigosa*

Source: U.S, Geological Survey 2011a.

[a] While the National Gap Analysis Program Land Cover Data (U.S. Geological Survey 2011a) did not indicate habitat for this species, the presence of this species has been reported in the project area (see Kamehameha Schools 2011). Additional survey work may be required to confirm habitat potential for this species.

3.3 Alternatives Considered and Eliminated

3.3.1 Development of Alternatives

An alternatives development and evaluation process was undertaken for the Punaluʻu restoration project in which different methods and components were developed to meet project goals. Through a qualitative and quantitative evaluation process, a preferred alternative was selected that best met project goals. The following summarizes the alternative selection process.

Scientific studies were conducted from 2010–2011 that characterized potential flooding problems and historic alterations, as well as site geomorphology, hydrology, and hydraulics. For much of the twentieth century, Punaluʻu Stream was constrained to a very un-natural straight and narrow channel requiring constant maintenance when near annual flood events would break through portions of the artificial berms constructed in an attempt to confine all flow within the channelized stream. Flood water would spill out onto the floodplain at unpredictable locations and cause damage to farmers and residents occupying the floodplain that was otherwise hydrologically disconnected from the channel. A fundamental element of this project's stream restoration and flood protection goals is recognition and delineation of an adequate corridor for accommodating natural processes of channel migration and flooding; thus, any realistic alternative needed to incorporate some sort of floodplain corridor rather than continue to attempt to unnaturally confine the channel.

Prior to developing the alternatives, the project team met with many of the local community members to identify the source of flooding problems, delineate areas typically flooded, and discuss possible mitigation efforts. Opportunities and constraints for restorative flood protection were described that would be consistent with KS' mission and specific goals for the lower Punaluʻu Stream Valley. The project team then developed five flood concept alternatives that were evaluated for their ability to restore and accommodate natural processes, refine flood risk certainty for land use planning, improve flood protection, and achieve other KS site goals, including educational opportunities and promotion of sustainable agricultural practices. The alternatives varied in complexity and cost.

3.3.2 Alternate Project Components

All five alternatives included creation of a new floodplain corridor in which the artificial berms confining Punaluʻu Stream and preventing flood flows from flowing on the floodplain were removed and a new setback berm was created on the valley margin to define the boundary between the floodplain and terrace. The size of the floodplain corridor varied between alternatives. All five alternatives also included removal of the fill placed on the floodplain over the years to restore natural floodplain elevations; as well as relocation of Green Valley Road that is currently aligned along the stream's south bank to the top of the new setback berm. The alternatives used different methods for addressing flood water in Punaluʻu Ditch. Punaluʻu Ditch is the main ditch that runs west to east along the southern floodplain margin and is responsible for draining large volumes of water during storm events. The ditch's HDOT culvert at Kamehameha Highway is very undersized and results in substantial flooding in the low-lying areas when water is backed up behind the culvert. One alternative considered replacing the undersized culvert with a much larger capacity culvert under the highway while other alternatives evaluated different amounts of deepening and widening the ditch to improve conveyance or using fill to elevate ground adjacent to the ditch. The option of constructing a flood distributary channel that would route a portion of the high flow from

Punaluʻu Stream to Punaluʻu Ditch was also included as an alternative component to evaluate its effect on reducing flood elevations along the lower reach of Punaluʻu Stream. Replacement of another undersized culvert under Kamehameha Highway to the far south of the project area was also considered as an alternative option for reducing flooding in the southeast Kahana area. Since vegetation plays a critical role on bank stability and flow conveyance in Punaluʻu Stream, a list of native Hawaiian and Polynesian introduced plants compatible with project goals was compiled for inclusion in the alternatives and different land uses within the flood corridor were evaluated.

The hydraulic performance and flood risk benefit of all alternatives were modeled and quantitatively assessed, which provided a key means of evaluating their ability to meet project goals. The five alternatives were presented at a meeting with KS in December 2011. During the meeting, the results of the alternatives evaluation and pros and cons of each alternative were discussed and the most desirable components of each alternative were combined by the group as a whole into a final concept alternative. The alternatives of replacing Punaluʻu Ditch's culvert under Kamehameha Highway and another undersized culvert under Kamehameha Highway further south were eliminated after discussions with the Hawaiʻi Department of Transportation showed cost-sharing for the culvert replacements was not a viable option. Furthermore, the alternatives evaluation process resulted in elimination of the flood distributary channel and enlargement of Punaluʻu Ditch components, and instead advancement of the estuary channel component to the final concept alternative since analysis showed the estuary channel would provide increased flood reduction and provide additional ecological value. The final concept alternative formed the basis of development of 50%, 75%, and 90% engineering plans, specifications, and cost estimates.

3.4 No Action Alternative

The only alternative to the Proposed Action is the No Action Alternative. Under this alternative, the Punaluʻu habitat restoration work would not be completed. Existing activities would continue within the Punaluʻu watershed. Punaluʻu Stream would remain channelized with a riparian zone of invasive plants, chronic flooding would continue to occur in the watershed, and sedimentation within the stream and nearshore environment would continue.

Chapter 4
Affected Environment

This chapter provides an overview of the existing environmental conditions within the project area and the surrounding Punalu'u valley. An analysis of the Proposed Action's impact on the different components of the affected environment is presented in Chapter 5, *Environmental Consequences*.

4.1 Air Quality

Under the authority of the Clean Air Act, the U.S. Environmental Protection Agency (EPA) has established nationwide air quality standards, known as the National Ambient Air Quality Standards (NAAQS). The NAAQS represent the maximum allowable atmospheric concentrations of seven "criteria pollutants" including ozone, carbon monoxide, nitrogen dioxide, sulfur dioxide, particulate matter less than 10 microns in diameter, particulate matter less than 2.5 microns in diameter, and lead. The primary NAAQS are set at a level to protect public health with an adequate margin of safety; the secondary NAAQS are set at a level to protect the public welfare from any known or anticipated adverse effects of a pollutant (e.g., damage to crops and materials). The EPA designates areas of the United States having air quality equal to or better than the NAAQS as being in "attainment." Areas with air quality worse than the NAAQS are referred to as being in "non-attainment." Under the Clean Air Act, state and local agencies may establish their own Ambient Air Quality Standards, provided these standards are at least as stringent as the Federal requirements. The national standards, as well as the standards set by the State of Hawai'i, are provided in Exhibit 4-1.

Exhibit 4-1. Hawaiʻi and National Ambient Air Quality Standards

Pollutant	Averaging Time[b]	Hawaiʻi Standards[a]	National Primary Standards[a]	National Secondary Standards[a]
Ozone (O_3)	8 Hours	0.08 ppm	0.075 ppm	0.075 ppm
Carbon Monoxide (CO)	8 Hours	4.4 ppm	9 ppm	–
	1 Hour	9 ppm	35 ppm	–
Nitrogen Dioxide (NO_2)	Annual Arithmetic Mean	0.04 ppm	0.053 ppm	0.053 ppm
	1 Hour	–	0.100 ppm	–
Sulfur Dioxide (SO_2)	Annual	0.03 ppm	–	–
	24 Hours	0.14 ppm	–	–
	3 Hours	0.5 ppm	–	0.5 ppm
	1 Hour	-	0.075 ppm	–
Particulate Matter <10 microns in diameter (PM_{10})	Annual	50 µg/m³	-	-
	24 Hours	150 µg/m³	150 µg/m³	150 µg/m³
Particulate Matter <2.5 microns in diameter ($PM_{2.5}$)	Annual	–	12 µg/m³	15 µg/m³
	24 Hours	–	35 µg/m³	35 µg/m³
Lead	3-Month Average	1.5 µg/m³ (calendar quarter)	0.15 µg/m³ (running 3-month)	0.15 µg/m³ (running 3-month)
Hydrogen Sulfide (H_2S)	1 Hour	0.025 ppm	-	-

Source: National – 40 CFR 50 (EPA 2012a). Hawaiʻi – Hawaiʻi Administrative Rules, Title 11, Chapter 59 (HDOH 2013a).

[a] ppm = parts per million; µg/m³ = micrograms per cubic meter.

[b] National standards other than ozone and those based on annual averages or annual arithmetic means are not to be exceeded more than once a year. The ozone standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above the standards, averaged over three years, is equal to or less than one. The 1-hour NO_2 standard is attained when the 3-year average of the 98th percentile of the daily maximum 1-hour average at each monitor within an area does not exceed 0.100 ppm. The 24-hour PM_{10} standard is attained when the 24-hour concentrations does not exceed 150 µg/m³ more than once per year on average over 3 years. The annual $PM_{2.5}$ standard is attained when the 3-year average of the weighted annual mean $PM_{2.5}$ concentrations from single or multiple community-oriented monitors does not exceed 15.0 µg/m³. The 24-hour $PM_{2.5}$ standard is attained when the 3-year average of the 98th percentile of 24-hour concentrations at each population-oriented monitor within an area does not exceed 35 µg/m³. The quarterly lead standard is not to be exceeded in a calendar year. The rolling 3-month lead standard is not to be exceeded over a 3-year period. The 1-hour sulfur dioxide standard is attained when the 3-year average of the 99th percentile of the daily maximum 1-hour average concentrations does not exceed 0.075 ppm.

The Punaluʻu watershed is on the windward coast of Oʻahu, approximately 15 miles north west of Honolulu. The Island of Oʻahu has been designated by the EPA to be in attainment for the NAAQS since 1985 (EPA 2012b). Ambient air quality in the Punaluʻu watershed is relatively pristine due to the lack of industrial pollution, the relatively small population, and the dense growth of vegetation.

4.2 Biological Resources

Biological resources include terrestrial and aquatic plants and animals and their respective habitats. This section is organized by: (1) general terrestrial and freshwater plant and animal species and associated habitat; (2) marine species and associated habitat; and (3) protected species and habitat. A biological assessment previously conducted for the site is included in Appendix C.

4.2.1 Terrestrial and Freshwater Biological Resources

Terrestrial Vegetation/Habitat

The Punaluʻu Valley supports mesic to wet grass and forest vegetation and wetland plants. Naturalized plants include hilograss (*Paspalum conjugatum*), California grass (*Urochloa mutica*), java plum (*Syzygium cumini*), and guava (*Psidium* spp.) (KS 2011). In addition to native plants, non-native or invasive plant species are prevalent throughout the project area. For example, the ma kai portions of the project area and lower ridgelines are dominated by invasive species and contain very few native plant species. Common invasive plants found in the low lying areas of the project area include octopus tree (*Schefflera actinophylla*), guava (*Psidium guajava*), christmas-berry (*Schinus terebinthifolius*), koa haole (*Leucaena leucocephal*a), and wild ginger (*Zingiber* spp.) (KS 2010).

The primary land cover of the Punaluʻu Valley is evergreen forest (38 percent), followed by grassland (27 percent), cultivated land (8.6 percent), and impervious surface (8.1 percent) (see Exhibit 4-2). Of the 90 acres owned by KS in the project area, approximately 9.3 acres (or 10.3 percent) are wetlands (Cardno ENTRIX 2011).

Exhibit 4-2. Land Cover Types within the Punaluʻu Valley

Land Cover Type	Acres
Evergreen	34.1
Grassland	23.9
Cultivated land	7.7
Impervious surface	7.2
Palustrine forested wetland	5.7
Scrub shrub	4.5
Palustrine emergent wetland	3.4
Open space developed	2.5
Estuarine forested wetland	0.2
Total	89.2

Exhibit 4-3. Distribution of Ecosystem Biodiversity Land Types within the Punaluʻu Valley

Native Biodiversity Class	Acres
Native ecosystems no longer exist due to development or agriculture	41.1
Native ecosystems highly degraded, in need of restoration	40.9
Intact native ecosystems, low natural biodiversity	2.0
Native ecosystems threatened, high native biodiversity	0.2
Intact native ecosystems, high biodiversity	0.0
Native ecosystems rapidly degrading, in need of restoration	0.0
Unclassified	7.6
Total	91.9

Approximately 40 percent of KS-owned land represents ecosystems that are no longer intact due to development or agricultural activities (Exhibit 4-3). In addition, approximately 40 percent of KS-owned land represents ecosystems that are degraded and in need of restoration. Approximately 0.2 percent is land with high biodiversity but is threatened. Intact native ecosystems with low biodiversity are present on only 2 percent, and there are no intact native ecosystems with high biodiversity present in the project area.

Terrestrial Wildlife and Freshwater Species/Habitat

Major wildlife species in the area include the federally-listed hoary bat (*Lasiurus cinereus*) and ʻelepaio (*Chasiempis sandwichensis*) (KS 2011), as well as native bird species such as the pueo, which is state-listed as endangered on Oʻahu, and the i'iwi (Hawaiʻi DOT 2005). Domestic and invasive wildlife species are prevalent in the project area, and include cats, mongooses, rats, mice, chickens, cattle, horses, sandpipers, mynahs, sparrows, doves, cardinals, pigeons and bulbuls (Hawaii DOT 2005). Invasive feral pigs have caused problems in the area by destroying crops. Apple snails are also of concern as the species feeds on kalo leaves; these snails have been reported to be moving further upstream (KS 2010).

The Hawaiian Watershed Atlas (Hawaiʻi Department of Land and Natural Resources 2008) identifies the Punaluʻu Stream as having native insect and macrofauna diversity and an abundance of native species (Hawaiʻi Department of Land and Natural Resources 2008). However, the Punaluʻu Stream, like most Oʻahu streams, is dominated by non-native species (KS 2009). SWCA Environmental Consultants studied the Punaluʻu Stream upstream and downstream of the diversion dam in 2008 (KS 2009). During the SWCA visits to this area of the stream, the entire bottom was covered with fairly thick sediments. These were easily suspended, turning the stream turbid. In locations with slower flow, mats of filamentous algae were abundant. By far, the dominant animals downstream of the dam were green swordtails (*Xiphophorus helleri*). These Poeciliids are live bearers and thus are able to reach large numbers in reaches where they occur. The usually abundant non-native prawn *Macrobrachium lar* was not common below the dam, although some were seen.

The only native species observed in this reach was the indigenous goby ʻoʻopu nakea (*Awaous guamensis*) (Kamehameha Schools 2009). While no living hihiwai (*Neritina vespertina*) were seen below the dam, one freshly dead shell was collected. In general, the habitat below the dam superficially appears suitable for native species in terms of the habitat types, the abundance of boulders, and flow (even at near base flow conditions). However, the extensive sediment cover renders much of this area less than ideal for native stream animals.

All native biota in Hawaiʻi originated from sources outside the archipelago (Ziegler 2002). The native Hawaiian stream fauna evolved from many taxa that arrived from other Pacific regions (KS 2009). The continuous, perennial stream provides habitat for most of Hawaiʻi's characteristic macrofauna including gobioid fishes (*ʻoʻopu*), neritid snails (*hihiwai* and *hapawai*), and decapod crustaceans (*ʻopae*). Many of these native Hawaiian species are amphidromous: larvae hatch from eggs laid or carried in the stream and are washed into the sea where they develop for periods between four to six months (Radtke et al. 1988). Tiny post-larvae then reinvade stream mouths and migrate upstream where they grow to adults (Ford and Kinzie 1982). An important ecological characteristic of the amphidromous fauna is the ability (in varying degrees among species) to move upstream, surmounting riffles and small falls, and for some species, even very high waterfalls (Ford and Kinzie 1982, Radtke and Kinzie 1996). No specific evidence is available to suggest that any of the amphidromous species is presently at risk of extinction (Kamehameha Schools 2009); however, these species populations are believed to have declined statewide due to the synergistic effects of cultural alterations to their habitats.

The native amphidromous fishes of Hawaiian streams include only five species of gobies: Awaous stamineus (ʻoʻopu nakea), Sicyopterus stimpsoni (ʻoʻopu nopili), Lentipes concolor (ʻoʻopu alamoʻo), Stenogobius hawaiiensis (ʻoʻopu naniha); and the eleotrid Eleotris sandwicensis (ʻoʻopu akupa). Native amphidromous invertebrates include two gastropods, Neritina granosa (hihiwai) and the estuarine Neritina vespertina (hapawai); and the decapods, Atyoida bisulcata (ʻopae kalaʻole) and Macrobrachium grandimanus (ʻopae ʻoehaʻa). These species have predictable patterns of distribution in Hawaiian streams based upon salinity, elevation, location of waterfalls, stream flow periodicity, the presence or absence of non-native species, channelization, and land use/land cover within the watershed.

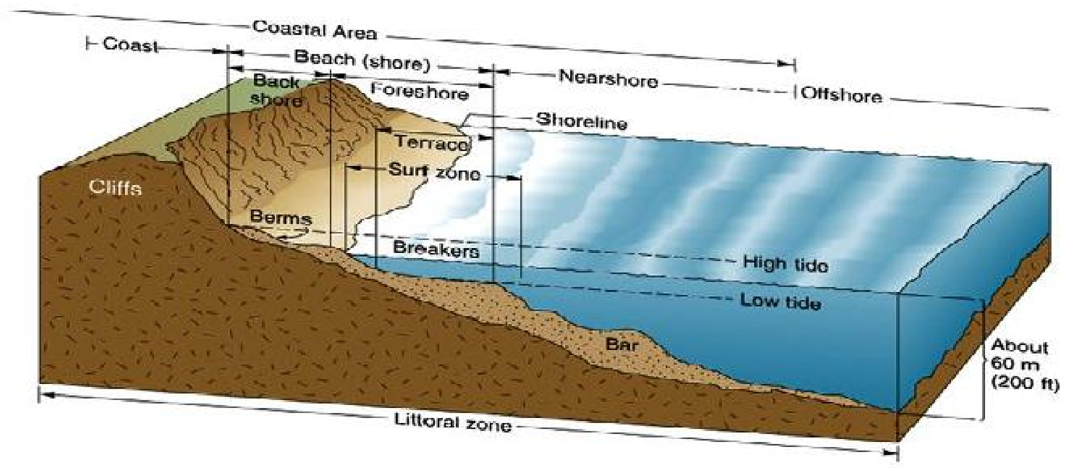
There is a host of other native marine and estuarine species important in Hawaiian stream ecology. These include an endemic predatory flagtail *Kuhlia xenura* (*ʻaholehole*) which are known to attack nests of goby eggs (Ha and Kinzie 1996), and may also consume returning post-larval gobies. Many other itinerant marine species undergo juvenile development in estuaries and the terminal reaches of streams. Alien species, including the introduced amphidromous *Macrobrachium lar,* are impacting native Hawaiʻi systems including fishes, amphibians, and crustaceans (Yamamoto and Tagawa 2000), yet there are few published studies available that quantify these impacts. Other important stream taxa include insects, lymnaeid snails, worms, sponges and smaller crustaceans.

4.2.2 Marine

Nearshore/Reef Flat

For the purpose of this EA, the nearshore marine habitat is defined as the area encompassing the transition from intertidal marine habitats to associated offshore habitat (Exhibit 4-4). The intertidal zone, also known as the foreshore and seashore, is the area that is above water at low tide and under water at high tide (in other words, the area between tide marks). Strong interactions occur between the marine environment and upland habitats within this area. For example, upland vegetation supports bank stability, shades the upper intertidal zone and adds terrestrial matter (e.g., woody debris) to the nearshore marine ecosystem.

Exhibit 4-4. Schematic View of a Typical Littoral Zone Including Nearshore Habitat



Source: http://www.longbeachislandjournal.com/habitat/nearshore-habitats

The nearshore marine habitat associated with the Punalu'u drainage is further divided into:

- Reef Flat - The nearshore marine environment at Punaluʻu is dominated by a shallow reef flat that extends along 1.5 kilometers (km) of coastline along Kamehameha Highway and is terminated at each end by drowned stream channels.
- Reef Crest - The reef flat at Punaluʻu is bounded along its seaward margin by a narrow fossil reef crest just a few meters wide that is exposed at mean lower low water (Rooney et al. 2004).
- Reef Slope - A gently sloping fossil reef terrace extends approximately one km further offshore from the reef crest and terminates in a near vertical wall that drops from -20 meters to approximately -30 m (Rooney et al. 2004).
- Reef Channel - A submerged sand channel extends over 500 m seaward from the mouth of Punaluʻu Stream. The substratum here consists of sand, cobbles and small boulders, and limestone outcrops (AECOS 2002).

Reef Flat

A diverse assemblage of algae typically dominates windward Oʻahu reef flats (AECOS 1994, 2002, 2006). Common species include branching *Hydrolithon gardineri* and *crustose H. reinboldii*, the chlorophyte *Halimeda* sp., and *Liagora* spp. Rock boring sea urchins (*Echinometra mathaei*), wana (*Echinothrix calamaris*), cone shells (*Conus* spp.), and heʻe (*Octopus vulgaris*) are found in reef depressions. Other marine invertebrates discovered on windward reef flats include sponges, brittle stars (*Ophiocoma erinaceus*), drupe shells (*Morula granulata*), and zebra horns (*Cerithium zebrum*). Stony corals, including cauliflower coral (*Pocillopora meandrina*), lobe coral (*Porites lobata*), and lace coral (*Pocillopora damicornis*) are present but cover less than five percent of the substratum over the reef flat (AECOS 2002, 2006, 2008).

Fishes observed on windward Oʻahu reef flats include juvenile mullet (*Mugil cephalus*), āholehole (*Kuhlia* spp.), lizardfish (*Synodus* spp.), and the cloudy goby (*Hazeus nephodes*) (AECOS 1994, 2006). AECOS (2002) reports use of the reef flat at Punaluʻu Beach Park for limu gathering, torch fishing, heʻe (octopus) fishing, spear and pole fishing, as well as trap and gill net fishing. The latter two activities are now restricted by the Department of Land and Natural Resources, Division of Aquatic Resources (Kamehameha Schools 2009).

Reef Crest

Along the reef crest, the algae limu līpoa (*Dictyopteris australis*) is abundant (AECOS 1994, 2006). Stony corals are more common towards the reef crest with cauliflower coral (*P. meandrina*) among the most abundant. The endemic blue rice coral (*Montipora flabellata*) is rare here (AECOS 2006; Jayewardene personal communication). Other invertebrates common along windward Oʻahu reef crests include cowry and cone shells, decapod crustaceans (lobster, shrimp, and crabs).

Fishes reported along the reef crest include manini (*Acanthurus triostegus*), other surgeonfish (*Acanthurus* spp.), and butterfly fish (*Chaetodon* spp.). Damselfish (*Plectoglyphidodon imparipennis*) and reef triggerfish (*Rhinecanthus rectangulus*) are rarely observed here (AECOS 1994, 2006). The threatened green sea turtle (*Chelonia mydas*) has also been observed seaward of the windward reef crest near Punaluʻu (AECOS 1994, 2006).

Reef Slope

This reef structure at Punaluʻu faces ocean swells created by the northeasterly trade winds, and provides some degree of protection to the shoreline from strong storm surge (Fletcher et al. 2008, Rooney et al. 2004). Rooney et al. (2004) observed substantial water circulation over the reef crest even during extended periods of negligible trade winds, and noted that the volume of offshore water flowing across the reef protects it from damage by upland fresh water and sediment runoff. This pattern of reef flat, reef crest, and slope also occurs along the shoreline north of Punaluʻu (AECOS 1994, 2006).

The seaward portion of the reef crest is covered in an algal turf consisting of numerous species, with *Ptercladiella capillacea* and *Coelothris irregularis* being dominant (AECOS 1994, 2006). The limestone shelf sloping to approximately 25 m offshore has very little relief and is covered with sand patches and algae. Though not abundant at any one location, *Coelothrix irregularis* is a common species forming irregular clumps or growing in thin layers across the substrate. The phaeophytes *Padina* sp. and *Turbinaria ornata* are locally abundant, densely covering the substratum just below the waves in some areas. Lace coral (*Pocillopora damicornis*) occasionally forms small colonies on the seaward edge of the shelf. The Hawaiian mussel (*Brachidontes crebristriatis*) is locally common in patches close to shore. Fishes expected to frequent these waters include those found on the reef crest (above) as well as damselfishes (Fam. *Pomacentridae*), wrasses (Fam. *Labridae*), needlefish (*Tylosaurus crocodylus*), *papio ulua* (Fam. *Carangidae*), oʻio (*Albula virgata*), *mu* (*Monotaxis grandoculis*), and *weke ʻula* (*Mulloidichthys vanicolensis*).

Reef Channel

Goatfish, surgeonfish, wrasses, lizardfish, milkfish, papio, and damselfish may be common in the reef channel. Juveniles of itinerant marine species such as *āholehole, mullet, papio,* and *oʻopu* (Fam. *Gobiidae* and *Eleotridae*) frequent the Punaluʻu estuary and may also be found within the reef channel close to shore. Salt tolerant non-native tilapia (*Oreochromis* spp.) species also may be found here.

4.2.3 Protected Species and Habitat

Congress passed the Endangered Species Act (ESA) in 1973, recognizing that the nation's rich natural heritage is of "esthetic, ecological, educational, recreational, and scientific value to our Nation and its people." The purpose of the ESA is to protect and recover imperiled species and the ecosystems upon which they depend. The USFWS has primary responsibility for terrestrial and freshwater organisms; the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) has primary responsibility for marine wildlife and anadromous fish.

Under the ESA, species may be listed as either endangered or threatened. "Endangered" means a species is in danger of extinction throughout all or a significant portion of its range. "Threatened" means a species is likely to become endangered within the foreseeable future. All species of plants and animals, except pest insects, are eligible for listing as endangered or threatened.

The ESA also requires the designation of "critical habitat" for listed species. Federally-designated critical habitat includes geographic areas that contain the physical or biological features that are essential to the conservation of the species and that may need special management or protection. Critical habitat designations affect only Federal agency actions or federally funded or permitted activities. Federal agencies are required to avoid "destruction" or "adverse modification" of designated critical habitat. Federally-designated critical habitat may include areas that are not occupied by the species at the time of listing but are essential to its conservation.

There are 102 plant and 10 animal species listed as threatened or endangered under the ESA in the Punaluʻu watershed (see Exhibit 4-5). While some areas of the Punaluʻu Valley are designated as federally-designated critical habitat for listed plant species, no federally-designated critical habitat exists within the project area (Kamehameha Schools 2011). Species richness values in the drainage correlate to the number of federally listed species that have potential for occurring within a given area (Exhibit 4-6). The greatest species richness within the Punaluʻu Valley is associated with the upland ridge top areas of the valley.

The only freshwater animals listed as endangered or as candidates for listing are insects (Kamehameha Schools 2009). Two endemic damselflies, the Hawaiian oceanic damselfly (*Megalagrion oceanicum*) and the Hawaiian orangeblack damselfly (*M. xanthomelas*) were recently listed as endangered species by the USFWS. Once widely distributed in streams, ponds, and wetlands on Oʻahu, their populations have dramatically declined. *Megalagrion oceanicum* has been reported as being present in the middle reaches of Punaluʻu Stream in one or more of the historic stream surveys summarized by the Department of Land and Natural Resources, Division of Aquatic Resources.

In the marine environment, no green sea turtle (*Chelonia mydas*) or Hawaiian monk seal (*Monachus schauinslandi*) sightings are found within the records of the Oʻahu Heritage Database for the marine habitats immediately offshore of Punaluʻu. However, green sea turtles have been reported foraging in nearshore waters fronting the property (AECOS 2002) and may actually frequent the area seaward of the reef crest. In addition, on December 7, 2012, NMFS proposed ESA listings for 66 coral species. In the Pacific, seven species would be listed as endangered and 52 as threatened (77 *Federal Register* 73220).

In addition to the ESA, Hawaiʻi Administrative Rule (HAR) 13-95 regulates the taking of mullet (*Mugil cephalus*), āholehole (*Kuhlia* spp.), milkfish (*Chanos chanos*), kala (*Naso unicornis*), manini (*Acanthurus triostegus hawaiiensis*), moana (*Parupeneus multifasciatus*), papio and ulua (Fam. *Carangidae*), weke (*Mulloidichthys flavolineatus*), ula (*Panulirus marginatus*), and other marine fishes, as well as Samoan crab (*Scylla serrata*). The marine waters of Punaluʻu once supported a historic mullet and akule (*Selar crumenopthalmus*) fishery (Handy and Handy 1991, Maly and Maly 2005).

HAR 13-100 and 188-43 also regulate taking of *ʻoʻopu akupa* (*Eleotris sandwicensis*) which is characteristically found within estuaries and the lower reaches of Hawaiian freshwater streams. Three stony coral species (*Porites lobata*, *Pocillopora damicormis*, *Pocillopora meandrina*) present on the reefs at Punaluʻu are also protected from harvesting by HAR 13-95-70.

Exhibit 4-5. Potential occurrence of Federally Listed/Proposed Species within the Punalu‘u Watershed

Common Name	Scientific Name	Status
ANIMALS		
Pupu Kuahiwi	*Achatinella bulimoides*	Endangered
Pupu Kuahiwi	*Achatinella decipiens*	Endangered
Pupu Kuahiwi	*Achatinella lila*	Endangered
Pupu Kuahiwi	*Achatinella sowerbyana*	Endangered
Hawaiian duck or Koloa maoli	*Anas wyvilliana*	Endangered
Hawaiian short-eared owl, pueo	*Asio flammeus sandwichensis*	
Hawaiian coot, ‘alae ke‘oke‘o	*Fulica alai*	Endangered
O‘ahu Elepaio	*Chasiempis sandwichensis ibidis*	Endangered
Hawaiian moorhen or ‘alae ‘ula	*Gallinula chloropus sandvicensis*	Endangered
Hawaiian Stilt or Ae‘o	*Himantopus mexicanus knudseni*	Endangered
Blackline Megalagrion Damselfly	*Megalagrion nigrohamatum nigrolineatum*	Endangered
n/a (damselfly)	*Megalagrion leptodemas*	
Flying earwig Hawaiian damselfly, pinapinao	*Megalagrion nesiotes*	Proposed Endangered
Oceanic Megalagrion Damselfly	*Megalagrion oceanicum*	Endangered
Pacific Hawaiian damselfly, pinapinao	*Megalagrion pacificum*	Proposed Endangered
Hawaiian Hoary Bat or ‘ope‘ape‘a[a]	*Lasirus cinereus semotus*	Endangered
PLANTS		
n/a	*Abutilon sandwicense*	Endangered
n/a	*Achyranthes splendens*	Endangered
Palai lā‘au	*Adenophorus periens*	Endangered
Māhoe	*Alectryon macrococcus*	Endangered
n/a	*Bonamia menziesii*	Endangered
Uhiuhi	*Caesalpinia kavaiensis*	Endangered
Kāmanomano	*Cenchrus agrimonioides*	Endangered
‘Āwiwi	*Centaurium sebaeoides*	Endangered
‘Akoko	*Chamaesyce celastroides*	Endangered

Exhibit 4-5. Potential occurrence of Federally Listed/Proposed Species within the Punaluʻu Watershed

Common Name	Scientific Name	Status
ʻAkoko	*Chamaesyce deppeana*	Endangered
ʻAkoko	*Chamaesyce herbstii*	Endangered
ʻAkoko	*Chamaesyce rockii*	Endangered
Kauila	*Colubrina oppositifolia*	Endangered
Pauoa	*Ctenitis squamigera*	Endangered
Hāhā	*Cyanea acuminata*	Endangered
Hāhā	*Cyanea calycina*	Endangered
Hāhā	*Cyanea crispa*	Endangered
Hāhā	*Cyanea grimesiana*	Endangered
Hāhā	*Cyanea humboldtiana*	Endangered
Hāhā	*Cyanea koolauensis*	Endangered
Hāhā	*Cyanea lanceolata*	Endangered
Hāhā	*Cyanea longiflora*	Endangered
Hāhā	*Cyanea pinnatifida*	Endangered
Hāhā	*Cyanea purpurellifolia*	Endangered
Hāhā	*Cyanea sessilifolia*	Endangered
Hāhā	*Cyanea st.-johnii*	Endangered
Hāhā	*Cyanea superba*	Endangered
Hāhā	*Cyanea truncata*	Endangered
n/a	*Cyperus pennatiformis*	Endangered
Haʻiwale	*Cyrtandra crenata*	Endangered
Haʻiwale	*Cyrtandra dentata*	Endangered
Haʻiwale	*Cyrtandra kaulantha*	Endangered
Haʻiwale	*Cyrtandra polyantha*	Endangered
Haʻiwale	*Cyrtandra sessilis*	Endangered
Haʻiwale	*Cyrtandra subumbellata*	Endangered
Haʻiwale	*Cyrtandra viridiflora*	Endangered

Exhibit 4-5. Potential occurrence of Federally Listed/Proposed Species within the Punalu‘u Watershed

Common Name	Scientific Name	Status
Ha‘iwale	*Cyrtandra waiolani*	Endangered
n/a	*Delissea subcordata*	Endangered
Palapalai lau li`i	*Diellia erecta*	Endangered
n/a	*Diellia falcata*	Endangered
n/a	*Eragrostis fosbergii*	Endangered
Nīoi	*Eugenia koolauensis*	Endangered
n/a	*Euphorbia haeleeleana*	Endangered
Mēhamehame	*Flueggea neowawraea*	Endangered
Nānū	*Gardenia mannii*	Endangered
n/a	*Gouania vitifolia*	Endangered
n/a	*Hesperomannia arborescens*	Endangered
n/a	*Hesperomannia arbuscula*	Endangered
n/a	*Huperzia nutans*	Endangered
Hilo ischaemum	*Ischaemum byrone*	Endangered
Aupaka	*Isodendrion longifolium*	Threatened
Hulumoa	*Korthalsella degeneri*	Endangered
Kāmakahala	*Labordia cyrtandrae*	Endangered
n/a	*Lepidium arbuscula*	Endangered
Nehe	*Lipochaeta lobata*	Endangered
n/a	*Lobelia gaudichaudii*	Endangered
n/a	*Lobelia niihauensis*	Endangered
n/a	*Lobelia oahuensis*	Endangered
n/a	*Lysimachia filifolia*	Endangered
Nehe	*Melanthera tenuifolia*	Endangered
Alani	*Melicope christophersenii*	Endangered
Alani	*Melicope hiiakae*	Endangered
Alani	*Melicope lydgatei*	Endangered

Exhibit 4-5. Potential occurrence of Federally Listed/Proposed Species within the Punaluʻu Watershed

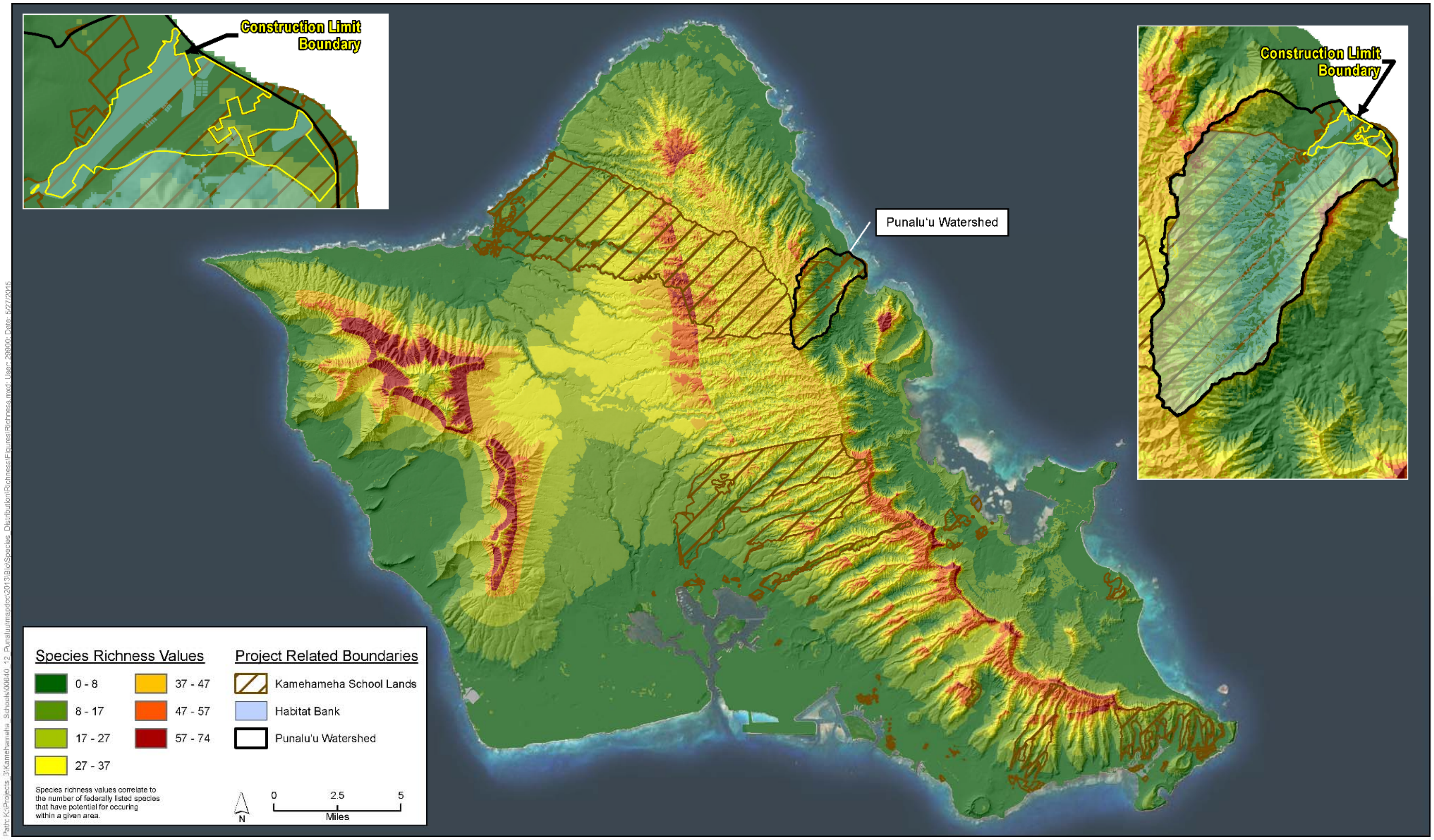
Common Name	Scientific Name	Status
Alani	*Melicope pallida*	Endangered
Alani	*Melicope saint-johnii*	Endangered
Kōlea	*Myrsine juddii*	Endangered
n/a	*Neraudia angulata*	Endangered
Kuluʻī	*Nototrichium humile*	Endangered
n/a	*Phyllostegia hirsuta*	Endangered
n/a	*Phyllostegia kaalaensis*	Endangered
n/a	*Phyllostegia mollis*	Endangered
n/a	*Phyllostegia parviflora*	Endangered
Laukahi kuahiwi	*Plantago princeps*	Endangered
n/a	*Platanthera holochila*	Endangered
n/a	*Platydesma cornuta*	Endangered
Hala pepe	*Pleomele forbesii*	Endangered
Loulu	*Pritchardia kaalae*	Endangered
Kōpiko	*Psychotria hexandra*	Endangered
Kaulu	*Pteralyxia macrocarpa*	Endangered
n/a	*Pteris lidgatei*	Endangered
n/a	*Sanicula purpurea*	Endangered
n/a	*Schiedea hookeri*	Endangered
n/a	*Schiedea kaalae*	Endangered
n/a	*Schiedea nuttallii*	Endangered
n/a	*Schiedea trinervis*	Endangered
n/a	*Silene lanceolata*	Endangered
Pōpoloʻaiakeakua	*Solanum sandwicense*	Endangered
n/a	*Spermolepis hawaiiensis*	Endangered
n/a	*Stenogyne kanehoana*	Endangered
n/a	*Tetramolopium filiforme*	Endangered

Exhibit 4-5. Potential occurrence of Federally Listed/Proposed Species within the Punaluʻu Watershed

Common Name	Scientific Name	Status
n/a	*Tetramolopium lepidotum*	Endangered
ʻOheʻohe	*Tetraplasandra gymnocarpa*	Endangered
Ōpuhe	*Urera kaalae*	Endangered
ʻOlopū	*Viola chamissoniana*	Endangered
n/a	*Viola oahuensis*	Endangered
Aʻe	*Zanthoxylum oahuense*	Endangered

Source: U.S. Geological Survey 2011a.
[a] While the National Gap Analysis Program Land Cover Data (U.S. Geological Survey 2011a.) did not indicate habitat for this species, the presence of this species has been reported in the project area (see Kamehameha Schools 2011). Additional survey work may be required to confirm habitat potential for this species.

Exhibit 4-6. Species Richness for the Island of O‘ahu, Punalu‘u Watershed, and Punalu‘u Project Area



Punalu‘u Floodplain Restoration
Species Richness for the Island of O‘ahu

4.3 Wetlands

Wetlands are lowland areas covered with shallow and sometimes temporary or intermittent waters. These areas include, but are not limited to, swamps, marshes, bogs, sloughs, wet meadows, river overflows, tidal overflows, estuarine areas, and shallow lakes and ponds with vegetation that is present for most of the growing season. Wetlands provide many benefits to the human, biological, and hydrological environment, including habitat for fish and wildlife, water quality improvement, flood storage, and opportunities for recreation.

A wetland delineation was performed for the project by wetland biologists with AECOS, Inc. in September 2014 (AECOS 2014). The wetland delineation report provided in Appendix B includes details on the site history, field methods, and results with accompanying maps. The delineation covered the 140 acre project area and also included a survey of the ordinary high water mark (OHWM). AECOS found three types of open water features and 6 "types" of wetlands in the project area. Open water features include: estuary, stream, and agriculture ditch. Wetlands are all palustrine wetlands (inland marshes and swamps) and include: temporarily flooded with broad-leaved evergreen trees (PFO3A), semi permanently flooded with broad-leaved evergreen scrub-shrub vegetation (PSSF), temporarily flooded with persistent, emergent vegetation (PEM1A), seasonally flooded with persistent, emergent vegetation (PEM1C), actively artificially flooded, diked and/or impounded with persistent, emergent vegetation (active PEM1Kh), and formerly artificially flooded, diked and/or impounded with persistent, emergent vegetation (relict PEM1Kh).

Jurisdictional wetlands are those that are regulated by the USACE under Section 404 of the Clean Water Act (also known as "Waters of the United States"). Exhibit 4-7 below summarizes AECOS' wetland delineation results and initial assessment of whether the wetlands are jurisdictional. AECOS determined that roughly 10.6 acres of the project area is wetland, of which 7.8 acres (74%) is jurisdictional. Exhibit 4-8 shows the locations of the wetlands mapped as part of the delineation as well as the proposed locations of cut and fill as part of the 90% design grading plan. Note that it was not reasonable to delineate meaningful area values for Punaluʻu Stream and open water areas (AECOS 2014). AECOS' delineation will be sent for review and concurrence by the USACE in order for the jurisdictional determination to become official. Much of the valley floor was likely wetland prior to extensive manipulation (e.g., leveling, ditching, diking, channelization) by humans, mostly for agriculture. The project's plan to restore natural hydrologic processes and remove artificial fill from the floodplain will cause many of these areas to revert back to wetland (AECOS 2014).

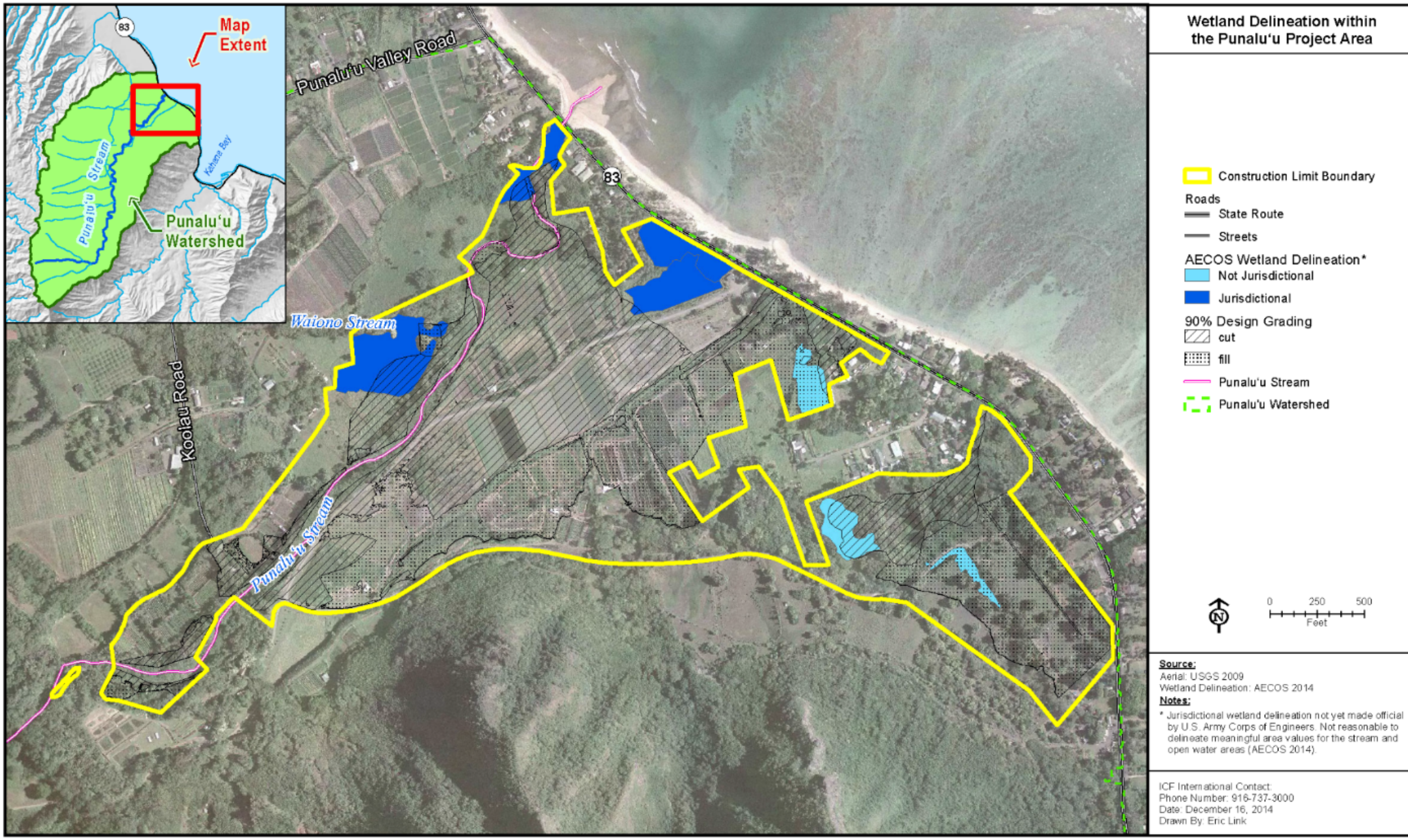
Exhibit 4-7. Summary of 2014 Wetland Delineation Survey

Wetland	Wetland Type	Area (acres)	Soil Pit(s)	Jurisdictional?[a]
Hau at Punaluʻu Strm mouth	PF03A	1.0	2-11, 2-9, 2-12	Yes
Hau by Kam. Hwy.	PF03A	1.5	2-2, 2-3	Yes
Hau wetland	PF03A	1	2-8, 2-14	No
Primrose willow & para grass wetland (SE)	PSS34/PEM1C	1.3	4-10, 4-14	No

SE cattle pasture	PEM1C	0.5	3-6	No
Grassland NW of Punaluʻu Stream	PEM1A/PEM1C	3.5	4-4, 4-6, 4-11, 4-12	Yes
Entrance road grassland	PEM1C	1.8	2-1, 2-1b	Yes
Total		**10.6**		
Jurisdictional Total		**7.8**		

Source: AECOS, Inc. 2014.
[a] AECOS' delineation will be sent for review and concurrence by the U.S. Army Corps of Engineers in order for the jurisdictional determination to become official.

Exhibit 4-8. Wetland Delineation of the Project Area



4.4 Noise

Noise is usually defined as unwanted sound that disturbs routine activities and can cause annoyance. The decibel (dB) is the accepted standard unit for the measurement of sound, and is a logarithmic unit that accounts for the large variation in sound pressure amplitudes. A-weighted (dBA) sound levels have been adjusted to correspond to the frequency response of the human ear. HAR Title 11 Chapter 46, *Community Noise Control*, defines noise as "any sound that may produce adverse physiological or psychological efforts or interfere with individual or group activities, including, but not limited to, communication, work, rest, recreation or sleep" and sets permissible sound levels to control excessive noise in Hawaiʻi. These standards are presented in Exhibit 4-9 and apply to stationary noise sources as well as to equipment related to agricultural, construction, and industrial activities. The standards apply to any source emanating within the zoning district and at any point at or beyond the property line of the premises. According to the standards, noise levels shall not exceed the maximum permissible sound levels for more than 10% of the time within any 20 minute period, except by permit or variance issued under HAR 11-46.

Exhibit 4-9. Maximum Permissible Sound Levels in dBA

Zoning districts	Daytime (7 am to 10 pm)	Nighttime (10 pm to 7 am)
Class A (residential, conservation, preservation, public space, open space, or similar type)	55	45
Class B (multi-family dwellings, apartment, business, commercial, hotel, resort, or similar type)	60	50
Class C (agriculture, country, industrial, or similar type)	70	70

Source: HAR § 11-46-4

The project area is located in a relatively rural area with low levels of ambient noise and is zoned for agriculture. The primary source of ambient noise is vehicular traffic along the Kamehameha Highway. Traffic noise levels are highest over the weekends when there is an influx of recreational visitors to the Punaluʻu Beach Park and other local beaches. (Hawaiʻi Department of Transportation 2005)

4.5 Land Use

KS owns approximately 86 percent of the 4,274.45 acres of land in the Punaluʻu watershed. The area has a long history of agricultural use dating back to pre-contact and early post-contact Hawaii and the cultivation of kalo. Today, KS leases out parcels of its Punaluʻu farm lands on a three year license basis to small farmers. Agriculture in the modern era is deviating away from large scale crop production that requires large acreages of mono crop farming and towards small field crop farming, orchard crops, and small aquaculture operations.

Approximately 617 acres of non-KS lands in Punaluʻu are owned by the State of Hawaiʻi or private landowners. County zoning designations for these lands are provided in Exhibit 4-10. A portion of the beachfront in the watershed makes up the Punaluʻu Beach Park, while the rest is primarily associated with private residences (City and County of Honolulu 2014). There are no areas designated for business, industrial, resort, or commercial use in the watershed.

Exhibit 4-10. County Zoning Designations for Non-KS Lands in Punaluʻu

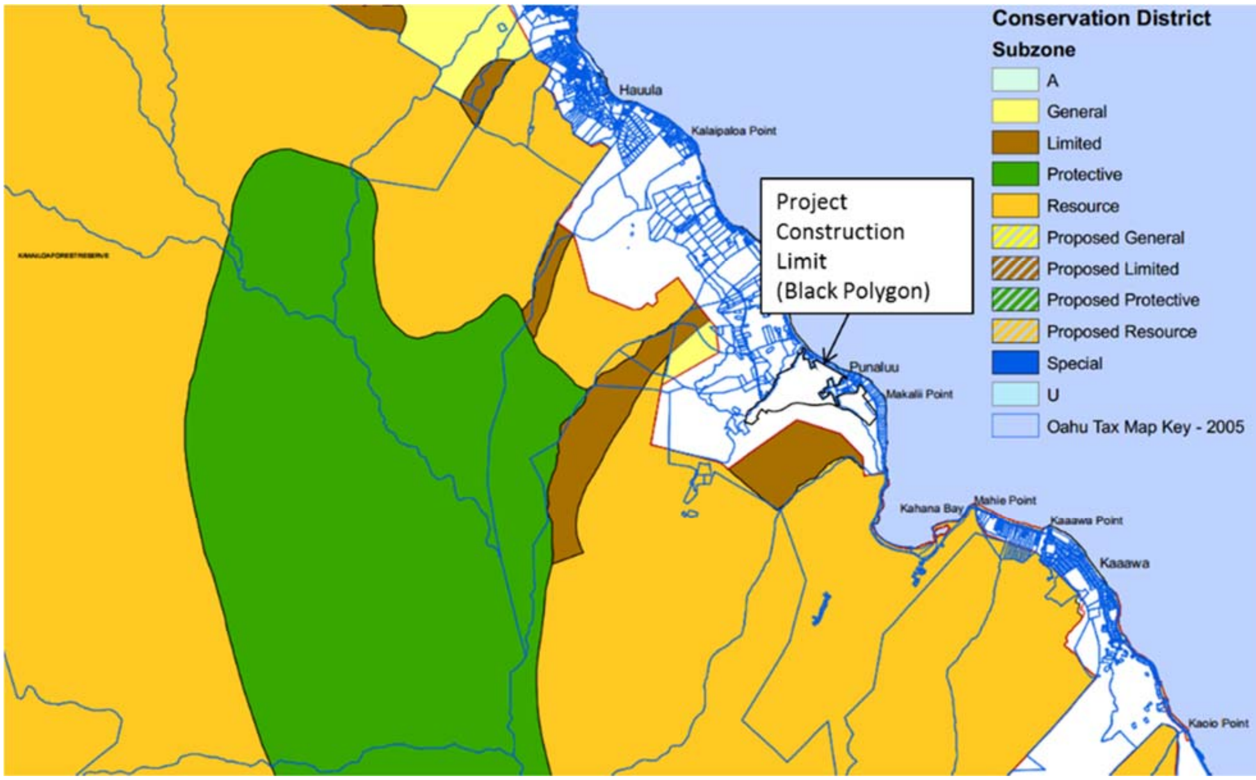
County Zoning District	Acreage	Description of Zoning District[a]
AG-2 General Agriculture	328	Permitted uses include aquaculture, crop production, forestry, livestock grazing and production
P-1 Restricted Preservation	259	Land within a state designated conservation district; all uses, structures, and development standards to be governed by the appropriate state agencies
Residential	24	Allows for a range of residential densities. Nondwelling uses which support and complement residential neighborhood activities are also permitted.
Country	3	Permitted uses include agricultural uses, low density residential development, and some supporting services and uses (e.g., single family dwellings, public structures)
P-2 General Preservation	3	Land designated urban by the state, but that is well-suited to the function of providing visual relief and contrast to the city's built environment or serving as outdoor space for the public's use and enjoyment. Also includes areas unsuitable for other uses because of topographical considerations related to public health, safety, and welfare concerns
Total	617	

Source: Revised Ordinances of Honolulu, Chapter 21, Article 3

[a] This table only provides a representative sample of permitted uses in these zoning districts. A complete list is provided in Chapter 21, Article 3 of the Revised Ordinances of Honolulu.

Most of the lands adjacent to the Punaluʻu watershed consist of preservation land contained in State Parks or Forest Reserves (see Exhibit 4-11 for regional overview and Exhibit 4-12 for close-up map of project area). To the north of the watershed is Sacred Falls State Park, a forested preserve encompassing the Kaluanui gulch. The park has been closed to public entry since 1999 (Hawaii News Now 2014). South of Sacred Falls is the Kaipapʻu Forest Reserve, part of Oʻahu's 36,600 acre reserve system. Forest reserves are managed for a variety of uses, including recreational and hunting opportunities; aesthetic benefits; watershed restoration; native, threatened, and endangered species habitat protection and management; cultural resources; and fire protection (Hawaii Division of Forestry and Wildlife 2014). South of the Punaluʻu watershed is the Ahupua'a O Kahana State Park, an almost 5,300 acre park ranging from sea-level at Kahana Bay to the crest of the Koʻolau mountains. The park contains two hiking trails available to the public, as well as a visitor center, picnic tables, camping facilities, and a beach area (Hawaii Department of Land and Natural Resources 2014a).

Exhibit 4-11. State Conservation District Subzones near Punaluʻu



Source: Hawaiʻi Department of Land and Natural Resources 2014b.

KS assumed day-to-day operations of its Punaluʻu lands in 2000 (Kamehameha Schools 2011). Today, roughly 505 acres of land owned by KS in the valley are zoned for agriculture. Approximately 150 acres are currently in agricultural production with approximately 30 tenants who conduct small scale, diversified agricultural and aquaculture operations (Kamehameha Schools 2011). Agriculture in the valley includes banana and guava; taro; fruit and vegetable row crops; horticulture; and cattle grazing (USGS 1998). Punaluʻu lands are still rural in character, with small farms, a scattering of house lots, a country store, a roadside restaurant, and a number of beachfront lots and homes.

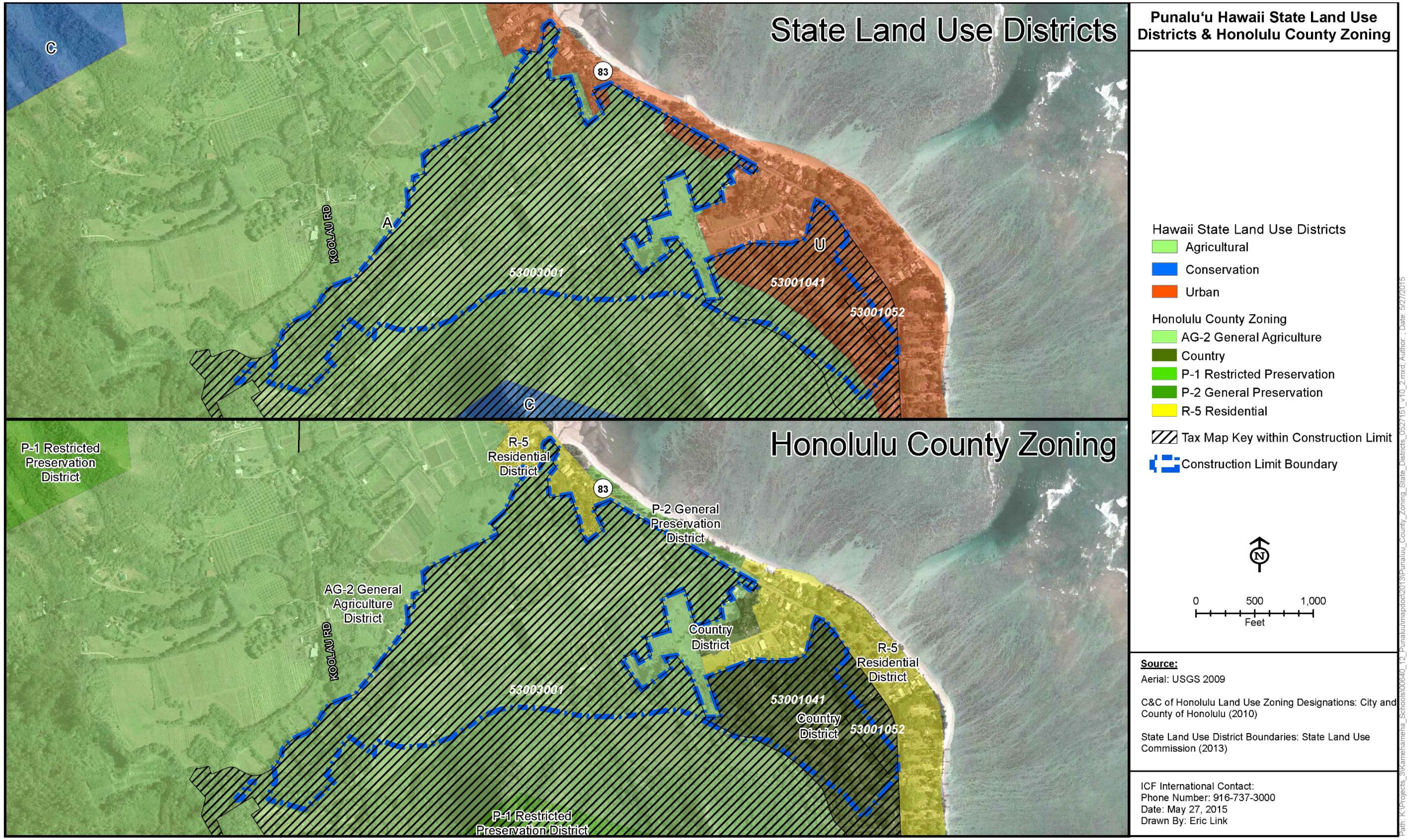
In addition, a heavy emphasis has been placed on using the land for educational activities. Through a partnership with the University of Hawai'i, 6,000 students come to Punaluʻu annually to experience traditional lo'i kalo production. Another site near the entrance to KS property introduces pre-school through 1st grade students to native Hawaiian agriculture. Other land uses include pasture, woodlands, riparian wetlands, wildlife habitat, scattered dwellings, unpaved roads, and a school. (Kamehameha Schools 2011)

The top half of Exhibit 4-12 illustrates the State Land Use Districts in the Punaluʻu area. Within the project area boundary (which is the same as the construction limit boundary) most of the land is in Agricultural District with a smaller portion to the east in Urban District. Tax map key 5-3-003:001, which is KS land that covers most of the project area, extends south out of the project area and into Conservation District.

The bottom half of Exhibit 4-12 illustrates the Honolulu County Zoning districts in the Punaluʻu area. Within the project area boundary most of the land is in AG-2 General Agriculture District with a smaller portion to the east in County District. Tax map key 5-3-003:001 extends south out of the project area and into P-1 Restricted Preservation District.

In addition to these state and county land use designations, the Koʻolau Loa Sustainable Communities Plan also similarly designates the primary land uses in the Punaluʻu watershed as rural residential, agricultural, and preservation (City and County of Honolulu, Department of Planning and Permitting 1999).

Exhibit 4-12. State Land Use Districts and Honolulu County Land Use Zoning Designations in Punalu‘u Project Area.



4.6 Cultural Resources

No historic sites or cultural resources listed on the National Register of Historic Places are known to exist in the vicinity of the project area (Environmental Protection Agency 2013a).

The Punaluʻu Valley has a rich agricultural history that is documented by legends, historical records, oral histories, and cultural sites. The earliest accounts of the area note that an extensive loʹi kalo and ʹauwai system existed in Punaluʻu and that significant amounts of kalo were cultivated in the area (Kamehameha Schools 2010). Kalamakua, the ruling chief of Oʻahu during the 15th century, is credited with establishing numerous ʻauwai and agricultural terraces throughout the entire island. The earliest accounts of the area note that these irrigation systems, which were primarily used for the cultivation of kalo, sustained a sizeable population in Ko'olau Loa for many generations. Kahana and Punaluʻu were known as the bread baskets of Ko'olau Loa (Kamehameha Schools 2010).

In the 20th century, rice cultivation brought a wave of Chinese immigrants to the Punaluʻu area. When the Ko'olau Agricultural Company was established by James B. Castle in the early part of the century, cultivation of taro and pineapples became more widespread, with hundreds of acres of land leased to Japanese tenant farmers. Sugar was also cultivated in Punaluʻu until the 1970's; the Punaluʻu Ditch system was constructed by James Castle to irrigate the sugarcane lands in Punaluʻu. (Kamehameha Schools 2010)

During the past nine years, KS has coordinated multiple consultation sessions relating to thePunaluʻu Ahupuaʻa in general, archaeological findings in the area, and most recently, the Proposed Action (see details in Appendix F). Consultations have taken the form of ethnographic/oral history interviews with Punaluʻu residents—kūpuna (ancestor) and kamaʻaina (native-born)—with genealogical ties to the area and group meetings to discuss project plans and archaeological results.

There have been thirteen archaeological surveys of various scales and nine monitoring projects linked to inadvertent discoveries of burials completed in the vicinity of Punaluʻu since 1933. A Punaluʻu oral history report was also completed in 2005 (Kamehameha Schools 2010). The most recent archaeological inventory survey in 2014 was completed by International Archaeological Research Institute, Inc., on behalf of KS for the purpose of identifying and documenting historic properties on lands owned by KS in anticipation of the stream restoration work. .This survey encompassed 119.8 acres within Punaluʻu, Makaua, and Waiʻono Ahupuaʻa. The work was conducted to fulfill KS's historic preservation obligations per Section 106 of the National Historic Preservation Act (NHPA) and Hawaiʻi Revised Statute Chapter 6E-42, and builds upon an earlier survey conducted by Keala Pono Archaeological Consulting, LLC. The inventory survey included a pedestrian survey and the excavation of 25 backhoe trenches within the two project parcels (identified as the Punaluʻu Valley and Kahana Components). Pedestrian survey was accomplished via three methods: re-location of sites previously recorded by Keala Pono, re-survey of previously surveyed areas, and inventory-level survey of unsurveyed areas. Survey work included textual feature descriptions, photography, and mapping of most features. During backhoe trench investigations, scaled stratigraphic profiles were drawn and soils recorded for each trench. Locations of all features and trenches were recorded with submeter accuracy using a Global Positioning System (GPS) unit. The archaeological inventory survey report is presented in Appendix F.

Six archaeological sites were identified. These sites are a valley-bottom irrigation network dating to the early to mid-20th century (Site 50-80-06-7236), a mid-20th century complex of concrete foundations and a pond (Site 50-80-06-7718), an isolated buried imu (Site 50-80-06-7727), a buried pondfield terrace (Site 50-80- 06-7728), and two buried 19th century loʻi soils (Sites 7733 and 7734).

Site 7236, a historic irrigation ditch network, is significant under Criteria a and d. Site 7236 is a local (Punaluʻu Valley) example of the 20th century agricultural infrastructure that was engineered across vast swaths of the islands as part of the archipelago-wide plantation agricultural economy (Criterion a). Plantation agriculture during the 19th and 20th centuries had wide-ranging and dramatic effects on the landscape, food and agricultural commodity production, larger economy, politics, and demography. This ditch network, which includes branches constructed as early as 1907 through the mid- to late-20th century, was an integral component of historic agricultural activities in the valley. The layout and orientation of these ditches provides important information pertaining to individual agricultural plots, the integration of these plots into a larger irrigated planting system, and the types of plants that could have been grown (Criterion d).

Site 7718, a complex of concrete foundations and a stone-lined pond, is significant under Criterion d. Following this criterion, recording of this site provides general information about habitation in this part of the valley during mid-20th century.

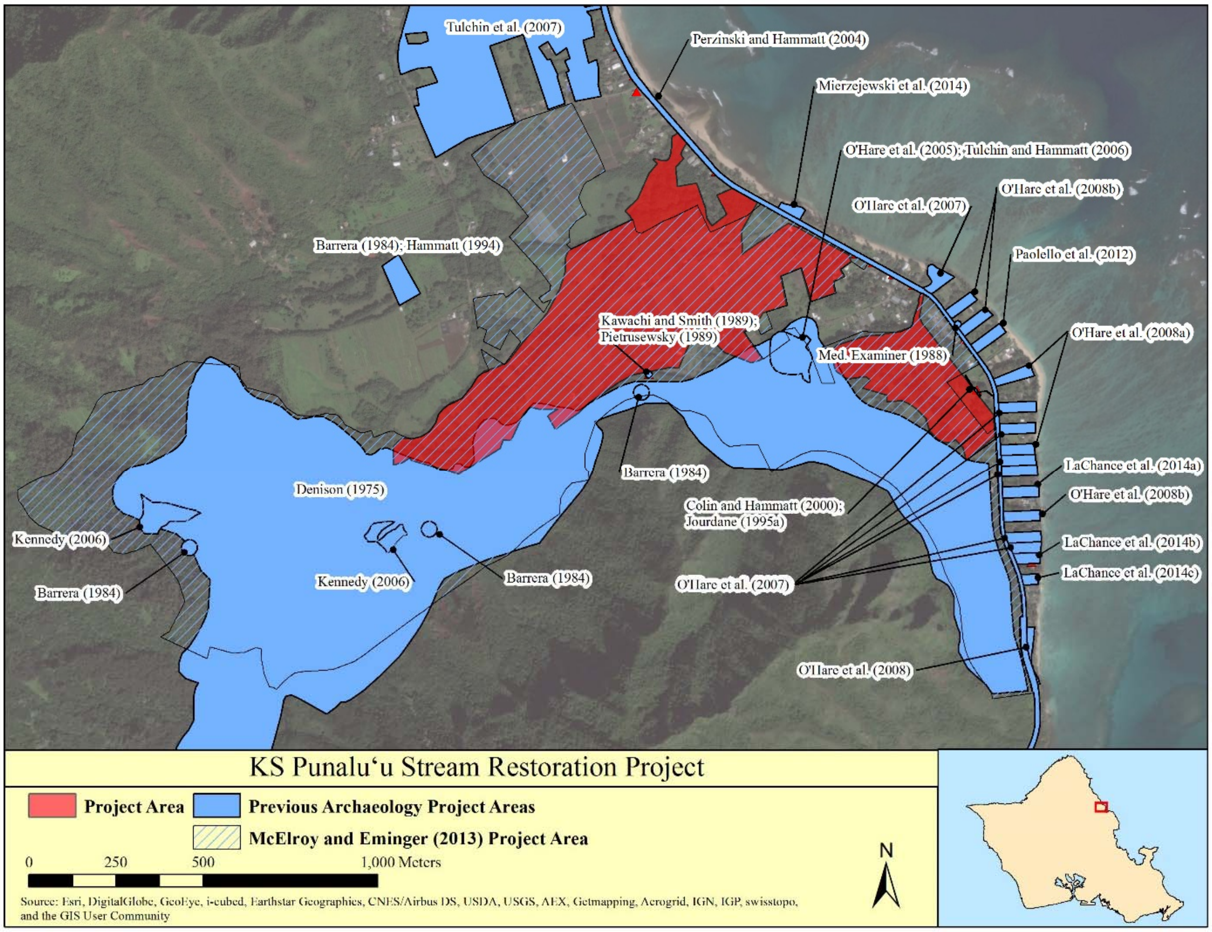
Site 7727, an imu, was destroyed and data recovered by excavation, and therefore is no longer significant. Data from this site does relate late pre- to early post-Contact habitation in the valley.

Site 7728, a buried terrace, is significant under Criterion d. Following this criterion, recording of this feature provides information about agriculture in this portion of the valley. This site is particularly informative because surface remnants of older agricultural infrastructure has been destroyed or modified by 19th and 20th century activities.

The Sites 7733 and 7734, buried 19th century loʻi soils, are significant under Criterion d. The agricultural soil relates to loʻi in production during the first half of the 19th century, and as such documents the last stage of traditional agriculture in the valley before the significant changes initiated by commercial agriculture.

One of the most documented cultural resources in Punaluʻu is the Hanawao Heiau, or sacred place, which sits on a small pu'u that is about 85 feet high on the south side of the valley. It has been almost completely destroyed for use as a cemetery (Kamehameha Schools 2012). Multiple burials have been located during various makai and Kamehameha Highway roadway construction projects in the vicinity of Punaluʻu; the number of previous burial findings indicates that more burials may exist in the ma kai area of the ahupua'a. Exhibit 4-13 illustrates the location of previous archaeological surveys conducted in Punaluʻu (Kamehameha Schools 2010).

Exhibit 4-13. Previous Archaeological Surveys Conducted in Punalu'u. Project Construction Limit Boundary shown as Yellow Polygon



Source: Kamehameha Schools 2014

4.7 Geology and Soils

4.7.1 Topography and Elevation

The topography of the project area is relatively flat and gets steeper toward the west and south in the direction of the Ko′olau mountain range. More than half the area is relatively flat (0 to 6 percent slope) and low in elevation (0 to 100 feet). The project area gets steeper and higher in elevation toward the Ko′olau Mountain Range with approximately 30 percent of the project area with slopes of 6 to 15 percent and the eastern and southern sections of the project area reaching slopes of between 15 to 50 percent slope and an elevation of 600 feet. (Kamehameha Schools 2011)

4.7.2 Geology

The floor of Punaluʻu Valley is composed of sedimentary deposits which are thickest at the coast and taper towards the back of the valley. Near the coast these deposits can be as much as 60 meters (200 feet) in thickness (Oki et al. 2006). Deeper layers of these deposits are weathered basalts, while the more recent upper layers are mixtures of marine sediments (carbonate) and alluvium. These sedimentary deposits are important for hydrology because they are much less permeable than the underlying basalts. The sedimentary deposits can serve as caps on the aquifers held in the basalts preventing or retarding the flow of ground water to the sea. (Kamehameha Schools 2009)

4.7.3 Soils

The project area falls within the Humid Oxidic Soils on Low and Intermediate Rolling Mountain Slopes (167) Major Land Resource Area (MLRA). MLRA's are geographically associated land resource units delineated by the Natural Resources Conservation Service (NRCS) and characterized by a particular pattern that combines soils, water, climate, vegetation, land use, and type of farming.

An NRCS Soil Survey delineated 25 soil types occurring in the project area (Kamehameha Schools 2011). The soil texture within the project area is predominantly silty clay, stony clay, and clay. The principal soil series found on the flatter lands at lower elevations are: *Hanalei silty clay, Kaena stony clay, Kaloko clay, Kawaihapai stony clay loam, Keaau clay, Mokuleia loam and clay loam, Pearl Harbor clay, Waialua stony silty clay,* and *Waikane silty clay*; the upper elevation soils are largely *Kaena clay*, *Lolekaa silty clay*, and *Waialua stony silty clay*.

The NRCS approved Conservation Plan for the Punaluʻu Valley is presented in Appendix D.

4.8 Water Resources

Water resources include surface water, groundwater, and floodplains. Water quality is also addressed when discussing water resources. Surface waters include streams, rivers, lakes, ponds, estuaries and oceans. Groundwater is subsurface water that occupies the space between sand, clay, and rock formations. Groundwater, an essential resource in many areas, is used for water consumption and agricultural irrigation.

This section is organized by (1) hydrology (surface water and groundwater) and water quality; and (2) floodplains.

4.8.1 Hydrology and Water Quality

Surface Water

Most of the surface water in the project area is associated with the Punaluʻu Stream, its tributaries, and its diversions (see Exhibit 4-8 in Section 4.3 Wetlands). Punaluʻu Stream is a "medium-sized," perennial stream (Kamehameha Schools 2010) that receives flow from overland runoff from frequent rainfall in the area and from groundwater discharges. Numerous lower order tributaries flow downstream from the valley walls to join the Punaluʻu Stream before it reaches the sea, forming a continuous, perennial 4th order stream (Polhemus et al. 1992). Steep terrain and stream gradients in the Punaluʻu watershed cause water to run off rapidly following precipitation creating characteristically flashy discharge, with high flood peaks and low base flows (see Exhibit 4-14). The differences between mean daily discharge and peak flows are typically very large.

Daily Flows

Water was previously diverted from Punaluʻu Stream via the Punaluʻu Ditch System, which consisted of a diversion located at about the 210-foot elevation, a flume, transmission tunnels, and an open concrete ditch that transported water into an underground pipe distribution system. The ditch provided water to farm lots on KS' property as well as users not on KS' lands. Approximately 7.0 million mgd of water was diverted from Punaluʻu Stream via the Punaluʻu Ditch (Kamehameha Schools 2010). There is a dry season from late May to early October when stream discharges typically decrease. Because irrigation needs are greater in summer months than in the rainy season there is an inverse relationship between flow in the stream and the ditch; hence, more water flows in the ditch than remains in the stream during the summer (Kamehameha Schools 2009).

KS recently replaced the old ditch system with a piped system that has reduced water loss due to evaporation and leakages. The piped system includes a shut-off valve that allows KS to better control the stream diversion's flow during different times of the year. As a result of the new piped system, the amount of water being diverted from Punaluʻu Stream has decreased. With the new piping system, water is diverted based on how much is needed, providing a much more efficient system (Kamehameha Schools 2010). Recent measurement data collected by KS for 2013 show the amount of Punaluʻu Stream flow diverted into the Punaluʻu Ditch averages about 4.25 cfs during months when maximum irrigation is occurring.

United States Geological Survey (USGS) records of stream flow are available for the Punaluʻu Stream upstream of the project area[2]. The mean daily discharge of Punaluʻu Stream downstream of the diversion for water years 1955–2004 at gage 16303000 is 16.4 cubic feet per second (cfs) (Oki et al. 2006). The mean daily discharge at gage 16303003, which includes the diverted flow, for 1955–2004 is 24.9 cfs (Oki et al. 2006). Thus, the mean discharge into the Punaluʻu Ditch diversion over the same period was 8.5 cfs.

In summary, based on an average diversion of about 4.25 cfs with the new efficient piped water diversion system, the average daily flow of Punaluʻu Stream in the project area is approximately 20.7 cfs.

Peak Flood Flows

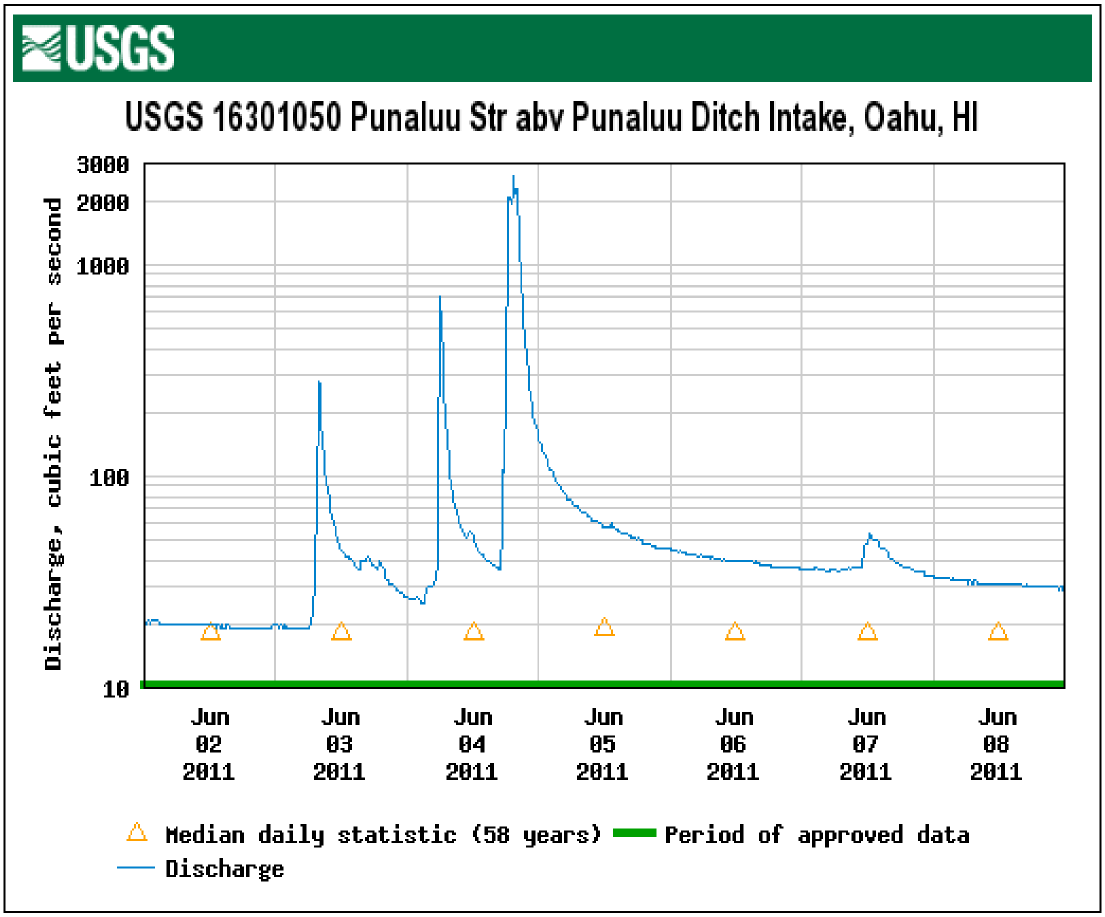
The largest peak flow measured by the USGS gage on Punaluʻu Stream for water years 1954–2013 is 6,900 cfs (1991), followed by 5,700 cfs in 1974 and 5,350 cfs in 2008 (USGS 2014). The drainage area at the USGS gage is 2.77 square miles, while the drainage area at the mouth near Kamehameha Highway is 6.24 square miles. The additional drainage area of the lower watershed results in higher peak flows than measured at the USGS gage. The regional regression equations developed by the USGS (Oki et al. 2010) were used to estimate peak annual flood recurrence intervals at the mouth.

---

[2] USGS gage records are available for water years 2010–2013 at gage 16301050 Punaluʻu Stream above Punaluʻu Ditch intake and for water years 1954–2009 at gage 16303000 Punaluʻu Stream near Punaluʻu, which was located downstream of the intake for the Punaluʻu Ditch diversion. The USGS measured flow diversion into Punaluʻu Ditch at gage 16302000, Punaluʻu Ditch near Punaluʻu, for water years 1954–2008. The USGS combined discharge from stations 16303000 (Punaluʻu Stream downstream of the intake) and 16302000 (the diverted flow) and assigned it station 16303003.

The estimated flow levels for the 2 through 100 year events at the USGS Punaluʻu Stream gage as well as at the mouth range from 1,840 cfs to 12,396 cfs (Exhibit 4-15).

Exhibit 4-14. Illustration of the Extremely Flashy Nature of Discharge in Punaluʻu Stream



Source: U.S. Geological Survey 2013, recorded during the unseasonal thunderstorms on June 3–4, 2011 (NOAA 2011).

Exhibit 4-15. Peak Flow (in cfs) Estimates by Annual Recurrence Interval

Recurrence Interval (year)	Bulletin 17B USGS Gage	Regression USGS Gage	Regression Punaluʻu Stream Mouth
2	1,840	1,820	2,358
5	2,960	2,940	4,433
10	3,760	3,740	6,091
25	4,820	4,810	8,451
50	5,650	5,650	10,386
100	6,490	6,530	12,396

Source: Oki et al. 2010.

Groundwater

The project area is located within the Koʻolau rift zone groundwater area (Nichols et al. 1996). The thickest sedimentary deposits along the floor of Punaluʻu Valley lay at the coast and taper inland toward the valley wall (Kamehameha Schools 2009). These sedimentary deposits are important because they form a caprock which confines fresh groundwater inland where it forms a lens that overlays more brackish seawater (Lau and Mink 2006). The *Makaliʻi* basal aquifer beneath Punaluʻu Valley is about one square mile in area and is recharged both from dike impounded aquifers and from precipitation and infiltration (Kamehameha Schools 2009). A study by CH2MHill in 1991 showed two aquifers underlying the valley, with the Koʻolauloa aquifer to the north and the Kahana aquifer to the south (Kamehameha Schools 2009). Volcanic dikes in the steep cliffs at the head of the valley impound perched groundwater, which is gradually discharged through seeps, springs, and the bed of Punaluʻu Stream to the ocean (Stearns and Vaksvic 1932). Additional groundwater is lost as withdrawals from wells, water development tunnels, and evapotranspiration (U.S. Geological Survey 2011b).

Seven ground water wells are located on KS' property in Punaluʻu. Of these, only the Makali'i 2 Well, an observation well, is in use. KS estimates that these seven wells could provide up to a combined 1.5 mgd of potable or non-potable water if put into production. Two of the unused wells on KS' property are owned by the City and County of Honolulu Board of Water Supply (BWS). BWS does operate other wells in the ahupuaʻa on non-KS lands that provide potable water to Hau'ula, Punaluʻu, Kahana, Ka'a'awa, and Ko'olau Poko. (Kamehameha Schools 2010)

Approximately 75 percent of the 0.156 mgd of water provided to Punaluʻu is used for residential purposes, 15 percent for commercial use, one percent for City Government, and nine percent for agriculture.

Water Quality

The USGS regularly performs surveys of surface and ground water quality on Oʻahu as part of the National Water-Quality Assessment Program (Brasher and Anthony 2000). Levels of contaminants have been determined for many Oʻahu streams and aquifers including Punaluʻu. Land use is usually a reliable predictor for water quality and problem areas on Oʻahu are focused in urban and central Oʻahu where commercial sugar and pineapple cultivation was once the predominant land use (Anthony et al. 2004). In 2004, the State of Hawaiʻi Department of Health (HDOH) found that Punaluʻu Stream did not exceed limits for nitrate, total nitrogen, total phosphorus, total suspended solids or turbidity for the years 1997 to 2003. However, the stream is designated a Category 2 stream, meaning "some designated uses are met, but insufficient data exist to evaluate all uses." Brasher et al. (2004) reported low concentrations for nitrogen and phosphorus within standards in Punaluʻu Stream, and metal concentrations (magnesium, manganese, iron) lower than in urban streams. ENPRO (2008) reported elevated values of mercury, chlorine, and aluminum in middle and lower reaches of Punaluʻu Stream; however, they noted that values were below HDOH numeric regulatory standards for 'dry season' (HAR 11-54-05.2); and chlorine was below the acute standard. They found turbidity and chlorophyll-a values elevated above HDOH standards for the middle reaches of the stream.

Ground water quality in the Ko'olau Loa and Kahana Aquifer System Areas is generally very high, with the main concern being salinity, which primarily affects the basal aquifer. Other potential threats to ground water quality include septic tanks, agricultural lands, utility stations, residential parcels, sewer lines, transformer PCBs, and cesspools (Kamehameha Schools 2010).

4.8.2 Floodplains

Floodplains are lowland areas located adjacent to bodies of water in which the ordinary high water level fluctuates on an annual basis. Along rivers, the ordinary high water level may fluctuate as a result of a precipitation event. Tidally influenced waters may fluctuate due to spring tides or as a result of a large storm event (e.g., storm surge). When one of these events is large enough, it causes the water level to exceed the ordinary high water mark and enter the adjacent floodplain. As a result, functioning floodplains provide critical protection for surrounding communities because of their ability to dissipate energy and water from flooding. Any fill to floodplains results in the decrease of the effectiveness of a floodplain to mitigate flooding. Floodplains are often discussed in terms of the 100-year flood (also known as the base flood), which is a flood having a one percent chance of occurring in any given year. Floodplains are valued for their natural flood and erosion control, enhancement of biological productivity, and socioeconomic benefits and functions.

Punaluʻu Stream is prone to flash flooding and often floods the lower valley lands. The unconsolidated and erodible push-up berms that line much of Punaluʻu Stream's banks are prone to breaching nearly every year, resulting in unpredictable flooding of farm fields, residences, and businesses in the valley. Undersized culverts and debris accumulation at the bridge also contribute to flooding problems.

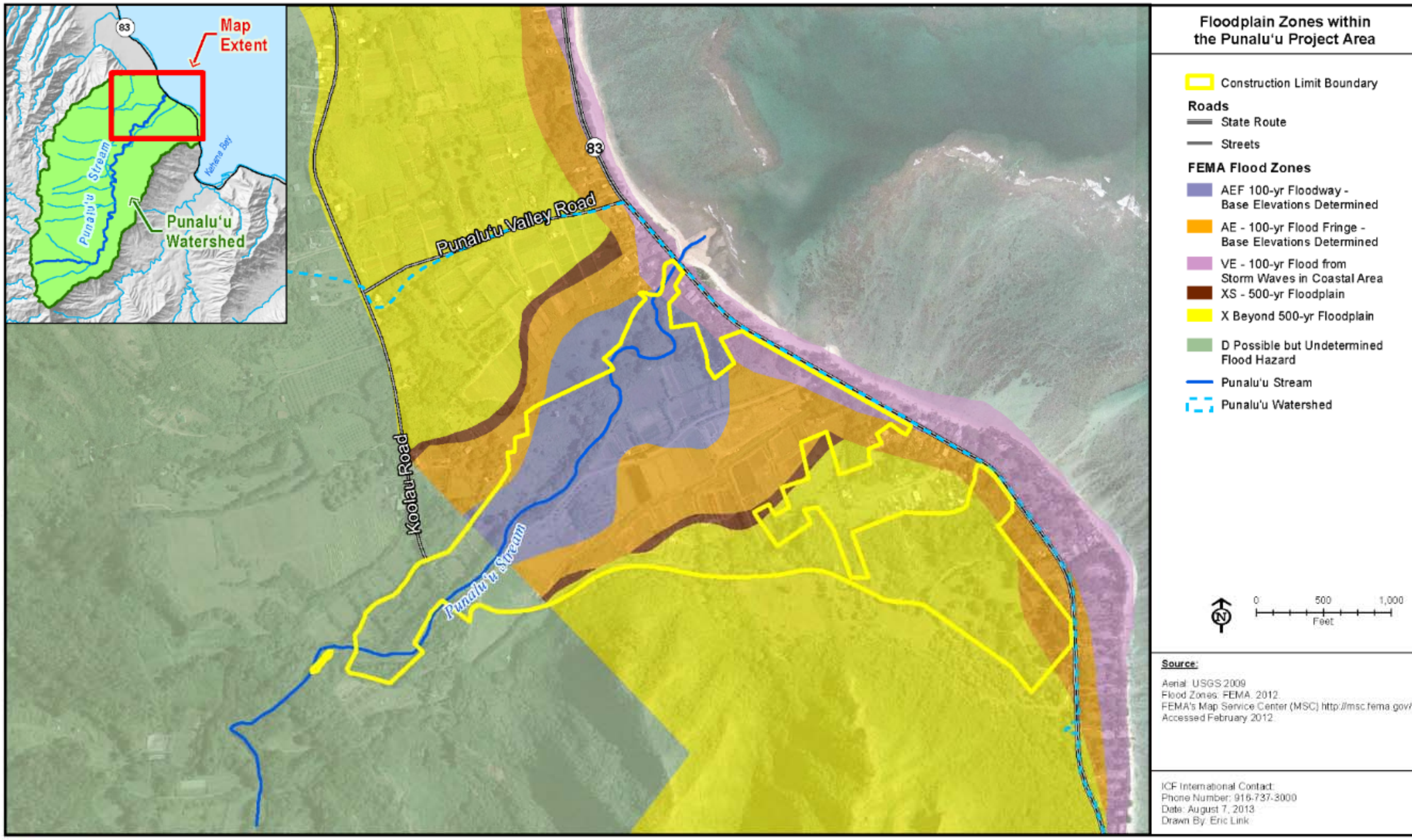
There are two types of flooding that occur on KS' property. One type of flooding is caused when the Punaluʻu Stream overflows during large rain events. This flooding affects the Hau'ula side of the property where commercial farming exists. The second type of flooding is caused by sheet flow off the mountain side during large rain events and occurs on the Kahana side of the property behind the existing restaurant.

Existing culverts in this area do not provide adequate drainage across Kamehameha Highway to the ocean and are both undersized and located in inappropriate locations. Currently, water backs up behind the highway and may take over a week to drain. Residents report that some type of flooding affects homes about once or twice a year. Additional drainage problems occur ma kai of the highway, where seawalls lack drainage features, therefore retaining water on the beach lots.

FEMA has designated the regulatory floodplains in the Punaluʻu Valley (Exhibit 4-16). Hydraulic modeling of flood flows for existing and proposed conditions were performed for this project as part of the design process to ensure that the restoration design attained flood control objectives (Appendix E). A HEC-RAS hydraulic model was created to model the 2, 5, 10, 25, 50, and 100-yr annual recurrence interval events. The flow magnitudes corresponding to the recurrence intervals were determined through analysis of USGS Punaluʻu Stream gaging records and application of the flood-frequency estimate methods published by the USGS for the Punaluʻu watershed (Oki et al. 2010). Ground elevations for the model were derived from an elevation surface created for the project composed of field surveyed and LiDAR topography. The LiDAR topography was flown in 2007 and was verified and supplemented for this project in 2011 with multiple field surveyed cross-sections spanning the channel and floodplain throughout the project area. The model's elevation surface also includes detailed field topography surveyed in the vicinity of the new Punaluʻu Bridge in 2006 in support of the bridge design. The new bridge design was included in both the existing and proposed conditions models. Field mapping was conducted to delineate the boundaries of different land use types and vegetation communities to develop roughness polygons for which Manning's n flow resistance values were assigned.

The restoration design does not create a rise in the 100-yr flood in the lower reach compared to existing conditions for the first 2,600 feet upstream of the bridge. The 90% design 100-yr water surface is up to 0.8 feet lower than the existing condition for stream stations 1200–2600. The 90% design produces up to 1.1 feet higher 100-yr water surface elevations for stations 2700–3900, within the proposed new floodplain corridor. The relocated and elevated Green Valley Road contains the increased water surface elevations in this reach. The rise in water surface elevations in this reach is due to increased flow resistance in the 90% design (use of higher Manning's n roughness values) to reflect the conversion of agricultural and fallow land, and aquaculture ponds, within the corridor into more flow restrictive forest and orchard. Similar trends are exhibited in the other recurrence interval plots. The effect of creation of the estuary and removing the stream's artificial berms on lowering the 90% design water surface elevations up to 3 feet in the lower reach is evident on the 2 and 5-yr plots.

Exhibit 4-16. Floodplains in the Punalu‘u Valley



Chapter 5
Environmental Consequences

5.1 Air Quality

5.1.1 Proposed Action

Adverse impacts to air quality would not be expected to result from the Proposed Action. All aspects of the Proposed Action would comply with HDOH Chapter 60.1, *Air Pollution Control*. Short-term impacts associated with the restoration work, such as exhaust emissions from construction equipment and construction workers' vehicles and fugitive dust generated during soil excavation and grading activities would be unavoidable. However, dust control measures and Best Management Practices (BMPs), such as phasing of construction; centralizing vehicular traffic routes; frequent spraying of construction vehicles; construction debris, and bare areas; and rapid covering of bare areas, would be applied during all excavation and grading activities. A dust control management plan would be developed prior to implementation of the Proposed Action; this plan would identify and address all activities that have the potential to generate fugitive dust. Long-term, operational impacts would be minimal and would result primarily from the operation of agricultural equipment in the restored floodplain. Upon completion of the restoration work, the air quality in the Punaluʻu watershed would be expected to return to its existing condition.

5.1.2 Restoration with Habitat Bank Option

Potential creation of the Punalu'u Habitat Bank would not require any additional construction or restoration work beyond the stream restoration activities that would take place under the Proposed Action. As a result, impacts to air quality under this option are anticipated to be the same as those described for the Proposed Action.

5.1.3 No Action Alternative

Under the No Action Alternative, the habitat restoration work would not be completed, and no additional impacts related to air quality would occur. Existing activities would continue within the Punaluʻu watershed.

5.2 Biological Resources

5.2.1 Proposed Action

Potential direct and indirect impacts on biological resources would result from construction activities associated with the habitat restoration work; however, potential construction-related impacts would be short-term, lasting only the duration of work. In addition, BMPs would be applied during construction activities to minimize impacts to the extent possible. As a result of the habitat restoration work, the overall or long-term impacts on biological resources are expected to be beneficial and outweigh the temporary adverse impacts. This impact discussion is organized like Section 4.2 – terrestrial and freshwater, marine, and protected species and habitat.

Terrestrial Vegetation/Habitat

As stated in Section 3.2.3, existing vegetation in the habitat restoration project area is comprised primarily of non-native and invasive species. Clearing and grubbing associated with cutting, grading, and filling activities, as well as the targeted removal of hau bush, will result in the removal and death of these plants in the project area.

Outside of those areas targeted for clearing and grubbing, trees, shrubs, and plants will be retained and protected during construction. In particular, tree protection zones will be established around Polynesian-introduced tree species or large trees important to the structural integrity of the stream bank so that these trees are retained and protected from injury or damage during construction.

Following clearing and grubbing activities, cleared debris, as well as non-native and invasive vegetation, will be disposed of at an authorized disposal site. All mulches used for erosion control will be clean and free of noxious weeds to prevent the future spread of invasive species in the project area.

Following completion of the habitat restoration work, cleared areas will be re-vegetated with native trees and grasses (see Section 3.2.3). In addition to replacing invasive and non-native species with native vegetation, planting of trees along the riparian corridor would provide the shading necessary to prevent shade-intolerant invasive grasses from re-establishing.

As impacts would be confined to the footprint of the construction area, the area to be cleared consists primarily of invasive and non-native species, and important native trees in the area would be protected, no significant adverse impacts to vegetation are expected. Additionally, through planting of native species, the project is expected to result in an increase in the amount of native, intact habitat in the long term.

Terrestrial Wildlife and Freshwater Species/Habitat

Terrestrial wildlife could be affected by temporary construction noise. Although many studies have been conducted on the effects of noise on animals, few long-term studies performed in natural settings have been completed. Those that are available often lack specific information concerning noise intensity, spectrum, and duration of exposure. Some studies have indicated a relatively high threshold noise level (80 to 120 dBA) for disturbance of many wildlife species (Dufour 1980, Manci et al. 1988, Bradley et al. 1990, McKechnie and Gladwin 1993). Sound levels above approximately 90 dBA are likely to have an adverse effect on mammals and are associated with behavior such as retreat from the sound source, freezing, or a strong startle response. Sound levels below 90 dBA usually cause much less adverse behavior (Manci et al. 1988). Ellis et al. (1978) reported a coyote family playing and feeding under high voltage power lines with a noise level of 63 dBA, which was relatively constant. Therefore, a temporary noise disturbance of approximately 81 dBA created by an excavator, the loudest construction equipment to be used at the site, would have minimal impacts on wildlife species located at or near the project area. Furthermore, some studies have shown that wildlife become accustomed to new noise sources, and that continuous noise has a minimal "startle factor" compared with individual noise events at similar maximum noise levels (Manci et al. 1988, Dufour 1980, McKechnie and Gladwin 1993, Bradely et al. 1990).

Clearing and grading activities would displace mobile terrestrial and aquatic species to adjacent undisturbed areas of similar habitat. Less mobile species, such as turtles, snakes, and small rodents, might be unable to escape. The displacement could, at least temporarily, increase the density of wildlife in the surrounding areas and increase the inter- and intra-specific competition for available resources, including foraging and nesting areas. Although some individuals would be affected, no major changes in wildlife populations are expected to occur.

Any runoff associated with construction activities could affect adjacent freshwater plant and wetland communities, and affect downstream aquatic environments by increasing siltation and turbidity. All necessary BMPs would be used during construction to control sedimentation and runoff; as a result, this impact would be minor and short-term.

In-water construction activities (earthwork) could affect some benthic organisms and their habitat through release of sediment into the water column, thereby increasing turbidity and decreasing the concentration of dissolved oxygen. The increased turbidity and reduced concentration of dissolved oxygen would cause fish and other mobile organisms to avoid such areas. Additionally, in-water noise produced from construction equipment might affect aquatic organisms. However, temporary barriers and earthen berms will be used for all in-water work to isolate work areas from active stream flow. As a result, any increase in turbidity and/or disturbance is expected to be minimal and temporary, lasting only during construction.

Potential adverse effects to freshwater communities would be at least in part, if not completely, offset by the long-term beneficial impacts of the habitat restoration work. Restoring the natural hydrology of the stream will result in a more natural meandering stream flow which provides important habitat for aquatic organisms throughout a variety of life stages. In addition, creating a larger floodplain and stream corridor will result in an increase in the amount of high quality wetland and riparian habitat in the project area. As a result, the project is intended to create an overall benefit to terrestrial and aquatic species and habitat.

Marine

Impacts to marine species are expected to be minimal as the project would not be in the shoreline area and is entirely mauka of the Kamehameha Highway. There is the potential for a small discharge of turbid water generated during construction activities to reach nearshore ocean waters. However, this discharge would be temporary, and would be minimized through the implementation of BMPs such as the installation of turbidity curtains. As a result, no significant impacts are expected as a result of the Proposed Action. In the long-term, the project would result in beneficial impacts to nearshore waters and coral communities by reducing the amount of sediment that is currently transported from upstream reaches to nearshore waters. By converting the Punaluʻu Ditch to a new estuary channel with a riparian forest corridor, sediment loads generated from the Kahana sub-basins would be deposited in the estuary instead of being directly transported into the coral reefs.

Protected Species and Habitat

As stated in Section 4.2.3, there is no federally-designated critical habitat in the project area. However, there are several protected species within the Punaluʻu watershed with potential habitat in the restoration project area (see Exhibit 4-5). Potential impacts on these species would be similar to those impacts described above for terrestrial and aquatic species and habitat. KS would survey the area to be affected by construction prior to conducting construction activities. KS would notify the Hawaiʻi Division of Forestry and Wildlife and the USFWS if any protected species were identified, and would coordinate with these agencies to avoid affected protected species and habitat. The overall positive ecological impacts of the project could benefit protected species and habitat in and around the project area.

5.2.2 Restoration with Habitat Bank Option

Potential creation of the Punaluʻu Habitat Bank would not require any additional construction or restoration work beyond the stream restoration activities that would take place under the Proposed Action. As a result, adverse impacts to biological resources under this option are anticipated to be the same as those described for the Proposed Action.

Establishment of the Punaluʻu Habitat Bank would preserve habitat for at least 17 federally-listed plant and animals species within the Punaluʻu stream, valley, and estuary. As a result, this option is anticipated to result in greater long-term benefits to biological resources in the watershed than would be anticipated under the Proposed Action.

5.2.3 No Action Alternative

Under the No Action Alternative, the habitat restoration work would not be completed, and no additional impacts related biological resources would occur. Existing activities would continue within the Punaluʻu watershed.

5.3 Wetlands

5.3.1 Proposed Action

The Proposed Action would create 9.55 acres of new wetland habitat and enhance 15.12 acres of existing habitat (Exhibit 3-5). Approximately 4.47 acres of new freshwater emergent wetland would be created and 0.86 acres of existing wetland would be enhanced as part of the construction of a settling basin for runoff from the Kahana hillslope. Construction of new taro ponds would result in creation of 2.98 acres and enhancement of 1.65 acres of freshwater emergent wetland. In addition, existing riverine and estuarine wetlands within the Punaluʻu Stream and estuary channel would be enhanced by restoring natural flood flows, removing invasive species, and reducing sedimentation.

AECOS determined that roughly 10.6 acres of the project area is wetland, of which 7.8 acres (74%) is jurisdictional (Exhibit 4-7 and Exhibit 4-8, and Appendix B).

No existing jurisdictional wetlands would have fill placed in them as part of the Proposed Action. The wetland delineation was performed after the 90% design grading plan was completed. The 90% design grading plan shows fill would be placed in jurisdictional wetlands of 0.05 acres (PF03A *Hau* at Punaluʻu Stream mouth) and 0.23 acres (PEM1A/PEM1C Grassland NW of Punaluʻu Stream) (Exhibit 5-1). Based on the results of the wetland delineation survey, the 90% design plans will be refined during development of the final construction drawings to not show any filling of jurisdictional wetlands. Therefore, filling of these two wetland areas is not included in the total acreage of filled wetlands.

Two existing non-jurisdictional wetland areas of 0.90 acres (PF03A *Hau* wetland) and 0.50 acres (PEM1C SE cattle pasture) totaling 1.40 acres would be filled with soil from the floodplain excavation as part of the project.

Three existing jurisdictional wetland areas of 0.24 acres (PF03A *Hau* at Punaluʻu Stream mouth), 1.06 acres (PEM1A/PEM1C Grassland NW of Punaluʻu Stream), and 0.04 acres (PEM1C Entrance road grassland) totaling 1.34 acres would be cut as part of the project. These area will continue to be wetland features, and will likely be enhanced due to improved hydrologic connection with the stream and revegetation to remove non-native species.

Two existing non-jurisdictional wetland areas of 0.13 acres (PF03A *Hau* wetland) and 0.86 acres (PSS34/PEM1C Primrose willow & para grass wetland (SE)) totaling 0.99 acres would be cut as part of the project. Proposed cut of the 0.99 acre wetland will likely enhance this feature as it would become part of the proposed wetland and settling basin that would be wet more frequently than existing conditions and would be replanted with native wetland species.

Recreation of a floodplain with native species north of Punaluʻu Stream would enhance 3.48 acres of existing wetland near the confluence of Waiono Stream in an area currently dominated by invasive grasses. Approximately 0.49 acres of new riverine wetland would be created by constructing a new estuary channel to deliver Kahana runoff to the estuary instead of diverting it through Punaluʻu ditch and directly into the ocean, as is currently done. Enlarging the existing estuary that has nearly filled with sediment and diverting flows from the former Punaluʻu Ditch to the estuary would create 1.61 acres of estuarine wetland and enhance 4.20 acres.

In total, the Proposed Action will result in creation of 9.55 acres of wetland with a loss due to filling of 1.40 acres of floodplain for a net creation of 8.15 wetland acres. Furthermore, the Proposed Action will create 36.14 acres of mixed species forest, some of which will likely revert to wetland habitat once natural hydrology is restored.

Exhibit 5-1. Existing Wetland Changes due to the Proposed Action

Wetland	Wetland Type	Soil Pit(s)	Jurisdictional?[a]	Total Area within Project Area (acres)	Proposed Grading Cut Disturbance (acres)	Proposed Grading Fill Disturbance (acres)
Hau at Punaluʻu Strm mouth	PF03A	2-11, 2-9, 2-12	Yes	1.0	0.24	0.00 [b]
Hau by Kam. Hwy.	PF03A	2-2, 2-3	Yes	1.5	0.00	0.00
Hau wetland	PF03A	2-8, 2-14	No	1	0.13	0.90
Primrose willow & para grass wetland (SE)	PSS34/PEM1C	4-10, 4-14	No	1.3	0.86	0.00

SE cattle pasture	PEM1C	3-6	No	0.5	0.00	0.50
Grassland NW of Punalu'u Stream	PEM1A/PEM1C	4-4, 4-6, 4-11, 4-12	Yes	3.5	1.06	0.00[b]
Entrance road grassland	PEM1C	2-1, 2-1b	Yes	1.8	0.04	0.00
Total				**10.6**	**2.33**	**1.40**
Jurisdictional Total				**7.8**	**1.34**	**0.00**

Source: AECOS, Inc. 2014.
[a] AECOS' delineation will be sent for review and concurrence by the U.S. Army Corps of Engineers in order for the jurisdictional determination to become official.
[b] The 90% grading plan shows minor fill of the mapped wetland in this area. The final grading plan will be revised to not show any fill of the wetland.

5.3.2 Restoration with Habitat Bank Option

Potential creation of the Punalu'u Habitat Bank would not require any additional construction or restoration work beyond the stream restoration activities that would take place under the Proposed Action. As a result, adverse impacts to wetlands under this option are anticipated to be the same as those described for the Proposed Action.

The wetland mitigation bank component of the Punalu'u Habitat Bank would comprise all wetland areas to be enhanced or created through the habitat restoration work, which includes approximately 24.67 acres of enhanced or created estuarine, riverine, and freshwater emergent wetlands. As these wetlands will be preserved as part of the bank, this option is anticipated to result in greater long-term benefits to wetlands than would be anticipated under the Proposed Action. Furthermore, the bank would include a more extensive revegetation effort compared to the Proposed Action, which would provide additional wetland enhancement.

5.3.3 No Action Alternative

Under the No Action Alternative, the habitat restoration work would not be completed, and no additional impacts related to water resources would occur. Existing activities would continue within the Punalu'u watershed.

5.4 Noise

5.4.1 Proposed Action

Construction activities such as those required for excavation or fill areas would generate temporary noise. The noise levels would vary depending on the activities conducted and the type of construction equipment required; however, the associated noise levels are expected to be short-term (the duration of construction activities is estimated at three to four months) and minor. Construction equipment will include an excavator, backhoe, dump trunk, compression-type roller, vibratory roller, road grader, bob cat, and front end loader; the loudest equipment expected to be used during the restoration work is an excavator. Typical heavy construction equipment noise levels are listed in Exhibit 5-2. No construction work would occur at night when noise would cause the most annoyance. Because construction noise is temporary; there are no sensitive receptors in the immediate vicinity; and the noises generated from the construction equipment that is anticipated to be used for the proposed project are lower than permissible sound levels, no significant adverse noise impacts associated with the Proposed Action would be expected.

Exhibit 5-2. Heavy Construction Equipment Noise Levels at 50 Feet

Equipment Type	Generated Noise Level (dBA)[a]
Backhoe	78
Front End Loader	79
Dozer	82
Dump Truck	76
Concrete Mixer Truck	79
Concrete Pump Truck	81
Crane	81
Roller	80
Flat-Bed Truck (18 Wheel)	74
Scraper	84

[a] Actual Measured L_{max} at 50 feet (dBA, slow) Samples Averaged
Source: FHWA 2011

5.4.2 Restoration with Habitat Bank Option

Potential creation of the Punalu'u Habitat Bank would not require any additional construction or restoration work beyond the stream restoration activities that would take place under the Proposed Action. As a result, noise impacts under this option are anticipated to be the same as those described for the Proposed Action.

5.4.3 No Action Alternative

Under the No Action Alternative, the habitat restoration work would not be completed, and no additional impacts related to noise would occur. Existing activities would continue within the Punaluʻu watershed.

5.5 Land Use

5.5.1 Proposed Action

The restoration work would not significantly impact land use in the Punaluʻu valley, as the Proposed Action is intended to restore traditional Hawaiian land use compatible with periodic flood inundation, making the valley more suitable for agricultural production. Furthermore, the Proposed Action is consistent with the *Punaluʻu Ahupuaʻa Plan*'s long range goals of ensuring healthy native ecosystems and working landscapes, and responsible and balanced utilization of agricultural lands (KS 2010).

Within the restored floodplain, various land uses consistent with existing agricultural zoning would focus on native and Polynesian plant communities and Hawaiian agriculture activities compatible with periodic flooding (e.g., fruit orchards, loʻi kalo). Land uses compatible with the proposed flood mitigation and restoration goals would continue within the active stream corridor; other areas would be reserved for habitat restoration and flood conveyance.

Construction work conducted as part of the restoration efforts could temporarily affect nearby land uses through increased traffic and the temporary elevation of noise levels; however, construction activities will be limited to daylight hours (7:00 am – 6:30 pm) to minimize disturbance from noise and construction vehicles will be limited to established travel corridors, which will avoid residential areas. As a result, these impacts would be temporary and would not have lasting impacts to local land use. In addition, local residents are anticipated to benefit from the alleviation of chronic flooding resulting from the Proposed Action.

Some re-designation of local land uses may occur due to the Proposed Action so that farmers on chronically flooded agricultural lands are relocated to the floodplain margins on elevated terraces. Existing tenant farmers working low-lying fields may be displaced and relocated to higher ground. Most farmers will only be displaced temporarily during construction activities, though a few farmers working low-lying areas prone to chronic flooding will be permanently relocated. No zoning changes would occur as a result of the Proposed Action.

5.5.2 Restoration with Habitat Bank Option

Potential creation of the Punaluʻu Habitat Bank would not significantly impact land use in the Punaluʻu valley, as the bank would not curtail other beneficial uses of KS lands in the Punaluʻu Valley. Current uses in the project area are agriculture and education activities, and these activities would continue under the banking mechanism. Within the restored floodplain, mixed land uses would focus on native and Polynesian plant communities and Hawaiian agriculture activities compatible with periodic flooding. Furthermore, this option is consistent with the Punaluʻu Ahupuaʻa Plan's long range goals of ensuring healthy native ecosystems and working landscapes, and responsible and balanced utilization of agricultural lands (KS 2010).

Establishment of the Punaluʻu Habitat Bank may provide a means to offset resource impacts associated with future development projects on Oahu; however, it is not individually anticipated to promote economic development. As a result, no significant long-term impacts are anticipated.

5.5.3 No Action Alternative

Under the No Action Alternative, the habitat restoration work would not be completed, and no impacts related to land use would occur. Existing activities would continue within the Punaluʻu watershed.

5.6 Cultural Resources

5.6.1 Proposed Action

Adverse impacts to cultural resources would not be expected to result from the Proposed Action. The proposed restoration work is intended to restore traditional cultural landscapes and is consistent with the KS Cultural Resource Management Plan.

As noted in Section 4.6, a total of six archaeological sites were recorded during the 2014 cultural resources survey. These sites included a valley-bottom irrigation network dating to the early to mid-20th century (Site 50-80-06-7236); a mid-20th century complex of concrete foundations and a pond (Site 50-80-06-7718), an isolated buried imu (Site 50-80-06-7727), a buried pondfield terrace (Site 50-80-06-7728), and two buried 19th century loʻi soils (Sites 7733 and 7734). (Kamehameha Schools 2014). Data recorded at all sites is recommended to be sufficient documentation; however, archaeological monitoring (based on an approved Archaeological Monitoring Plan) is recommended during all ground-disturbing construction activities. Monitoring will also include educating the construction personnel about the presence of the archaeological site and the potential for additional discoveries.

If any cultural resources were to be inadvertently discovered during staging or construction activities, all work would be stopped immediately and the State Historic Preservation Division (SHPD) would be notified of the discovery. Burial finds would be treated in accordance with HRS Chapter 6E-43, *Prehistoric and historic burial sites*. The SHPD would determine the appropriate treatment of any burials and associated cultural resources in consultation with recognized descendants in the Oʻahu Island Burial Council.

5.6.2 Restoration with Habitat Bank Option

Potential establishment of the Punalu'u Habitat Bank would not impact cultural resources in the Punaluʻu watershed as no additional ground disturbing activities are associated with this option. Impacts to cultural resources under this option are anticipated to be the same as those described for the Proposed Action.

5.6.3 No Action Alternative

Under the No Action Alternative, the habitat restoration work would not be completed. Existing activities would continue within the Punaluʻu watershed, and cultural resources in the area would continue to be affected by chronic flooding.

5.7 Geology and Soils

5.7.1 Proposed Action

Significant impacts to geology and soils are not expected to occur as a result of the Proposed Action, as all proposed earthwork would occur in areas that have been previously altered. In addition, BMPs would be applied during construction activities to minimize soil erosion to the extent possible. Although the restoration activities would involve cutting, grading, and filling, the intent of the Proposed Action is to restore the geomorphic and ecologic processes of the Punaluʻu Valley. The new corridor landscape that would be created by the floodplain excavation and elevated road is based on a natural alluvial valley morphology in which the Kahana (southern) hillslope transitions into a terrace elevated above the floodplain that in turn transitions into a lower elevation floodplain and stream channel. Areas outside the floodplain corridor where flood risks would be reduced would not be subjected to the chronic damages they have experienced under the site's current conditions.

5.7.2 Restoration with Habitat Bank Option

Potential creation of the Punalu'u Habitat Bank would not require any additional construction or restoration work beyond the stream restoration activities that would take place under the Proposed Action. As a result, impacts to geology and soils under this option are anticipated to be the same as those described for the Proposed Action.

5.7.3 No Action Alternative

Under the No Action Alternative, the habitat restoration work would not be completed. Existing activities would continue within the Punaluʻu watershed, and there would continue to be widespread erosion as a result of chronic flooding.

5.8 Water Resources

5.8.1 Proposed Action

Potential direct and indirect impacts on water resources would result from construction activities associated with the restoration work. Potential construction-related impacts would be short-term, lasting only during the duration of work. In addition, BMPs would be applied during construction activities to minimize impacts to the extent possible. As a result of the habitat restoration work, the overall or long-term impacts on water resources are expected to be beneficial and outweigh the temporary adverse impacts. This impacts discussion is organized like Section 4.8–hydrology and water quality and floodplains.

Hydrology and Water Quality

Construction activities that occur in or along Punaluʻu Stream would result in temporary impacts to the stream, including displacement of sediment and increased turbidity in the water column. These impacts would be temporary, lasting only during the duration of work (three to four months); in addition, BMPs would be used to reduce turbidity during construction.

Site preparation (clearing and grading) during construction would expose soils, thereby creating the potential for erosion and runoff into adjacent surface waters. KS would implement BMPs to avoid erosion and runoff into adjacent surface waters during construction.

The potential impacts of sedimentation to surface waters include increased turbidity in the water column; increased suspended nutrients and organic matter in the water column leading indirectly to a reduction in dissolved oxygen levels; and deposition of sediment on water body beds. Again, these impacts would be temporary, lasting only during the duration of work.

Potential adverse impacts to surface waters would be outweighed by the expected long-term benefits created by the project. By restoring or improving the natural hydrology of the project area, the project would result in beneficial impacts to surface waters by reducing the amount of sediment that is currently transported from upstream reaches to the nearshore environment. By converting the Punaluʻu Ditch to a new estuary channel with a riparian forest corridor, sediment loads generated from the Kahana sub-basins would be deposited in the estuary instead of being directly transported into marine waters. Additionally, elimination of the existing streambank berms would remove an artificial constraint imposed on the stream's ability to meander and would enable the channel to gradually regain a more natural channel sinuosity through natural channel migration into the new floodplain corridor. These activities would benefit surface water quality by filtering runoff and reducing the amount of sediment deposited in the stream.

There are no expected adverse impacts on groundwater from construction activities. In the long-term, as a result of restoring natural ecological processes, including creating a floodplain corridor, groundwater recharge may occur more quickly and groundwater quality may improve.

Floodplains

Restoration work would take place within floodplains, as the primary objective of the Proposed Action is to develop sustainable flood protection and restore hydrologic processes in the Punaluʻu watershed. However, no significant adverse impacts to floodplains are expected from the proposed project, as the project is expected to benefit floodplains by creating a larger floodplain to store floodwaters, thus improving flood conveyance. The fill that was placed in the floodplain over the past 100 years would be excavated to restore natural floodplain elevations and contours. The Green Valley Road would be located to the top of the newly constructed berm that would elevate the road out of the floodplain. The relocated road would form the southern boundary of the new approximate 4,200 feet long, 70-acre floodplain corridor (measured within KS property). Punaluʻu Stream's floodplain corridor would be changed from the existing 100–125 feet width into a new corridor over 700 feet wide, on average. The road would be elevated about 3–5 feet, on average, to prevent floodwaters from entering the southern side of the valley where excavated fill would be placed on the upland side of the berm to create new productive agricultural lands.

5.8.2 Restoration with Habitat Bank Option

Potential creation of the Punalu'u Habitat Bank would not require any additional construction or restoration work beyond the stream restoration activities that would take place under the Proposed Action. As a result, adverse impacts to water resources under this option are anticipated to be the same as those described for the Proposed Action.

Establishment of the Punalu'u Habitat Bank would preserve floodplain function in the Punalu'u valley by protecting up to 60 acres within the stream corridor and estuary in perpetuity. As a result, this option is anticipated to result in greater long-term benefits to biological resources in the watershed than would be anticipated under the Proposed Action.

5.8.3 No Action Alternative

Under the No Action Alternative, the habitat restoration work would not be completed. Existing activities would continue within the Punaluʻu watershed, and the area would continue to be subject to chronic flooding..

5.9 Impacts and Resources Not Analyzed in Detail

The following environmental resource areas are not analyzed in detail, as explained below.

- **Recreational areas and beach resources**–Restoration work due to the Proposed Action would only occur up to the edge of Kamehameha Highway; therefore, no work would take place near Punaluʻu Beach Park or other local beaches. Expansion of the estuary and estuary channel is not expected to have a measureable effect on local beaches. No project elements are anticipated to result in changes that would affect the park or other beaches.
- **Water Rights–**As outlined in the Hawaiʻi State water code at HRS Chapter 174C, the State of Hawaiʼi owns all water and grants revocable allocations. Water diverted from Punaluʻu Stream, Oʻahu, has served agricultural uses in Punaluʻu Valley since pre-contact times (Handy and Handy 1991). Currently, the minimum stream flow of the Punaluʻu stream is approximately 12 million gallons per day (mgd), with a maximum of six mgd diverted by a piped irrigation system. The average stream flow diverted for irrigation is 2.5 mgd. No additional diversions are planned as part of the Proposed Action; as a result, the proposed action will not make any changes to existing water rights and/or water diversion practices.
- **Environmental Justice**–The Proposed Action would alleviate chronic flooding in the area, and therefore would not result in any negative impacts to surrounding populations, including minorities or low-income populations. As a result, no environmental justice impacts are expected.

Chapter 6
Cumulative Impacts

As stated in Section 1508.7 of the Council on Environmental Quality's *Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act* (40 CFR parts 1500-1508), a cumulative impact is the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

Both lands within and surrounding Punaluʻu were reviewed for projects that, when considered in conjunction with the Proposed Action, would form the basis for the cumulative impacts analysis.

6.1 Punaluʻu Watershed

Past, present and reasonably foreseeable actions on KS lands in the Punaluʻu watershed are outlined in KS' *Punaluʻu Ahupuaʻa Plan* (KS 2010).

The *Punaluʻu Ahupuaʻa Plan* outlines twelve priority projects that KS is reasonably foreseeable to implement in the near term. These projects are organized by the five components of KS' management strategy for their Punaluʻu lands (see Exhibit 6-1).

Exhibit 6-1. Priority Projects Outlined in the *Punaluʻu Ahupuaʻa Plan*

PRIORITY PROJECTS LISTED BY LAD VALUES	EXPECTED OUTCOMES
ECONOMICS	
Renovation of the Agriculture Water System	New Water Management Entity Formed
Overall Agriculture Production/Land Conversion Plan	Increased agricultural production
Longer Term Agreements for Tenant Farmers and Program Partners	Increased investment in land improvements by farmers
Construct a Central Baseyard Facility	Proper storage of fuels, chemicals, & equipment
EDUCATION	
Enhance And Maintain Punaluʻu Facilities	Facilities serve 200 groups per year
Provide Support to Nā Kamalei- KEEP	Support and strengthen program
Provide Support to UH Mānoa Ka Papa Loʻi o Punaluʻu	Support and strengthen program
Develop Natural Resource and Agriculture Program	New education programs implemented
CULTURE	
Undertake Priority Cultural Studies	Cultural resources identified and protected
ENVIRONMENT	
Develop a Comprehensive Stream Stewardship and Flood Mitigation Plan	Flooding mitigated
Secure Access to Kamehameha Schools' Punaluʻu Ma Uka Lands	Access to ma uka lands secured
Evaluate the Sale of Plat 2 Residential Beach Lot Properties	Properties sold

Source: Kamehameha Schools 2010

6.2 Proposed Action

When combined with other foreseeable activities in Punaluʻu, beneficial cumulative impacts from the Proposed Action are expected to include an increase in agricultural activities (particularly traditional and organic crops), an increase in community-based education activities, and a reduction in flooding and soil erosion. As shown in Exhibit 6-1, the flood mitigation and restoration work is identified as one of KS' priority projects in the *Punaluʻu Ahupuaʻa Plan*. The expected outcomes of this project, when combined with other identified priority projects, are shown in Exhibit 6-2. As this project is consistent with KS' long-term planning goals for the region, project impacts to land use and water resources are expected to be beneficial.

Exhibit 6-2. Expected Outcomes of KS' Priority Project Implementation in Punaluʻu

	Current	After Priority Projects Implemented (3–5 yrs.)
Acreage in Agriculture	140	400
Acreage in Traditional Crops	2	50+
Acreage in Organic Crops	0	50+
% of Ag Land Covered by Cultural Surveys	50%	100%

Ag Acreage Adversely Affected by Annual Flooding	100+	0
Community-based Management Entities	0	2
Community-based Education Programs	2	3
Students in Punaluʻu Community-based Educational Programs	5,152	8,000+
Risk of Soil Erosion and/or Chemical Spillage	Moderate to High	Low
Tenant Investment in Ag Land and Improvements	Low	Moderate to High

Source: Kamehameha Schools 2010.

Non-KS land uses in and surrounding the watershed are primarily agricultural, preservation, and residential, and would not be expected to result in significant environmental impacts. The construction elements of the habitat restoration work could result in a minor, temporary increase in fugitive dust and air emissions. These emissions would be limited to the direct vicinity of construction activities, and when combined with other planned activities in Punaluʻu would not affect local attainment levels for any NAAQS. Noise generated from construction equipment would be infrequent and of short duration. When combined with other noise producing activities in the vicinity of Punaluʻu, no impact would be expected.

6.3 Restoration with Habitat Bank Option

Potential creation of the Punaluʻu Habitat Bank is expected to help promote a strong conservation ethic within the valley, in addition to demonstrating the viability of future habitat banking efforts in other parts of Hawaii. In addition, preservation of lands in Punaluʻu for conservation, when combined with surrounding conservation areas such as the forest reserve and State Park land, would help to promote habitat connectivity for terrestrial species. As a result, this option is anticipated to result in greater long-term cumulative benefits than would be anticipated under the Proposed Action.

Establishment of the Punaluʻu Habitat Bank has the potential to shape future development activities on an island-wide scale. However, while establishment of the Punaluʻu Habitat Bank is expected to help expedite the permitting of other projects on Oʻahu (as project proponents would be able to purchase bank credits to offset project impacts), the bank would not affect how and if projects are permitted. Therefore, establishment of the bank would not promote future development projects on Oʻahu.

6.4 No Action Alternative

Under the No Action Alternative, the habitat restoration work would not be completed. Chronic flooding would continue, resulting in damage to roads, properties, fields, and crops. Invasive species would continue to dominate the Punaluʻu Stream's riparian corridor, and soil erosion would continue to result in sediment transport from upstream reaches to the nearshore environment.

Chapter 7
Consistency with Existing Policies, Controls, and Land Use Plans

7.1 City and County of Honolulu

7.1.1 Revised Ordinances of Honolulu (ROH), Chapter 25

As noted in Section 1.4, the City and County of Honolulu has established a permit program for use of SMA's in order to preserve, protect, and where possible, restore the natural resources of the coastal zone of Hawaii. Permit requirements for any proposed development within an SMA are provided in Chapter 25 of the ROH. As the proposed stream restoration project would take place almost entirely within the SMA, completion of the proposed project would require issuance of a major SMA permit by the City and County of Honolulu. As the objectives and policies of the SMA program are the same as those in HRS Section 205A, consistency with this chapter is discussed under Section 7.2.1, below.

7.1.2 Oʻahu General Plan

The Oʻahu General Plan, amended October 3, 2002, sets forth the long-range aspiration of Oʻahu's residents and establishes a comprehensive planning process that addresses physical, social, economic and environmental concerns affecting the City and County of Honolulu. There have been several amendments to the plan since its adoption in 1977; most recently, the plan was revised and released for public review in November 2012. Finalization of these changes is currently pending (City and County of Honolulu 2013).

The plan is organized into eleven subject areas; for each subject area, the plan sets forth a list of Objectives and Policies intended to achieve those objectives. For the *natural environment* subject area, Objective A of the general plan states "To protect and preserve the natural environment". There are several policies associated with this Objective that are relevant to the proposed action; a discussion of the proposed action's consistency with these policies is provided below.

> **Policy 2:** Seek the restoration of environmentally damaged areas and natural resources.

The primary objective of the proposed action is to alleviate chronic flooding and restore natural ecosystem processes in the Punaluʻu watershed with a focus on the lower reach of Punaluʻu Stream, its floodplain, and estuary. A key component of the restoration design is to restore a natural valley floodplain and terrace landscape and re-designate land uses so that farmers on chronically flooded agricultural lands are relocated to the floodplain margins on elevated terraces and a new stream corridor with a new riparian forest is created that restores a floodplain connection with Punaluʻu Stream.

> **Policy 6:** Design surface drainage and flood-control systems in a manner which will help preserve their natural settings.

The primary restoration objective of the proposed action is to develop sustainable flood protection and restore hydrologic processes in the Punaluʻu watershed. This will be accomplished using natural materials and methods that augment natural physical processes, are aesthetically pleasing, are sustainable with little to no maintenance, and that enhance aquatic and wetland habitats.

> **Policy 8:** Protect plants, birds, and other animals that are unique to the State of Hawaiʻi and the Island of Oʻahu.

The restoration components of the proposed action will restore hydrologic processes in the Punaluʻu watershed and enhance aquatic and wetland habitats.

7.1.3 Koolauloa Sustainable Communities Plan

The Punaluʻu watershed is part of the Koolauloa region, which spans the northern half of Oʻahu's windward coast. The Koolauloa Sustainable Communities Plan (City and County of Honolulu, Department of Planning and Permitting 1999) establishes a vision, policies, and guidance for how to maintain the country character of Koolauloa, and protect and enhance its natural, scenic, and cultural qualities. The Plan was last updated in 1999, and is currently under revision, with the Planning Commission recommending approval of the revised plan in April 2013. Final approval is pending further hearings and action.

The general vision for Koolauloa as described in the plan is to:

- Establish rural community, agricultural, and preservation boundaries;
- Preserve and enhance the natural recreation and cultural resources which contribute to Koolauloa's sense of "Old Hawaii";
- Preserve agricultural lands;
- Enhance existing recreational areas and resources;
- Establish rural area development standards to maintain the rural character of residential areas; and
- Enhance the character of the regions' commercial areas and recognize the contribution of country stores to Koolauloas' rural fabric.

As the Proposed Action will not alter the agricultural or rural character of Punaluʻu, but rather will serve to promote traditional agricultural and enhance the natural character of the watershed, the Proposed Action is consistent with the goals of this Plan.

7.1.4 Punaluʻu Ahupuaʻa Plan

KS' *Punaluʻu Ahupuaʻa Plan* (Kamehameha Schools 2010) is the long-term planning document for the Punaluʻu land division segment, of which KS is the primary landholder. It represents KS' vision and long-term goals to enhance and expand upon the economic, educational, cultural and environmental values of Punaluʻu. As part of this plan, KS outlined its long range goals of ensuring healthy native ecosystems and working landscapes, and responsible and balanced utilization of agricultural lands. The Proposed Action is identified as a priority project in the Plan, and as such, is key to achieving progress towards these goals.

7.2 State of Hawaiʻi

7.2.1 Coastal Zone Management (CZM) Program

HRS Chapter 205A sets forth the Hawaiʻi Coastal Zone Management (CZM) Program to provide for the effective management, beneficial use, protection, and development of the coastal zone. The CZM program accomplishes this through guiding human activities to assure that activities are carried out in a manner that sustains the resources and their values. Activities are evaluated for consistency in ten areas: recreational resources; historic resources; scenic and open space resources; coastal ecosystems; economic uses; coastal hazards; managing development; public participation; beach protection; and marine resources. A discussion of the Proposed Action's consistency with each of these areas is provided below.

Recreational Resources

As stated in Section 3.5, restoration work due to the Proposed Action would only occur up to the edge of Kamehameha Highway; therefore, no work would take place near Punaluʻu Beach Park or other local beaches. No project elements are anticipated to result in changes that would affect the park or other beaches.

Historic Resources

As described in Section 5.6, the Proposed Action is not expected to impact historic resources. All earthwork would occur on previously disturbed land, and no ground disturbing activities associated with the Proposed Action would occur where sites of cultural importance have been previously identified.

If any cultural resources were to be inadvertently discovered during staging or construction activities, all work would be stopped immediately and the SHPD would be notified of the discovery.

Scenic and Open Space Resources

The Proposed Action would have no impact on scenic and open space resources. Restoration activities would not involve the construction of any buildings or visual obstructions and therefore would not alter the visual character of the watershed.

Coastal Ecosystems

The Proposed Action will benefit coastal ecosystems by reducing the amount of sediment that is currently transported from upstream reaches to the nearshore environment.

Economic Uses

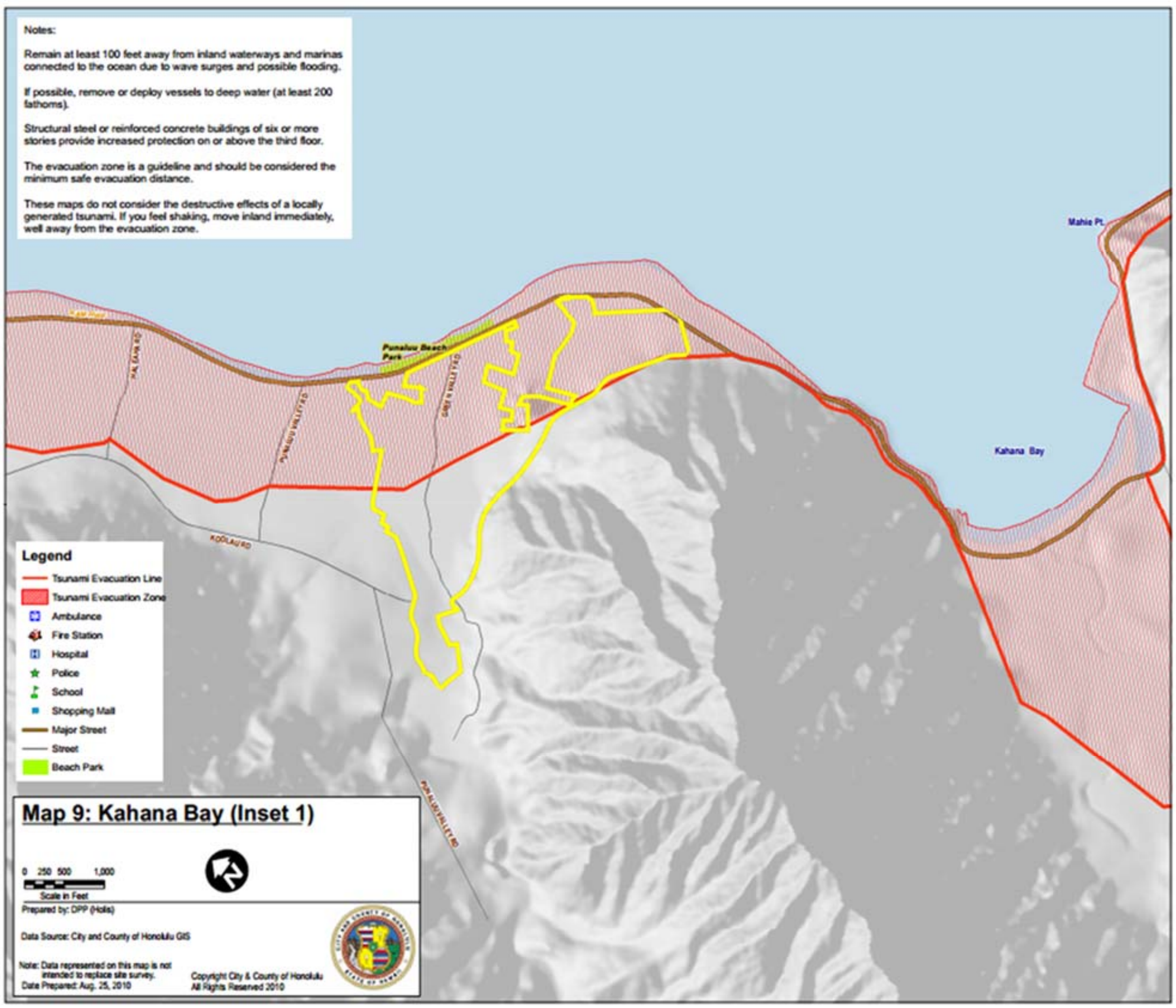
The Proposed Action would not lead to a change in the pattern of coastal development in the Punaluʻu Valley. Current uses in the project area are agriculture and education activities, and these activities would continue under the Proposed Action.

Coastal Hazards

As described in Sections 4.8 and 5.8, restoration work would take place in designated Flood Hazard districts, as the primary restoration objective of the Proposed Action is to develop sustainable flood protection and restore hydrologic processes in the Punaluʻu watershed. The restoration components of the Proposed Action will reduce hazards to life and property in the watershed by alleviating chronic flooding, restoring hydrologic processes, and enhancing aquatic and wetland habitats.

In addition, a portion of the project bounded by the Kamehameha Highway, Green Valley Road, Punaluʻu Valley Road, and Ko'olau Road would take place within the City and County of Honolulu's Tsunami Evacuation Zone (see Exhibit 7-1). However, as stated above, the Proposed Action would serve to restore hydrologic processes in the watershed, thereby reducing the potential for damaging floods. No new structures or residences would be constructed in the evacuation zone, and project elements would help to redirect and control flooding in the valley.

Exhibit 7-1. Punaluʻu Tsunami Evacuation Zone. Project Construction Limit Boundary shown as Yellow Polygon



Source: City and County of Honolulu 2014.

Managing Development

KS is working cooperatively with all Federal, State, and local agencies to ensure that the Proposed Action is completed in a manner consistent with all Federal, State, and local permits and requirements in place for the protection of environmental resources and the management of development.

Public Participation

The public will have the opportunity to review and comment on this EA as part of the Federal and State environmental review processes.

Beach Protection

The Proposed Action would not impact beaches. No construction would occur seaward of the Kamehameha Highway and no project elements are anticipated to result in changes that would affect the shoreline or natural shoreline processes.

Marine Resources

The Proposed Action would not adversely impact marine resources. The Proposed Action has the potential to benefit coral reef ecosystems by reducing the amount of sediment transported from upstream reaches to the nearshore environment.

7.3 Required Permits and Approvals

Exhibit 7-2 lists the Federal, State, and local permits which may be required as part of the Proposed Action.

Exhibit 7-2. Federal, state, and local permits required as part of the Proposed Action

Permit or Approval	Act/Statute/Ordinance	Agency
Federal Environmental Permits and Reviews		
Nationwide Permit 27 Aquatic Habitat Restoration	Clean Water Act, Section 404	U.S. Army Corps of Engineers, Honolulu District Regulatory Branch
Section 10 permit	Rivers and Harbors Act, Section 10	U.S. Army Corps of Engineers, Honolulu District Regulatory Branch
Biological Opinion	Endangered Species Act, Section 7	U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office & NOAA Fisheries, Habitat Branch
Approval	National Historic Preservation Act, Section 106	Hawaiʻi State Historic Preservation Officer
Consistency Certification	Coastal Zone Management Act, Section 307	Hawaiʻi Department of Business, Economic Development, and Tourism
National Pollution Discharge Elimination System Permit	Clean Water Act, Section 402	Hawaiʻi Department of Health, Clean Water Branch
Water Quality Certification	Clean Water Act, Section 401	Hawaiʻi Department of Health, Clean Water Branch
State Environmental Permits and Reviews		
Safe Harbor Agreement	Hawaiʻi Revised Statutes, Chapter 195D-22	Hawaiʻi Department of Land and Natural Resources, Division of Forestry & Wildlife
Stream Channel Alteration Permit	Hawaiʻi Revised Statutes, Chapter 174C and Hawaiʻi Administrative Rules 13-169	Hawaiʻi Commission on Water Resource Management
Noise Permit	Hawaiʻi Administrative Rules 11-46	State of Hawaiʻi Department of Health
Local Environmental Permits and Reviews		
Special Management Area Permit, Major	Revised Ordinances of Honolulu, Chapter 25	City and County of Honolulu, Department of Planning and Permitting
Flood Hazard District Variance	Revised Ordinances of Honolulu, Land Use Ordinance, Section 21-9.10, Chapter 21	City and County of Honolulu, Department of Planning and Permitting, Site Development Division
Grading/Grubbing/ Stock Piling Permit	Revised Ordinances of Honolulu, Chapter 14	City and County of Honolulu, Department of Planning and Permitting, Site Development Division

Chapter 8
Hawai'i State Determination

8.1 Anticipated Determination

This section describes KS' determination regarding whether the proposed stream restoration project will have a significant impact on the environment, and the reasons for this anticipated determination.

KS anticipates a Finding of No Significant Impact for this project, based on a comparison of project impacts to the significance criteria established under the State of Hawai'i's environmental review process, as stated in HRS, Chapter 343, and its implementing regulations in HAR § 11-200 (see Sections 8.1.1 through 8.1.13 below).

The following significance criteria are established for determining if an action may have a significant effect on the environment. An action is determined to have a significant effect if it:

1. Involves an irrevocable commitment to loss or destruction of any natural or cultural resource;
2. Curtails the range of beneficial uses of the environment;
3. Conflicts with the State's long-term environmental policies or goals as expressed in Chapter 344, HRS, and any revisions thereof and amendments thereto, court decisions, or executive orders;
4. Substantially affects the economic or social welfare of the community or State;
5. Substantially affects public health;
6. Involves substantial secondary impacts, such as population changes or effects on public facilities;
7. Involves a substantial degradation of environmental quality;
8. Is individually limited but cumulatively has considerable effect on the environment or involves a commitment for larger actions;
9. Substantially affects a rare, threatened, or endangered species, or its habitat;
10. Detrimentally affects air or water quality or ambient noise levels;
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;
12. Substantially affects scenic vistas and view planes identified in county or state plans or studies; or,
13. Requires substantial energy consumption.

An analysis of the impacts of the Proposed Action in relation to these significance criteria is presented below.

8.1.1 Irrevocable Loss or Destruction of Valuable Resource

All work associated with the Proposed Action would be conducted in order to protect and restore natural ecosystem processes in the Punaluʻu Valley. There would be no loss of any significant cultural or natural resources.

8.1.2 Curtails Beneficial Uses

The Proposed Action would not curtail other beneficial uses of KS lands in the Punaluʻu Valley. Current uses in the project area are agriculture and education activities, and these activities would continue under the Proposed Action. The proposed restoration work would restore traditional Hawaiian land use compatible with periodic flood inundation, making the valley more suitable for agricultural production. Within the restored floodplain, mixed land uses would focus on native and Polynesian plant communities and Hawaiian agriculture activities compatible with periodic flooding.

8.1.3 Conflicts with Long-Term Environmental Policies or Goals

The Proposed Action is consistent with the General Oʻahu Development Plan, the Koolauloa Sustainable Communities Plan, the *Punaluʻu Ahupuaʻa Plan*, the CZMA, and HRS Chapter 205 (see Sections 7.1 and 7.2). The proposed project is designed to produce environmental benefits, and as such is consistent with the State of Hawaiʻi's environmental policies and goals.

8.1.4 Substantially Affects Economic or Social Welfare

The Proposed Action is expected to result in beneficial impacts to economic and social welfare: in the short-term through employment for construction activities; and in the long-term by alleviating chronic flooding; thereby protecting roads, properties, fields, and crops.

8.1.5 Substantially Affects Public Health

The Proposed Action is designed to produce environmental benefits; as a result, it will not adversely affect air or water quality or produce other emissions that would substantially affect public health.

8.1.6 Involves Substantial Secondary Impacts

The Proposed Action will not foster population growth.

8.1.7 Involves Substantial Degradation of Environmental Quality

The Proposed Action is designed to produce environmental benefits. There may be minimal environmental impacts during construction activities (such as noise and fugitive dust) but these impacts will be temporary, limited to the direct vicinity of construction activities, mitigated to minimize environmental impacts, and in compliance with applicable Federal, State, and local permits.

8.1.8 Cumulative Effects or Commitment to a Larger Action

The Proposed Action is designed to produce environmental benefits; no negative cumulative effects are anticipated (see Section 6.0). The Proposed Action is not a commitment to a larger action.

8.1.9 Substantially Affects Rare, Threatened, or Endangered Species

The Proposed Action is designed to restore the natural floodplain morphology of the Punaluʻu Valley, thereby enhancing aquatic and wetland habitats for rare, threatened, and endangered species.

8.1.10 Detrimentally Affects Air or Water Quality or Ambient Noise Levels

The Proposed Action is designed to produce environmental benefits. There may be minimal environmental impacts during construction activities (such as noise and fugitive dust) but these impacts will be temporary, limited to the direct vicinity of construction activities, and in compliance with applicable Federal, State, and local permits.

8.1.11 Affects Environmentally Sensitive Areas

The Proposed Action is designed to restore the natural floodplain morphology of the Punaluʻu Valley, thereby enhancing environmentally sensitive areas (including floodplains, estuary, and coastal waters) in the valley.

8.1.12 Substantially Affects Scenic Vistas and View Planes

The Proposed Action would not change the visual character of the Punaluʻu Valley. While there will be some clearing of large trees and vegetation along the stream corridor during construction, the corridor will be re-planted with native vegetation as part of the Proposed Action. As a result, no impacts to scenic vistas or view plans are anticipated.

8.1.13 Requires Substantial Energy Consumption

The Proposed Action will consume some energy during the construction phase of the project; however, these impacts are expected to be minimal and temporary (approximately four months in duration). No energy will be consumed by the project elements after construction is complete.

8.2 Significance Determination

As shown in the analysis above, the Proposed Action would not trigger any of the significance criteria outlined in the Chapter 343 environmental review process. As a result, the Proposed Action is not anticipated to have a significant adverse effect on the environment.

Chapter 9
Consultation

9.1 Consultation

KS has coordinated development of this draft EA with a variety of Federal, State, and local agencies and organizations; these entities are listed in Sections 9.1.1 through 9.1.4 below. KS conducted a series of in-person meetings in June 2013 to discuss the project with agency officials, and has remained in coordination through follow-up meetings, conference calls, and email communications. General feedback from all parties has been supportive of the project; no formal comments have been received to-date.

9.1.1 Federal

- NOAA Fisheries Service, Pacific Islands Regional Office, Habitat Branch
- U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office
- U.S. Army Corps of Engineers, Honolulu District Regulatory Branch

9.1.2 State

- Department of Land and Natural Resources, Division of Forestry and Wildlife, Oʻahu Branch
- Office of State Planning, Hawaiʻi Coastal Zone Management Program
- State Department of Health, Environmental Management Division, Clean Water Branch
- Commission on Water Resource Management

9.1.3 Local Agencies

- City and County of Honolulu, Department of Planning and Permitting

9.1.4 Local Organizations

- Punaluʻu Community Association
- Punaluʻu Watershed Alliance

Chapter 10
List of Preparers

10.1 Kamehameha Schools

Name
Kaeo Duarte, Director of Strategic Initiatives – West Hawaii
Imiola Lindsey, Water Resources Engineer
Jo Anne Hanada, Senior Capital Program Manager
Joey Char, Land Assets and Operations Manager

10.2 ICF International

Name	Education:	Experience
Leo Lentsch	MS Fishery and Wildlife Biology, BS Fishery and Biology and Zoology	30 years of experience in environmental assessment and conservation biology
Brendan Belby, PH	MS Fluvial Geomorphology, BA Physical Geography	18 years of experience in quantitative fluvial geomorphology and surface water hydrology
Shawna Barry	MA Environmental and Resource Policy, BS Biology (focus in Ecology)	9 years of experience in environmental assessment
Eric Link	MS Conservation Biology, BS Ecology	13 years of experience in GIS analysis

10.3 Planning Solutions, Inc.

Name
Perry White

Chapter 11
References

AECOS, Inc., 1994. A follow-up marine biological survey for the Laʻie waste water reclamation facility. Unpublished contract manuscript.

AECOS, Inc. 2002. Reconnaissance survey of aquatic biota and riparian vegetation for Kamehameha Highway bridge replacement at Punaluʻu, Windward Oʻahu. Prepared for Sea Engineering, Inc. AECOS Report No. 1011.

AECOS, Inc. 2006. Water quality and biological survey of Kaluanui Stream for Kamehameha Highway Bridge replacement, Hauʻula, windward Oʻahu. AECOS Report No. 1120.

AECOS, Inc. 2008. Biological and water quality surveys of Malaekahana Stream and the marine environment off the proposed Kahuku Village subdivision in Kahuku, Oʻahu. AECOS Report No. 1172.

AECOS. Inc. 2014. Wetlands Delineation on TMK: 5-3-003:001 por. and 041 por. for Kamehameha Schools Punaluʻu Agricultural Lands, Punaluʻu, Oʻahu. Prepared for ICF International.

Animizu, J. Personal Communication, January 2013. U.S. Army Corps of Engineers, Honolulu.

Bradley, F., C. Book, and A. E. Bowles. 1990. Effects of Low-altitude Aircraft Overflights on Domestic Turkey Poults. U.S. Air Force Systems Command. Noise and Sonic Boom Impact Technology Program. Report No. HSD-TR-90-034. June.

Brasher, A.M. and Anthony, S.S. 2000. Occurrence of Organochlorine Pesticides in Stream Bed Sediment and Fish From Selected Streams on the Island of Oʻahu, Hawaiʻi, 1998: U.S. Geological Survey, Fact Sheet 140-00, 6 p.

Brasher, A.M.D., R.H Wolff and C.D. Luton. 2004. Associations among land-use, habitat characteristics, and invertebrate community structure in nine streams on the island of Oʻahu, Hawaiʻi: U.S. Geological Survey Water-Resources Investigations Report 03-4256, 47p.
Burney, D.A., H.F. James, L Pigott- Burney, S.L. Olson, W. Kikuchi, W.L. Wagner, M. Burney, D. McCloskey, D. Kikuchi, F.V. Grady, R. Gage II, and R. Nishek. 2001. Fossil evidence for a diverse biota from Kauaʻi. Ecol. Monog. 71: 615-641.

Cardno ENTRIX. 2011. Preliminary Habitat Banking Prospectus. July 8.

City and County of Honolulu, Department of Emergency Management. 2014. Tsunami Evacuation Zones. O'ahu –Map 9: Kahana Bay. Available at: https://www1.honolulu.gov/dem/map9kahanabaytohauulainset1.pdf. Accessed on March 17, 2014.

City and County of Honolulu, Department of Planning and Permitting. 1999. Koʻolau Loa Sustainable Communities Plan. Available at: http://www.honoluludpp.org/Portals/0/pdfs/planning/Koolauloa/KoolauloaSCP.pdf. Accessed on May 2, 2014.

City and County of Honolulu, Department of Planning and Permitting. 2013. General Plan – Update Program. Available at: http://www.honoluludpp.org/Planning/GeneralPlan.aspx. Accessed on March 17, 2014.

City and County of Honolulu, Department of Planning and Permitting. 2014. HOLIS-Fast MAPS: Parcels & Zoning. Available at: http://gis.hicentral.com/FastMaps/ParcelZoning/. Accessed on April 1, 2014.

Dufour, P. A. 1980. Effects of Noise on Wildlife and Other Animals: Review of Research Since 1971. U.S. Environmental Protection Agency. Report 550/9-80100. July.

Ellis, D. H., J. G. Goodwin, Jr., and J. R. Hunt. 1978. Wildlife and Electric Power Transmission. In: Dufour, P.A. 1980. Effects of Noise on Wildlife and Other Animals: Review of Research Since 1971. U.S. Environmental Protection Agency. Report 550/9-80100. July.

ENPRO™ Environmental. 2008. Water Quality Assessment of Punaluu Stream. ENPRO Project # 804-00091-OTH. Prepared for Kamehameha Schools.

Environmental Protection Agency. 2012a. National Ambient Air Quality Standards (NAAQS). Available at: http://www.epa.gov/air/criteria.html. Accessed on August 2, 2013.

Environmental Protection Agency. 2012b. Historical Whole or Part County Nonattainment Status by Year Since 1978 for Hawaiʻi. Available at: http://www.epa.gov/oaqps001/greenbk/phistory_hi.html. Accessed on August 2, 2013.

Environmental Protection Agency. 2013a. NEPAssist. Available at: http://nepassisttool.epa.gov/nepassist/entry.aspx. Accessed on August 2, 2013.

Environmental Protection Agency. 2013b. Nonroad Engines, Equipment, and Vehicles. Available at: http://www.epa.gov/nonroad/. Accessed on August 2, 2013.

Federal Highway Administration. 2011. Construction Noise Handbook. Construction Equipment Noise Levels and Ranges. Available at: http://www.fhwa.dot.gov/environment//noise/construction_noise/handbook/handbook09.cfm. Accessed on August 8, 2013.

Fletcher, C. H, C. Bochicchio, C. L. Conger, M. S. Engels, E. J. Feirstein, M. Frazer, C.R. Glenn, R. W. Grigg, E. E. Grossman, J. N. Harney, E. Isoun, C. V. Murray-Wallace, J. J. Rooney, K. H. Rubin, C. E. Sherman and S. Vitousek. 2008. *Geology of Hawaii Reefs*. Pages 435-487 in Coral Reefs of the USA, B. M. Riegl and R. E. Dodge (eds.) Springer Science + Business Media B.V.

Ford, J.I. and R.A. Kinzie III. 1982. Life crawls upstream. Natural History 91(12): 51-66.

Ha, P.Y. and R.A. Kinzie III. 1996. Reproductive biology of Awaous guamensis, an amphidromous Hawaiian goby. Environmental Biology of Fishes 45: 383-396.

Handy, E. C. S. and E. G. Handy. 1991. Native Planters of Old Hawaii: Their Life, Lore, and Environment. B. P. Bishop Museum Bulletin 233. Bishop Museum, Honolulu, HI. 641p.

Hawaiʻi Biodiversity and Mapping Program. 2013. Rare and Endangered Taxa for Oʻahu 2013.

Hawaiʻi Biological Survey. 2011. Taking inventory of the fauna and flora of the Hawaiian Islands. Available at: http://hbs.bishopmuseum.org/. Accessed on May 2, 2014.

Hawaiʻi Department of Health. 2013a. Clean Air Branch. Federal and State Ambient Air Quality Standards. Available at: http://health.hawaii.gov/cab/files/2013/05/naaqs_jan_2013.pdf. Accessed on August 2, 2013.

Hawaiʻi Department of Health. 2013b. Clean Air Branch. Hawaii Ambient Air Quality Data. Available at: http://health.hawaii.gov/cab/hawaii-ambient-air-quality-data/. Accessed on August 2, 2013.

Hawaiʻi Division of Forestry and Wildlife. 2014. Forest Reserve System. Available at: http://dlnr.hawaii.gov/forestry/frs/. Accessed on April 1, 2014.

Hawaiʻi Department of Land and Natural Resources. 2014a. Hawaii State Parks: Oʻahu's State Parks. Ahupua'a O Kahana State Park. Available at: http://www.hawaiistateparks.org/parks/oahu/index.cfm?park_id=13. Accessed on April 1, 2014.

Hawaiʻi Department of Land and Natural Resources. 2014b. Office of Conservation and Coastal Lands. Subzone Maps: Oʻahu Conservation Subzones. Available at: http://dlnr.hawaii.gov/occl/files/2013/08/oahu_consv_subz2012_1101.pdf. Accessed on April 1, 2014.

Hawaiʻi Department of Land and Natural Resources. 2008. Hawaiian Watershed Atlas. Division of Aquatic Resources. Available at: http://www.hawaiiwatershedatlas.com/. Accessed on August 7, 2013.

Hawaiʻi Department of Transportation. 2005. Kamehameha Highway Replacement of South Punaluʻu Bridge Environmental Assessment. March. Available at: http://oeqc.doh.hawaii.gov/Shared%20Documents/EA_and_EIS_Online_Library/Oahu/2000s/2005-04-08-OA-FEA-SOUTH-PUNALUU-BRIDGE-REPLACEMENT.pdf. Accessed on August 4, 2013.

Hawaiʻi News Now. 2014. Hawaiʻi state park draws hikers despite closure. March 20, 2014. Available at: http://www.hawaiinewsnow.com/story/25031370/hawaii-state-park-draws-hikers-despite-closure. Accessed on April 1, 2014.

Jayewardene, D. Personal Communication, March 2012. NOAA National Marine Fisheries Service, Honolulu.

Kamehameha Schools. 2009. Biological Assessment Punaluʻu Stream, Oʻahu, Hawaiʻi with Recommendations for Stream Enhancement.

Kamehameha Schools. 2010. Punaluʻu Ahupuaʻa Plan. May 2010 Review Version.

Kamehameha Schools. 2011. Kamehameha Schools Punaluʻu Agricultural Lands Soil and Water Conservation Plan – Punaluʻu, O'ahu'. May 2011.

Kamehameha Schools. 2014. Draft Archaeological Inventory Surveyfor the Punaluʻu Habitat Bank and Stream Restoration Project, Makaua, Punaluʻu, and Waiʻono Ahupuaʻa, Koʻolauloa Moku, Oʻahu, Island of Oʻahu. December.

Kinzie III, R. A. and J. I. Ford. 1982. Population biology in small Hawaiian streams. Water Resources Research Center Cooperative Report No. 147, Hawaiʻi Cooperative Fishery Research Unit, No. A-080-HI. 60 pp.

Lau, L.S. and J.F. Mink. 2006. Hydrology of the Hawaiian Islands. University of Hawaiʻi Press, Honolulu. 274 pp.

Maly, K. and O. Maly. 2005. *He Wahi Moʻolelo no Punaluʻu ma Koʻolauloa, Mokupuni ʻo Oʻahu. A Collection of Traditions, Historical Accounts and Kamaʻaina Recollections of Punaluʻu and Vicinity, Koʻolauloa, Island of Oʻahu*. Contract report prepared for The Kamehameha Schools, Honolulu, HI.

Manci, K. M., D. N. Gladwin, R. Villella, and M. G. Cavendish. 1988. Effects of Aircraft Noise and Sonic Booms on Domestic Animals and Wildlife: A Literature Synthesis. U.S. Fish and Wildlife Service National Ecology Research Center. Ft. Collins, CO. Report NERC-88/29.

McKechnie, M., and D. N. Gladwin. 1993. Aircraft Overflight Effects on Wildlife Resources. U.S. National Park Service. NPOA Report No. 93-8. November.

National Oceanic and Atmospheric Administration. 2011. Windward Oʻahu Flash Flood Event – June 4, 2011. Available at: http://www.prh.noaa.gov/hnl/pages/events/HeavyRain20110604/. Accessed August 8, 2013.

Nichols, W.D., Shade, P.J., and Hunt, C.D., Jr. 1996. Summary of the Oahu, Hawaii, regional aquifer-system analysis: U.S. Geological Survey Professional Paper 1412-A, 61 p.

Oki, D. S., Wolff, R. H. and Perreault, J. A. 2006. Effects of surface-water diversion and ground-water withdrawal on streamflow and habitat, Punaluʻu Stream, Oʻahu, Hawaiʻi: U.S. Geological Survey, Scientific Investigations Report 2006-5153.

Oki, D. S., Rosa, S. N. and Yeung, C. W. 2010. Flood-frequency estimates for streams on Kauaʻi, Oʻahu, Molokaʻi, Maui, and Hawaiʻi, State of Hawaiʻi: U.S. Geological Survey Scientific Investigations Report 2010-5035.

Polhemus, D.A., J.A. Maciolek, and J.I. Ford. 1992. An ecosystem classification of inland waters for the tropical Pacific islands. Micronesica 25: 155-173.

Price, J.P., J.D. Jacobi, S.M. Gon, III, D. Matsuwaki, L. Mehrhoff, W. Wagner, M. Lucas, and B. Rowe. 2012. Mapping plant species ranges in the Hawaiian Islands— Developing a methodology and associated GIS layers: U.S. Geological Survey Open-File Report 2012-1192.

Radtke, R. L. And R. A. Kinzie III. 1996. Evidence of a marine larval stage in endemic Hawaiian stream gobies from isolated high-elevation localities. Trans. Am. Fish. Soc. 125: 613-621.

Radtke, R. L., Kinzie III, R. A. & Folsom, S. D. 1988. Age at recruitment of Hawaiian freshwater gobies. Environmental Biology of Fishes 23, 205–213.

Rooney, J. J. R., C. H. Fletcher, E. E. Grossman, M. Engels, and M. E. Field. 2004. *El Nino control of Holocene reef accretion in Hawaii*, Pacific Science 58 (305-324).

Stearns, H.T. and K.N. Vaksvik. 1932. Geology and groundwater resources of the Island of Oahu, Hawaii. U.S. Geological Survey Water-Supply.

U.S. Army Corps of Engineers. Regulatory In Lieu Fee and Bank Information Tracking System. Available at http://geo.usace.army.mil/ribits/index.html. Accessed on August 5, 2013.

U.S. Fish and Wildlife, Pacific Fish and Wildlife Office. 2012. Endangered Species. Available at: http://www.fws.gov/pacificislands/species.html. Accessed on August 5, 2013.

U.S. Fish and Wildlife. 2013. National Wetlands Inventory Mapping Tool. Available at: http://www.fws.gov/wetlands/Wetlands-Mapper.html. Accessed on August 8, 2013.

U.S. Geological Survey. 1998. Land Use on the Island of Oʻahu, Hawaiʻi. Water-Resources Investigations Report 02-4301.

U.S. Geological Survey, Gap Analysis Program. 2011a. National Land Cover, Version 2.

U.S. Geological Survey 2011b. Groundwater Atlas of the United States: Alaska, Hawaii, Puerto Rico and the U. S. Virgin Islands. HA 730-N. Available at: http://pubs.usgs.gov/ha/ha730/ch_n/N-HItext3.html. Accessed May 2, 2014.

U.S. Geological Survey. 2013. USGS Water Data for Hawaii. Available at: http://nwis.waterdata.usgs.gov/hi/nwis. Accessed August 8, 2013.

U.S. Geological Survey. 2014. USGS Surface-Water Annual Statistics for Hawaii, USGS 16301050 Punaluʻu Str abv Punaluʻu Ditch Intake, Oʻahu, HI. Available at: http://waterdata.usgs.gov/hi/nwis/annual/?referred_module=sw&site_no=16301050&por. Accessed February 12, 2014.

Yamamoto, M.N. and A.W. Tagawa. 2000. Hawaiʻi's Native & Exotic Freshwater Animals. Mutual Publishing: Honolulu, HI.

Ziegler, A. C. 2002. Hawaiian Natural History, Ecology, and Evolution. University of Hawaiʻi Press, Honolulu. 477 pp.

Appendix A

90% Design Level Engineering Drawings

Appendix B

Wetlands Delineation on TMK: 5-3-003:001 por. and 041 por. for Kamehameha Schools Punalu‘u Agricultural Lands, Punalu‘u, O‘ahu

Appendix C

Biological Assessment Punalu‘u Stream, O‘ahu, Hawai‘i with Recommendations for Stream Enhancement

Appendix D

Kamehameha Schools Punalu‘u Agricultural Lands Soil and Water Conservation Plan

Appendix E

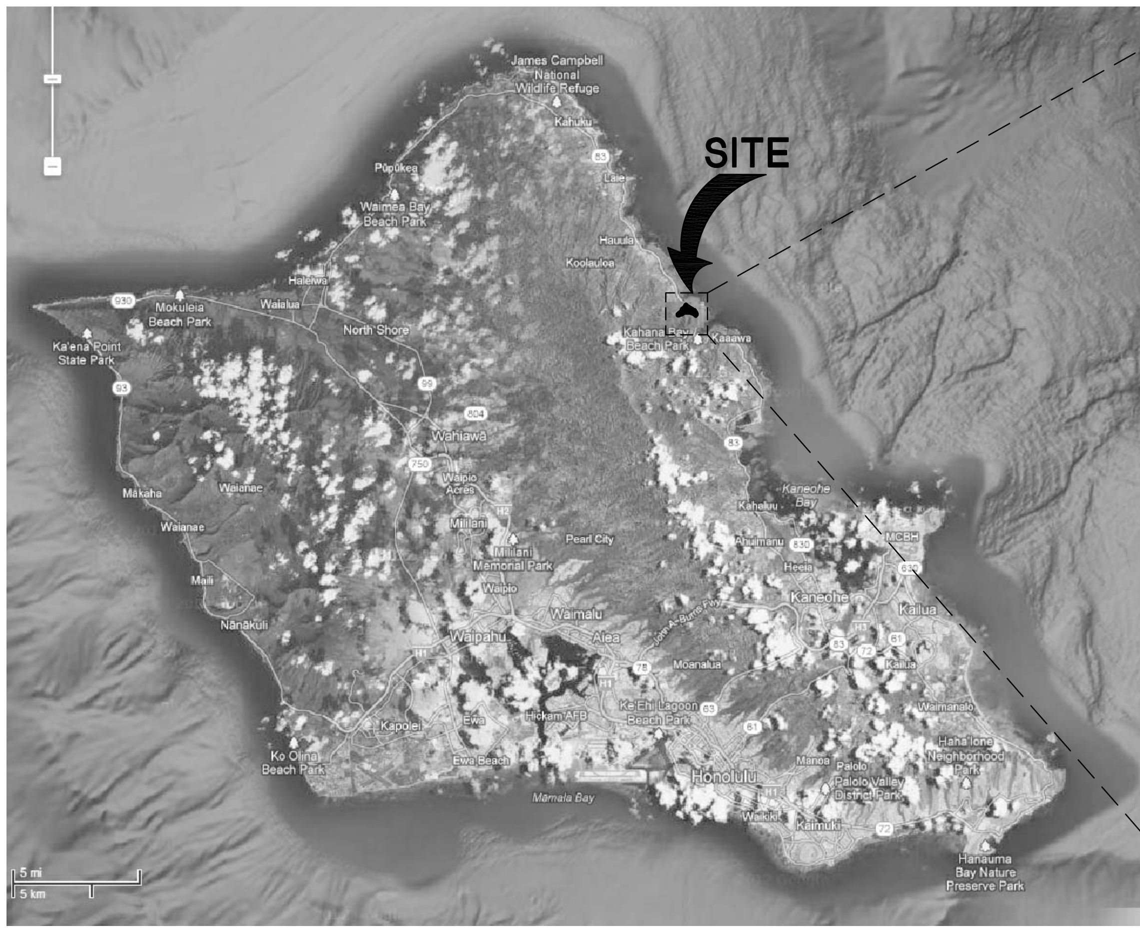
Hydraulic Modeling Output of 90% Level Restoration Design

Appendix F

Archaeological Inventory Survey

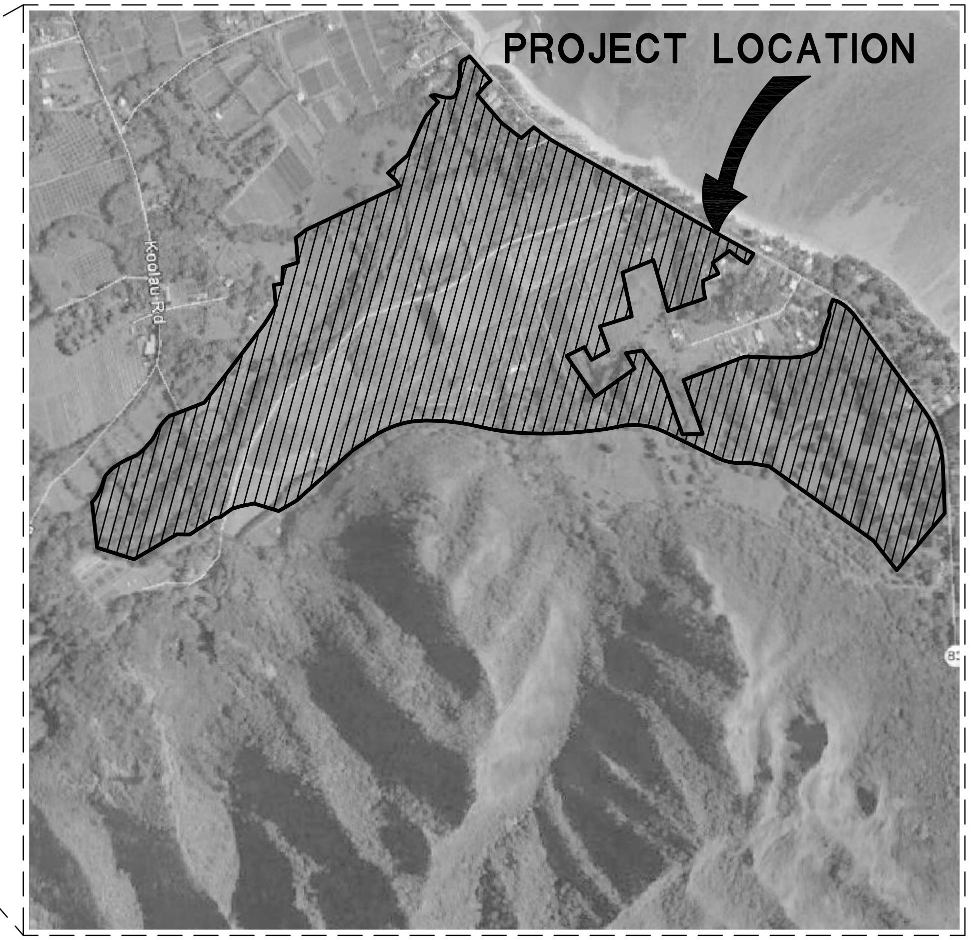
Appendix A
90% Design Level Engineering Drawings

PUNALU'U FLOOD MITIGATION AND STREAM RESTORATION PROJECT



HAWAII OAHU ISLAND

SCALE: NTS



PUNALU'U

SCALE: 1"=1000'

N

CONTACT INFORMATION

NATURAL SYSTEMS DESIGN, INC
1900 N NORTHLAKE WAY, SUITE 211
SEATTLE, WA 98103
(206) 834-0175

KAMEHAMEHA SCHOOLS
78-6831 ALII DRIVE, SUITE 235
KAILUA-KNOA, HAWAII 96740

LIST OF DRAWINGS

Sep-25-2013 90% DRAWINGS DRAFT

MICHAEL E. HRACHOVEC
LICENSED PROFESSIONAL ENGINEER
No. 15237-C
HAWAII U.S.A.

THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.

Signature — Expiration Date of the License

0 Ø 1
IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT PLOTTED TO ORIGINAL SCALE.

NAME OR INITIALS AND DATE	
DESIGNED	TA, MH, BB
CHECKED	TA, MH
DRAWN	GD, GM
CHECKED	MH

GEOGRAPHIC INFORMATION	
LATITUDE	21°34'29"N
LONGITUDE	157°52'58"W
TN/SC/RG	-/-/-
DATE	9/20/2013

PUNALU'U FLOOD MITIGATION AND STREAM RESTORATION

TITLE AND INDEX

1

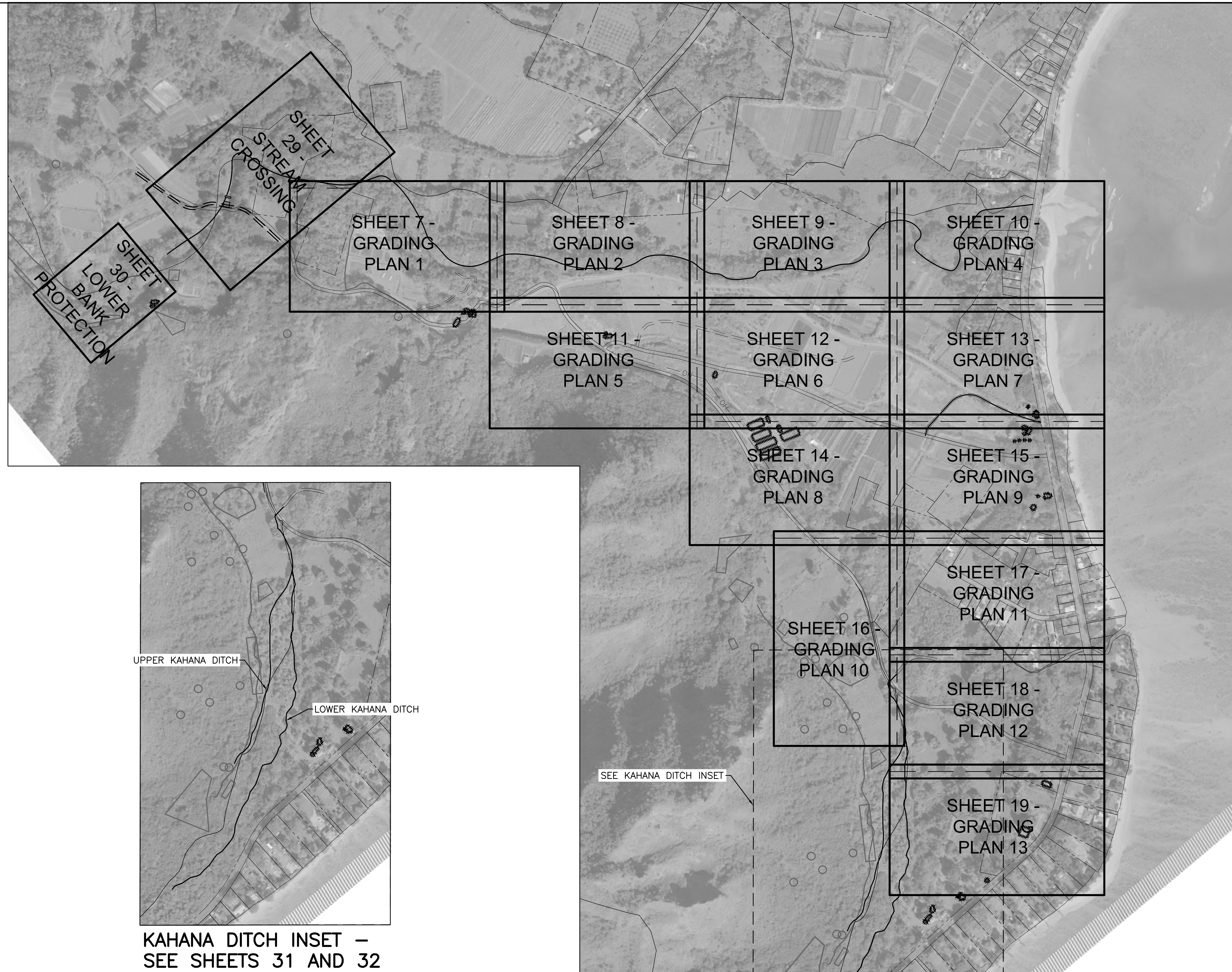
CONTROL POINTS

CROSS-SECTION	NORTHING	EASTING	ELEVATION
A-A	148943.46'	1679700.31'	-1.27'
AA-AA	149618.93'	1679525.90'	-3.40'
B-B	148783.38'	1679758.17'	-0.60'
BB-BB	149451.23'	1679417.27'	-1.78'
C-C	148629.73'	1679851.90'	0.07'
CC-CC	149255.93'	1679447.38'	-2.00'
D-D	148457.86'	1679776.50'	0.75'
DD-DD	149109.45'	1679574.59'	-2.00'
E-E	148267.09'	1679810.32'	1.71'
EE-EE	149003.42'	1679427.45'	-2.01'
F-F	148104.83'	1679703.18'	3.16'
FF-FF	149073.25'	1679285.69'	3.34'
G-G	148645.04'	1680662.29'	8.31'
GG-GG	149001.22'	1679119.89'	5.72'
H-H	148518.12'	1680508.01'	9.43'
HH-HH	148809.35'	1679114.77'	1.42'
I-I	148399.46'	1680347.04'	9.52'
II-II	148639.84'	1679152.35'	2.53'
J-J	148284.61'	1680183.30'	9.67'
JJ-JJ	148465.02'	1679057.21'	2.77'
K-K	148169.77'	1680019.55'	9.85'
KK-KK	148317.81'	1678922.99'	4.73'
L-L	148063.18'	1679850.39'	11.00'
LL-LL	148147.19'	1678838.04'	7.26'
M-M	147978.57'	1679669.56'	12.24'
MM-MM	148001.95'	1678712.78'	6.70'
N-N	147888.27'	1679491.11'	13.43'
NN-NN	147916.02'	1678538.36'	6.95'
O-O	147792.01'	1679316.63'	14.80'
OO-OO	147797.60'	1678379.46'	7.68'
P-P	147661.77'	1679164.85'	16.65'
PP-PP	147615.66'	1678306.85'	9.65'
Q-Q	147545.29'	1679002.47'	17.83'
QQ-QQ	147453.34'	1678193.71'	9.32'
R-R	147425.33'	1678842.66'	18.85'
RR-RR	147316.83'	1678049.30'	10.34'
S-S	147307.04'	1678681.83'	19.94'
SS-SS	147204.56'	1677884.71'	12.58'
T-T	147154.98'	1678537.14'	21.26'
TT-TT	147049.37'	1677762.90'	12.57'
U-U	147127.49'	1678339.43'	22.82'
UU-UU	146866.98'	1677686.28'	17.03'
V-V	147167.72'	1678145.20'	24.07'
VV-VV	146802.06'	1677504.53'	18.65'
WW-WW	146822.37'	1677310.09'	19.48'
XX-XX	147594.33'	1681893.90'	1.18'
YY-YY	147197.34'	1682197.87'	4.73'
ZZ-ZZ	147829.29'	1681800.35'	-0.01'

N

300' 150' 0 300' 600'

SCALE: 1"=300'-0"



KAHANA DITCH INSET – SEE SHEETS 31 AND 32

MICHAEL E. HRACHOVEC
LICENSED PROFESSIONAL ENGINEER
No. 15237-C
HAWAII U.S.A.

THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.

Signature | Expiration Date of the License

KAMEHAMEHA SCHOOLS 1887 IMUA

Natural Systems Design

ICF INTERNATIONAL

0 Ø 1

IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT PLOTTED TO ORIGINAL SCALE.

NAME OR INITIALS AND DATE	
DESIGNED	TA, MH, BB
CHECKED	TA, MH
DRAWN	GD, GM
CHECKED	MH

GEOGRAPHIC INFORMATION	
LATITUDE	21°34'29"N
LONGITUDE	157°52'58"W
TN/SC/RG	-/-/-
DATE	9/20/2013

PUNALU'U FLOOD MITIGATION AND STREAM RESTORATION

KEY MAP

2

SHEET 2 OF 46

Sep-25-2013 90% DRAWINGS DRAFT

GENERAL NOTES

1. THESE PLANS HAVE BEEN PREPARED FOR THE EXCLUSIVE USE OF KAMEHAMEHA SCHOOLS, HEREAFTER REFERRED TO AS "OWNER" AND "CONTRACTOR" AND THEIR AUTHORIZED AGENTS.
2. NATURAL SYSTEMS DESIGN HEREAFTER REFERRED TO AS "ENGINEER" IS RESPONSIBLE FOR THE PREPARATION OF THESE ORIGINAL PLANS AND ASSOCIATED SPECIFICATIONS AND WILL NOT BE RESPONSIBLE FOR, OR LIABLE FOR UNATHORIZED CHANGES TO OR USES OF THESE PLANS. ANY USE WHICH INCLUDES ALTERATION, DELETION, OR EDITING OF THIS DOCUMENT WITHOUT EXPLICIT WRITTEN PERMISSION FROM THE ENGINEER, IS STRICTLY PROHIBITED. ANY OTHER UNAUTHORIZED USE OF THIS DOCUMENT IS PROHIBITED.
3. MINOR MODIFICATIONS ARE EXPECTED TO SUIT JOB SITE DIMENSIONS OR CONDITIONS. SUCH MODIFICATIONS SHALL BE INCLUDED AS PART OF THE WORK. THE OWNER, ENGINEER AND APPROPRIATE REGULATORY AGENCIES WILL BE NOTIFIED OF ANY OWNER–AUTHORIZED CHANGE RESULTING IN MORE THAN A 10% DESIGN CHANGE OF PROPOSED FOOTPRINT OR SIGNIFICANTLY AFFECTING THE INTENDED BENEFIT OR FUNCTION OF A PROJECT ELEMENT.
4. THE LOCATION OF ALL FEATURES SHOWN IS APPROXIMATE.
5. THE CONTRACTOR AGREES TO ASSUME SOLE AND COMPLETE RESPONSIBILITY FOR JOB SITE CONDITIONS DURING THE COURSE OF CONSTRUCTION OF THIS PROJECT, INCLUDING SAFETY OF ALL PERSONS AND PROPERTY, AND FURTHER AGREES THAT THIS REQUIREMENT SHALL APPLY CONTINUOUSLY AND NOT BE LIMITED TO NORMAL WORKING HOURS IN ACCORDANCE WITH THE PROVISIONS OUTLINED BY THE PROJECT CONTRACT AND SPECIFICATIONS.
6. ALL IMPROVEMENTS SHALL BE ACCOMPLISHED UNDER THE APPROVAL, INSPECTION, AND TO THE SATISFACTION OF THE OWNER. IMPROVEMENT CONSTRUCTION SHALL COMPLY WITH THESE PLANS AND THE HAWAII STATE DEPARTMENT OF TRANSPORTATION (HDOT) STANDARD PLANS FOR CONSTRUCTION OF ROAD, BRIDGE, AND MUNICIPAL CONSTRUCTION, CURRENT EDITION UNLESS NOTED OTHERWISE. ALL REFERENCES TO THE "STANDARD SPECIFICATIONS" SHALL MEAN THE HAWAII STATE DEPARTMENT OF TRANSPORTATION (HDOT) STANDARD SPECIFICATIONS FOR CONSTRUCTION OF LOCAL STREETS AND ROADS, CURRENT EDITION. CONSTRUCTION NOT SPECIFIED ON THESE PLANS SHALL CONFORM TO THE REQUIREMENTS OF THE STANDARD SPECIFICATIONS. THE CONTRACTOR IS OBLIGATED TO BE FAMILIAR WITH APPLICABLE SECTIONS OF THE STANDARD SPECIFICATIONS NOT DISCUSSED IN THE GENERAL NOTES. THE CONTRACT SPECIAL PROVISIONS SHALL SUPERSEDE THOSE OF THE STANDARD SPECIFICATIONS WHERE DISCREPANCIES OCCUR.
7. IT IS THE RESPONSIBILITY OF THE CONTRACTOR AND HIS SUBCONTRACTOR(S) TO EXAMINE THE PROJECT SITE PRIOR TO THE OPENING OF BID PROPOSALS. THE CONTRACTOR SHALL BECOME FAMILIAR WITH THE CONDITIONS UNDER WHICH THE WORK IS TO BE PERFORMED, SUCH AS THE NATURE AND LOCATION OF THE WORK AND THE GENERAL AND LOCAL CONDITIONS, PARTICULARLY THOSE AFFECTING THE AVAILABILITY OF TRANSPORTATION, THE DISPOSAL, HANDLING, AND STORAGE OF MATERIALS, AVAILABILITY OF LABOR, WATER, ELECTRICITY, ROADS, THE UNCERTAINTIES OF WEATHER, THE CONDITIONS OF THE GROUND, SURFACE AND SUBSURFACE MATERIALS, GROUNDWATER, THE EQUIPMENT AND FACILITIES NEEDED FOR AND DURING THE PERFORMANCE OF THE WORK, AND THE COSTS THEREOF. ANY FAILURE BY THE CONTRACTOR AND SUBCONTRACTOR(S) TO ACQUAINT THEMSELVES WITH ALL THE AVAILABLE INFORMATION WILL NOT RELIEVE THE CONTRACTOR AND SUBCONTRACTOR(S) FROM RESPONSIBILITY FOR PROPERLY ESTIMATING THE DIFFICULTY AND COST OF SUCCESSFULLY PERFORMING THE WORK.
8. THE CONTRACTOR IS RESPONSIBLE FOR REVIEWING THE CONTRACT DOCUMENTS AND FOR ALL SUBMITTALS REQUIRED TO THE OWNER FOR REVIEW AND ACCEPTANCE.

PERMIT NOTES

1. EVERY REASONABLE EFFORT SHALL BE MADE TO CONDUCT THE ACTIVITIES SHOWN IN THESE PLANS, IN A MANNER THAT MINIMIZES THE ADVERSE IMPACT ON WATER QUALITY, FISH AND WILDLIFE, AND THE NATURAL ENVIRONMENT.
2. ALL WORK WILL BE IN COMPLIANCE WITH PERMIT CONDITIONS ISSUED BY VARIOUS REGULATORY AGENCIES. IT IS THE CONTRACTOR'S RESPONSIBILITY TO HAVE COPIES OF ALL PERMITS ON THE JOB SITE, UNDERSTAND AND COMPLY WITH ALL PERMIT CONDITIONS.
3. ALL WORK THAT DISTURBS THE SUBSTRATE, BANK, OR SHORE OF A WATERS OF THE STATE THAT CONTAINS FISH LIFE SHALL BE CONDUCTED ONLY DURING THE WORK PERIOD FOR THAT WATERBODY AS INDICATED IN THE MOST RECENT ALLOWABLE WORK PERIODS FOR HYDRAULIC PROJECTS IN FRESHWATER FOR THE PROJECT AREA. THOSE PORTIONS OF THE PROJECT WORK THAT OCCUR OUTSIDE OR ABOVE THE ORDINARY HIGH WATER MARK (ABOVE THE CORPS JURISDICTIONAL LINE) ARE NOT SUBJECT TO THE WORK PERIODS DESCRIBED ABOVE UNLESS SPECIFIED IN THE RELEVANT PERMITS.
4. ALL ACTIVITIES THAT INVOLVE WORK ADJACENT TO OR WITHIN THE WETTED CHANNEL SHALL, AT ALL TIMES, REMAIN CONSISTENT WITH ALL APPLICABLE WATER QUALITY STANDARDS, EFFLUENT LIMITATION AND STANDARDS OF PERFORMANCE, PROHIBITIONS, PRETREATMENT STANDARDS, AND MANAGEMENT PRACTICES ESTABLISHED PURSUANT TO THE CLEAN WATER ACT OR PURSUANT TO APPLICABLE STATE AND LOCAL LAW.
5. IF AT ANY TIME, AS A RESULT OF PROJECT ACTIVITIES, FISH ARE OBSERVED IN DISTRESS, A FISH KILL OCCURS, OR WATER QUALITY PROBLEMS DEVELOP (INCLUDING EQUIPMENT LEAKS OR SPILLS), OPERATIONS SHALL CEASE AND THE OWNER SHALL BE NOTIFIED IMMEDIATELY.
6. IF, DURING CONSTRUCTION, ARCHAEOLOGICAL REMAINS ARE ENCOUNTERED, CONSTRUCTION IN THE VICINITY SHALL BE HALTED, AND THE STATE OFFICE OF HISTORIC PRESERVATION AND THE OWNER SHALL BE NOTIFIED IMMEDIATELY.

SURVEY NOTES

1. UNLESS NOTED OTHERWISE ON THE PLANS, THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE PROTECTION OF ALL EXISTING SURVEY MONUMENTS AND OTHER SURVEY MARKERS DURING CONSTRUCTION.
2. THE CONTRACTOR SHALL MAINTAIN A SET OF PLANS ON THE JOB SHOWING "AS–CONSTRUCTED" CHANGES MADE TO DATE. UPON COMPLETION OF THE PROJECT, THE CONTRACTOR SHALL SUPPLY TO OWNER A SET OF PLANS, MARKED UP TO THE SATISFACTION OF THE OWNER, REFLECTING THE AS–CONSTRUCTED MODIFICATIONS.
3. ELEVATIONS SHOWN ON THE PLANS FOR PIPE INVERTS, TOPS OF BANKS, THALWEG, GRADE CONTROLS, ETC., ARE BASED UPON THE TOPOGRAPHIC INFORMATION SHOWN ON THE PLANS. THE CONTRACTOR SHALL VERIFY ALL NECESSARY SURFACE ELEVATIONS IN THE FIELD AND NOTIFY THE OWNER OF ANY DISCREPANCIES, WHICH MIGHT AFFECT PROPER OPERATION OF THE NEW FACILITIES BEFORE BREAKING GROUND AND PRIOR TO FACILITY INSTALLATION. THE OWNER SHALL BE CONTACTED IN THE EVENT ELEVATIONS ARE INCORRECT SO THAT THE PROPER ADJUSTMENTS CAN BE MADE BY ENGINEER PRIOR TO THE INSTALLATION OF THE FACILITIES, AS SET FORTH IN THE SPECIAL PROVISIONS.
4. LIDAR FOR THIS PROJECT WAS PROVIDED BY NOAA AND IS REPRESENTATIVE OF 2007 CONDITIONS. THE VERTICAL DATUM IS NAVD 88 (FT). THE HORIZONTAL DATUM IS UTM ZONE 4, NAD27 HAWAII (FT). LIDAR WAS SUPPLEMENTED BY 2006 FIELD SURVEYS BY THE KAMEHAMEHA HIGHWAY BRIDGE AND 2011 SITE SURVEY DATA.

EROSION, SEDIMENT CONTROL AND WATER MANAGEMENT NOTES

1. THE CONTRACTOR SHALL BE RESPONSIBLE FOR IMPLEMENTING ALL TEMPORARY EROSION CONTROL MEASURES. THE EROSION CONTROL MEASURES SHALL BE IN ACCORDANCE WITH ALL FEDERAL, STATE, AND LOCAL REQUIREMENTS. THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE MAINTENANCE AND PERFORMANCE OF THE TEMPORARY EROSION CONTROL MEASURES THROUGHOUT THE DURATION OF THE PROJECT.
2. A SEDIMENT AND EROSION CONTROL PLAN WILL BE DEVELOPED BY THE CONTRACTOR AND SUBMITTED FOR APPROVAL BY OWNER AND/OR THE ENGINEER BEFORE ANY CONSTRUCTION MAY BEGIN. THE SEDIMENT AND EROSION CONTROL PLAN WILL IDENTIFY BEST MANAGEMENT PRACTICES TO ENSURE THAT THE TRANSPORT OF SEDIMENT TO SURFACE WATERS, DRAINAGE SYSTEMS, AND ADJACENT PROPERTIES IS MINIMIZED.
3. ACTIVITIES SHALL BE DESIGNED AND CONSTRUCTED TO AVOID AND MINIMIZE ADVERSE IMPACTS TO WATERS OF THE UNITED STATES TO THE MAXIMUM EXTENT PRACTICAL THROUGH THE USE OF PRACTICAL ALTERNATIVES. ALTERNATIVES THAT SHALL BE CONSIDERED INCLUDE THOSE THAT MINIMIZE THE NUMBER AND EXTENT OF IN–WATER WORK AND EQUIPMENT CROSSINGS OF WETTED CHANNELS.
4. AT NO TIME SHALL SEDIMENT–LADEN WATER BE DISCHARGED OR PUMPED DIRECTLY INTO THE SUBJECT RIVER, STREAM, OR WETLAND. WATER SHALL BE DISCHARGED IN ACCORDANCE WITH REQUIREMENTS SET FORTH IN THE PROJECT PERMITS AND / OR SPECIFICATIONS.
5. IF HIGH WATER LEVEL CONDITIONS THAT CAUSE SILTATION OR EROSION ARE ENCOUNTERED DURING CONSTRUCTION, WORK SHALL STOP UNTIL THE WATER LEVEL SUBSIDES.
6. PERMIT CONDITIONS CONTAIN SPECIFIC REQUIREMENTS FOR THE CONTROL OF EROSION AND TURBIDITY FROM PROJECT OPERATIONS. TURBIDITY WILL BE MONITORED ON A FREQUENT BASIS BY THE PROJECT MANAGEMENT AND INSPECTION STAFF ON–SITE. TURBIDITY AMOUNTS IN EXCESS OF THE PERMITTED CONCENTRATIONS AND/OR DURATIONS WILL CAUSE WORK TO BE STOPPED UNTIL IMPROVED PRACTICES ARE IN EFFECT AND THE PROBLEMS CONTROLLED. THE CONTRACTOR IS COMPLETELY RESPONSIBLE FOR ANY PROJECT DELAYS THAT OCCUR BY NATURE OF THIS FAILURE TO ADEQUATELY CONTAIN SEDIMENT ON–SITE.
7. CONTRACTOR SHALL LIMIT MACHINERY MOVEMENT TO CONSTRUCTION AREAS DEFINED ON SITE PLAN OR IDENTIFIED AS ACCEPTABLE BY THE ENGINEER OR OWNER.
8. ALL EXTERNAL GREASE AND OIL SHALL BE PRESSURE–WASHED OFF THE EQUIPMENT PRIOR TO TRANSPORT TO THE SITE.
9. THE CONTRACTOR IS RESPONSIBLE TO ENSURE THAT NO PETROLEUM PRODUCTS, HYDRAULIC FLUID, SEDIMENTS, SEDIMENT–LADEN WATER, CHEMICALS, OR ANY OTHER TOXIC OR DELETERIOUS MATERIALS ARE ALLOWED TO ENTER OR LEACH INTO THE SUBJECT RIVER, STREAM, OR WETLAND.
10. THE CONTRACTOR SHALL HAVE AN EMERGENCY SPILL KIT ONSITE AT ALL TIMES.
11. NO TREES OR WETLAND VEGETATION SHALL BE REMOVED UNLESS THEY ARE SHOWN AND NOTED TO BE REMOVED ON THE PLANS OR AS DIRECTLY SPECIFIED ON–SITE BY THE PROJECT MANAGEMENT STAFF. ALL TREES CONFLICTING WITH GRADING SHALL BE REMOVED. NO GRADING SHALL TAKE PLACE WITHIN THE DRIP LINE OF TREES NOT TO BE REMOVED UNLESS OTHERWISE APPROVED.
12. FOLLOWING CONSTRUCTION, SITE RESTORATION WILL INCLUDE ESTABLISHING LONG–TERM EROSION PROTECTION MEASURES. THESE MEASURES WILL INCLUDE PLANTINGS, EROSION CONTROL FABRIC, SEED, AND MULCH. EQUIPMENT AND EXCESS SUPPLIES WILL BE REMOVED AND THE WORK AREA WILL BE CLEANED. MAINTENANCE ACTIVITIES FOR THE NEWLY CONSTRUCTED RESTORATION PROJECTS ARE ANTICIPATED TO OCCUR PERIODICALLY.

CONSTRUCTION NOTES

1. CONTRACT DOCUMENTS REFER TO THESE PLANS.
2. CONTRACTOR SHALL FURNISH ALL MATERIALS, EQUIPMENT, AND LABOR NECESSARY TO COMPLETE ALL WORK AS INDICATED IN THE CONTRACT DOCUMENTS.
3. CONSTRUCTION HOURS SHALL BE WEEKDAYS BETWEEN 7:00 A.M. AND 6:30 P.M. UNLESS PRIOR APPROVAL IS RECEIVED FROM THE OWNER.
4. SOILS AT THE SITE CONTAIN SOFT SILT, CLAY AND HIGH GROUNDWATER AND MAY REQUIRE EQUIPMENT MATS TO SUPPORT CONSTRUCTION EQUIPMENT. CONSOLIDATION OF THE GROUND SURFACE SHOULD BE EXPECTED. CONTRACTOR IS RESPONSIBLE FOR DETERMINING NEED FOR, DESIGNING, PROCURING, INSTALLING, USING AND REMOVING ANY EQUIPMENT MATS NEEDED TO ALLOW FOR EQUIPMENT OPERATION SUFFICIENT TO CONSTRUCT THE PROJECT.
5. PORTIONS OF THE PROJECT SITE ARE WITHIN THE ELEVATION RANGE OF TIDAL INUNDATION. THE CONSTRUCTION SEQUENCING PLAN, TESC PLAN, AND WATER MANAGEMENT PLAN SHALL INCLUDE DISCUSSION OF MANAGEMENT OF FLUCTUATING WATER SURFACE.
6. ANY DISCREPANCIES ARE TO BE BROUGHT TO THE ATTENTION OF THE OWNER PRIOR TO PROCEEDING WITH THE WORK.
7. THE CONTRACTOR SHALL INSTALL ALL EQUIPMENT AND MATERIALS IN ACCORDANCE WITH MANUFACTURER'S RECOMMENDATIONS UNLESS SPECIFICALLY INDICATED OTHERWISE BY THE OWNER OR WHERE LOCAL CODES OR REGULATIONS TAKE PRECEDENCE.
8. ALL WORK PERFORMED AND MATERIALS INSTALLED SHALL BE IN STRICT ACCORDANCE WITH ALL APPLICABLE CODES, REGULATIONS, AND ORDINANCES.
9. THE CONTRACTOR SHALL SUPERVISE AND DIRECT THE WORK USING THE BEST SKILLS AND ATTENTION. THE CONTRACTOR SHALL BE SOLELY RESPONSIBLE FOR ALL CONSTRUCTION MEANS, METHODS, TECHNIQUES, SEQUENCES, AND PROCEDURES AND FOR COORDINATING ALL PORTIONS OF THE WORK UNDER THIS CONTRACT.
10. THE CONTRACTOR SHALL MAKE ALL NECESSARY PROVISIONS TO PROTECT EXISTING IMPROVEMENTS, ROADWAY, DRAINAGE WAYS, PRIVATE BRIDGE, CULVERTS, AND VEGETATION UNTIL SUCH ITEMS ARE TO BE DISTURBED OR REMOVED AS INDICATED ON THE CONTRACT DOCUMENTS.
11. THE CONTRACTOR SHALL KEEP THE JOB SITE CLEAN AND HAZARD FREE. CONTRACTOR SHALL DISPOSE OF ALL DIRT, DEBRIS, AND RUBBISH FOR THE DURATION OF THE WORK. UPON COMPLETION OF WORK, CONTRACTOR SHALL REMOVE ALL MATERIAL AND EQUIPMENT NOT SPECIFIED AS REMAINING ON THE PROPERTY.
12. NOTES AND DETAILS ON THE PLANS SHALL TAKE PRECEDENCE OVER GENERAL NOTES HEREIN.
13. DIMENSIONS CALLOUTS SHALL TAKE PRECEDENCE OVER SCALES SHOWN ON THE PLANS.
14. THE PLANS REPRESENT THE FINISHED STRUCTURE. THEY DO NOT INDICATE THE METHOD OF ALL CONSTRUCTION. THE CONTRACTOR SHALL PROVIDE ALL MEASURES NECESSARY TO PROTECT THE STRUCTURES, WORKS, AND THE PUBLIC DURING CONSTRUCTION.
15. MATERIAL SHALL NOT BE STORED OUTSIDE OF IDENTIFIED STAGING AREAS. THE CONTRACTOR SHALL USE ONLY DESIGNATED SPECIFIC SITES FOR STORAGE OF EQUIPMENT AND MATERIALS AS SHOWN ON THESE PLANS. THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE SECURITY OF ALL EQUIPMENT AND MATERIALS.
16. ALL 36" CPEP TO BE OWNER–FURNISHED AND INSTALLED BY CONTRACTOR.
17. COMPACTION FOR FILL AREAS SHALL MEET THE FOLLOWING REQUIREMENTS:
    - 17.1. GREEN VALLEY ROAD PRISM, AG PROCESSING AREA, AND FARMERS MARKET AREA SHALL BE INSTALLED IN 6" LIFTS AND COMPACTED TO MIN 90% MAX DENSITY PER ASTM D1557.
    - 17.2. FILL OUTSIDE OF GREEN VALLEY ROAD PRISM, AG PROCESSING AREA, AND FARMERS MARKET AREA SHALL BE INSTALLED IN 12" LIFTS AND COMPACTED TO MIN 90% MAX DENSITY PER ASTM D1557 FROM EXISTING GRADE TO AN ELEVATION 3' BELOW PROPOSED GRADE. FROM 3' BELOW GRADE TO PROPOSED GRADE SHALL BE INSTALLED IN 12" LIFTS AND COMPACTED TO 80–85% MAX DENSITY PER ASTM D1557.
18. ON–SITE CONCRETE DEBRIS MAY INCLUDE, BUT IS NOT LIMITED TO BOULDERS, CARS, FARM EQUIPMENT, PIPES, METAL, CONCRETE, ASPHALT, AND CONSTRUCTION DEBRIS, WHICH IS TO BE MANAGED AS FOLLOWS:
    - 18.1. BOULDERS – MAY BE INCORPORATED INTO PROJECT IN FILL 3' OR MORE BELOW FINISHED GRADE OR WITHIN STREAM CROSSING.
    - 18.2. CARS, FARM EQUIPMENT, METAL, PIPES – DISPOSE OF OFF SITE AT PERMITTED DISPOSAL SITE.
    - 18.3. CONCRETE, ASPHALT, AND CONSTRUCTION DEBRIS – MAY BE CRUSHED OR BROKEN INTO PIECES NO LARGER THAN 18"X18"X18" AND INCORPORATED INTO PROJECT IN GENERAL FILL 3' OR MORE BELOW FINISHED GRADE.
19. THIS SITE HAS RELIC MILITARY INSTALLATIONS AND MAY HAVE UNEXPLODED ORDINANCE. IF UNEXPLODED ORDINANCE ARE FOUND STOP WORK IN THE IMMEDIATE VICINITY AND NOTIFY OWNER.
20. ACTIVE FARMING WILL BE OCCURRING MAUKA OF THE PROJECT SITE DURING CONSTRUCTION. PROVIDE CONTINUAL ACCESS FOR FARMERS AND OWNER TO ACCESS ACTIVE FARM LANDS.
21. SOIL MANAGEMENT. THE TOP 3' LAYER OF EXISTING SOIL SHALL BE STRIPPED AND STOCKPILED FOR INSTALLATION AS THE TOP 3' OF GENERAL FILL. SOURCES CONTAINING OVER 30% ROCK OR DEBRIS SHALL BE EXCLUDED FROM THIS MATERIAL.

MICHAEL E. HRACHOVEC
LICENSED PROFESSIONAL ENGINEER
No. 15237–C
HAWAII U.S.A.
THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.
Signature — Expiration Date of the License

KAMEHAMEHA SCHOOLS 1887 IMUA
Natural Systems Design
ICF INTERNATIONAL

0 Ø 1
IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT PLOTTED TO ORIGINAL SCALE.

NAME OR INITIALS AND DATE	
DESIGNED	TA, MH, BB
CHECKED	TA, MH
DRAWN	GD, GM
CHECKED	MH

GEOGRAPHIC INFORMATION	
LATITUDE	21°34'29"N
LONGITUDE	157°52'58"W
TN/SC/RG	–/–/–
DATE	9/20/2013

PUNALU'U FLOOD MITIGATION AND STREAM RESTORATION

CONSTRUCTION NOTES

3

Sep-25-2013 90% DRAWINGS DRAFT

N:\Projects\Kamehameha Schools Hawaii\Punaluu\Design\CAD DWGs – Current\CAD DWGS\CONSTRUCTION NOTES.dwg | garvey | Sep–25–2013 7:42pm

LEGEND

- PROPERTY/PARCEL LINE
- EXISTING MAJOR CONTOUR
- EXISTING MINOR CONTOUR
- PROPOSED MAJOR CONTOUR
- PROPOSED MINOR CONTOUR
- ACCESS ROAD
- OHWM — EXISTING ORDINARY HIGH WATER MARK
- OHWM — PROPOSED ORDINARY HIGH WATER MARK
- W — EXISTING WATER LINE
- W — PROPOSED WATER LINE
- CL — CONSTRUCTION LIMIT
- GL — GRADING LIMIT
- SF — SILT FENCE
- T — TURBIDITY CURTAIN
- OH — EXISTING OVERHEAD POWER LINE
- PROPOSED DITCH CENTERLINE
- PROPOSED STREAM BYPASS
- DEMOLITION/REMOVAL AREA
- LAND CLEARING AREA
- PROPOSED CULVERT, FOR SECTION SEE 1/45
- EXISTING STRUCTURE
- EXISTING CULTURAL AREA

DETAIL AND SECTION REFERENCING

- 1 — NOTE REFERENCING NUMBER
- 2/1 — DETAIL REFERENCE NUMBER / SHEET ON WHICH DETAIL APPEARS
- 2/1 — DETAIL REFERENCE NUMBER / SHEET ON WHICH DETAIL APPEARS
- (TYP) — SPECIFIES THAT DETAIL IS UNIFORMLY TYPICAL THROUGHOUT PROJECT EXCEPT WHERE OTHERWISE NOTED
- (VAR) — SPECIFIES THAT DETAIL WAS TAKEN FROM SEVERAL SHEETS
- A A32 — SECTION A–A IS SHOWN ON SHEET 32
- SECTION A–A 32, SCALE: NTS — SECTION A–A IS SHOWN ON SHEET 32

CONSTRUCTION LIMIT CONTROL POINTS

NORTHING	EASTING
146516.4	1682224.7
146584.8	1677462.3
146658.4	1677165.1
146702.4	1682077.4
146813.5	1677707.6
146873.4	1682524.2
146880.7	1677645.4
146942.6	1677198.5
147044.6	1678051.4
147050.8	1682517.4
147081.0	1677756.8
147126.8	1678493.7
147137.9	1678072.0
147139.0	1677312.4
147163.8	1678122.3
147167.4	1681424.9
147187.7	1681296.6
147197.5	1677850.7
147222.6	1681097.3
147291.1	1677538.9
147347.9	1678948.4
147365.6	1680886.6
147369.9	1681013.0
147372.1	1679940.0
147422.1	1680634.0
147452.4	1679283.9
147476.3	1677678.0
147563.2	1677897.8
147600.7	1680339.9
147705.8	1680892.6
147725.3	1680757.4
147754.2	1681970.7
147771.7	1682002.6
147777.3	1680588.2
147831.8	1680318.9
147850.0	1681269.2
147850.9	1681632.0
147856.6	1680162.6
147870.9	1682086.6
147873.7	1680533.9
147889.6	1680425.2
147890.6	1680636.9
147909.4	1681743.7
147911.8	1680273.7
147936.9	1682086.5
148040.5	1680369.6
148054.5	1678274.5
148104.0	1680570.1
148136.3	1680796.4
148144.3	1681928.8

CONSTRUCTION LIMIT CONTROL POINTS

NORTHING	EASTING
148170.5	1678346.1
148201.6	1681850.0
148208.3	1681825.9
148217.2	1681028.5
148266.3	1681018.4
148300.3	1678334.5
148308.8	1678386.9
148327.1	1681014.6
148370.7	1681112.2
148377.9	1680512.4
148410.3	1678390.9
148434.4	1681292.4
148439.0	1681074.5
148440.6	1678484.9
148456.0	1680704.5
148456.6	1681252.7
148495.1	1681329.6
148513.2	1681179.0
148595.8	1678472.5
148647.0	1678535.9
148853.4	1679873.1
148919.5	1679118.4
148926.1	1679824.4
148952.9	1679098.8
148961.6	1680016.6
149000.2	1679047.6
149033.7	1679808.6
149111.9	1679171.5
149145.0	1679916.4
149204.6	1680070.9
149228.6	1679549.8
149258.5	1679728.6
149358.4	1679286.1
149406.2	1679533.9
149442.9	1679360.4
149478.6	1679461.8
149483.4	1679316.3
149491.4	1679607.4
149537.4	1679582.6
149601.3	1679498.3
149632.9	1679640.9
149699.3	1679508.1
149729.5	1679557.6

MICHAEL E. HRACHOVEC
LICENSED PROFESSIONAL ENGINEER
No. 15237-C
HAWAII U.S.A.
THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.
Signature — Expiration Date of the License

KAMEHAMEHA SCHOOLS — IMUA

Natural Systems Design

ICF INTERNATIONAL

0 Ø 1
IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT PLOTTED TO ORIGINAL SCALE.

NAME OR INITIALS AND DATE	
DESIGNED	TA, MH, BB
CHECKED	TA, MH
DRAWN	GD, GM
CHECKED	MH

GEOGRAPHIC INFORMATION	
LATITUDE	21°34'29"N
LONGITUDE	157°52'58"W
TN/SC/RG	-/-/-
DATE	9/20/2013

PUNALU'U FLOOD MITIGATION AND STREAM RESTORATION

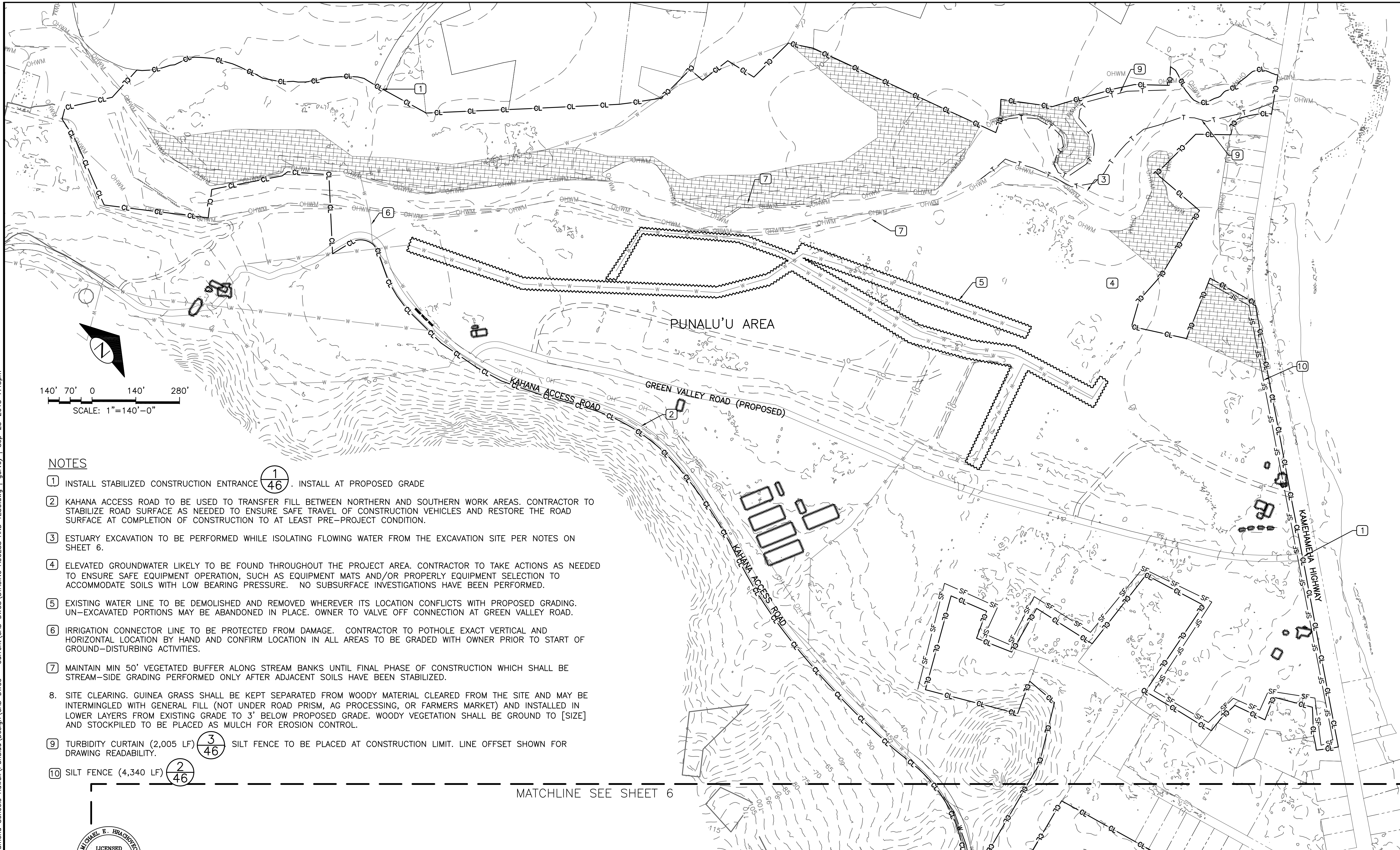
LEGEND

4

SHEET 4 OF 46

Sep-25-2013 90% DRAWINGS DRAFT

N:\Projects\Kamehameha Schools Hawaii\Punaluu\Design\CAD DWGs - Current\CAD DWGS\LEGEND.dwg | garvey | Sep-25-2013 7:42pm



NOTES

1. INSTALL STABILIZED CONSTRUCTION ENTRANCE (1/46). INSTALL AT PROPOSED GRADE
2. KAHANA ACCESS ROAD TO BE USED TO TRANSFER FILL BETWEEN NORTHERN AND SOUTHERN WORK AREAS. CONTRACTOR TO STABILIZE ROAD SURFACE AS NEEDED TO ENSURE SAFE TRAVEL OF CONSTRUCTION VEHICLES AND RESTORE THE ROAD SURFACE AT COMPLETION OF CONSTRUCTION TO AT LEAST PRE-PROJECT CONDITION.
3. ESTUARY EXCAVATION TO BE PERFORMED WHILE ISOLATING FLOWING WATER FROM THE EXCAVATION SITE PER NOTES ON SHEET 6.
4. ELEVATED GROUNDWATER LIKELY TO BE FOUND THROUGHOUT THE PROJECT AREA. CONTRACTOR TO TAKE ACTIONS AS NEEDED TO ENSURE SAFE EQUIPMENT OPERATION, SUCH AS EQUIPMENT MATS AND/OR PROPERLY EQUIPMENT SELECTION TO ACCOMMODATE SOILS WITH LOW BEARING PRESSURE. NO SUBSURFACE INVESTIGATIONS HAVE BEEN PERFORMED.
5. EXISTING WATER LINE TO BE DEMOLISHED AND REMOVED WHEREVER ITS LOCATION CONFLICTS WITH PROPOSED GRADING. UN-EXCAVATED PORTIONS MAY BE ABANDONED IN PLACE. OWNER TO VALVE OFF CONNECTION AT GREEN VALLEY ROAD.
6. IRRIGATION CONNECTOR LINE TO BE PROTECTED FROM DAMAGE. CONTRACTOR TO POTHOLE EXACT VERTICAL AND HORIZONTAL LOCATION BY HAND AND CONFIRM LOCATION IN ALL AREAS TO BE GRADED WITH OWNER PRIOR TO START OF GROUND-DISTURBING ACTIVITIES.
7. MAINTAIN MIN 50' VEGETATED BUFFER ALONG STREAM BANKS UNTIL FINAL PHASE OF CONSTRUCTION WHICH SHALL BE STREAM-SIDE GRADING PERFORMED ONLY AFTER ADJACENT SOILS HAVE BEEN STABILIZED.
8. SITE CLEARING. GUINEA GRASS SHALL BE KEPT SEPARATED FROM WOODY MATERIAL CLEARED FROM THE SITE AND MAY BE INTERMINGLED WITH GENERAL FILL (NOT UNDER ROAD PRISM, AG PROCESSING, OR FARMERS MARKET) AND INSTALLED IN LOWER LAYERS FROM EXISTING GRADE TO 3' BELOW PROPOSED GRADE. WOODY VEGETATION SHALL BE GROUND TO [SIZE] AND STOCKPILED TO BE PLACED AS MULCH FOR EROSION CONTROL.
9. TURBIDITY CURTAIN (2,005 LF) (3/46) SILT FENCE TO BE PLACED AT CONSTRUCTION LIMIT. LINE OFFSET SHOWN FOR DRAWING READABILITY.
10. SILT FENCE (4,340 LF) (2/46)

MICHAEL E. HRACHOVEC
LICENSED PROFESSIONAL ENGINEER
No. 15237-C
HAWAII U.S.A.
THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.
Signature Expiration Date of the License

KAMEHAMEHA SCHOOLS 1887 IMUA

Natural Systems Design

ICF INTERNATIONAL

0 Ø 1
IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT PLOTTED TO ORIGINAL SCALE.

NAME OR INITIALS AND DATE	
DESIGNED	TA, MH, BB
CHECKED	TA, MH
DRAWN	GD, GM
CHECKED	MH

GEOGRAPHIC INFORMATION	
LATITUDE	21°34'29"N
LONGITUDE	157°52'58"W
TN/SC/RG	-/-/-
DATE	9/20/2013

PUNALU'U FLOOD MITIGATION AND STREAM RESTORATION

STAGING, ACCESS AND TESC 1

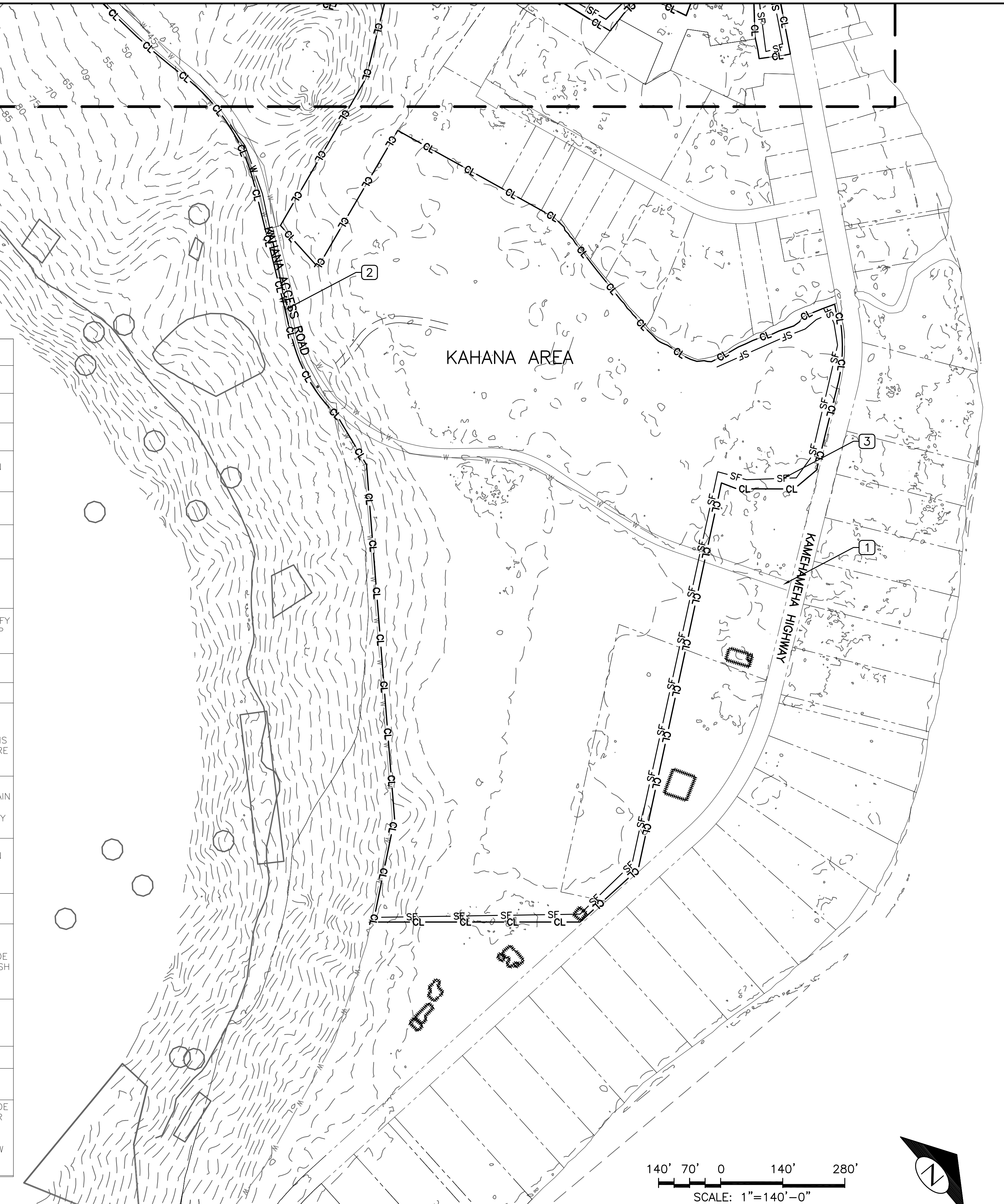
Sep-25-2013 90% DRAWINGS DRAFT

MATCHLINE SEE SHEET 5

NOTES

1. INSTALL STABILIZED CONSTRUCTION ENTRANCE (1/46)
2. KAHANA ACCESS ROAD TO BE USED TO TRANSFER FILL BETWEEN NORTHERN AND SOUTHERN WORK AREAS. CONTRACTOR TO STABILIZE ROAD SURFACE AS NEEDED TO ENSURE SAFE TRAVEL OF CONSTRUCTION VEHICLES AND RESTORE THE ROAD SURFACE AT COMPLETION OF CONSTRUCTION TO AT LEAST PRE-PROJECT CONDITION.
3. INSTALL 2,370 LF SILT FENCE (2/46)
4. CONSTRUCTION SEQUENCE AND BMPS: CONSTRUCTION SEQUENCE TO BE DEVELOPED BY CONTRACTOR, REVIEWED AND MODIFIED AS NEEDED TO SATISFY OWNER. THE FOLLOWING SEQUENCE OUTLINES A POTENTIAL CONSTRUCTION SEQUENCE AND IDENTIFIES ASSOCIATED BMPS.

CONSTRUCTION ELEMENT	BMPS
INSTALL CONSTRUCTION ENTRANCES AND IDENTIFY MATERIAL STAGING AREAS	3 CONSTRUCTION ENTRANCES
CORDON OFF VEGETATIVE BUFFER 50' WIDE ON BOTH SIDES OF PUNALU'U STREAM	MAINTAIN VEGETATIVE BUFFER ALONG STREAM CORRIDOR, INSTALL STAKES AND FLAGGING AT 50 FT SPACING
INSTALL SILT FENCE ALONG DOWNSLOPE PERIMETERS ALONG CONSTRUCTION LIMIT AS SHOWN	INSTALL 6710 LF SILT FENCE AS PERIMETER PROTECTION
CLEAR AND GRUB 10 ACRES OF FORESTED AREAS SHOWN ON SHEETS 5 AND 6 (EXCEPT THAT 50 FT WIDE PORTION OF WHICH IS THE VEGETATIVE BUFFER ALONG PUNALU'U STREAM)	CHIP THE VEGETATION INTO SLASH (6" MAX DIAMETER, 12" MAX LENGTH) AND STOCKPILE FOR APPLICATION AS MULCH ON CLEARED LAND
CLEAR VEGETATION ON AREAS WITHIN THE PUNALU'U BASIN TO BE FILLED	CHIP FARM VEGETATION INTO MULCH AND STOCKPILE. LIMIT TOTAL AREA OF BARE SOILS TO 5 ACRES IN DRY MONTHS (APRIL – OCT AND 2 ACRES IN WET MONTHS (NOV – MAR)
CLEAR VEGETATION ON FLOODPLAIN CREATION AREAS WITHIN PUNALU'U BASIN	CHIP FARM VEGETATION INTO MULCH AND STOCKPILE. LIMIT TOTAL AREA OF BARE SOILS TO 5 ACRES IN DRY MONTHS (APRIL – OCT AND 2 ACRES IN WET MONTHS (NOV – MAR)
CUT MATERIAL FROM FLOODPLAIN CREATION AREAS SOUTH OF PUNALU'U STREAM AND PLACE FILL ON FILL AREAS, INCLUDING GREEN VALLEY ROAD PRISM.	LOCAL HAUL OF CUT WITHOUT TRANSPORT ON KAMEHAMEHA HWY. COMPACT GREEN VALLEY ROAD PRISM AND TERRACE AREAS AS FILL LAYERS ARE INSTALLED. COVER FLOODPLAIN CUT AND FILL AREAS WITH MULCH OR SLASH AS FINAL GRADE IS ACHIEVED. ENSURE NO BARE SOIL IS VISIBLE AT COMPLETION OF MULCH OR SLASH APPLICATION.
MONITOR WATER QUALITY AND SOIL EROSION/SEDIMENTATION CONDITIONS CONTINUALLY ON SITE WITHIN THE PROJECT AREA	IF TURBIDITY OCCURS WITHIN PUNALU'U STREAM WHICH RESULTS FROM EROSION OF SOILS WITHIN PROJECT SITE, IDENTIFY SOURCE OF SOIL EROSION AND STABILIZE SOILS TO ELIMINATE EROSION AND TRANSPORT OF SEDIMENT OFF-SITE. STOP WORK IN THE AREA ASSOCIATED WITH THE EROSION UNTIL SOILS ARE STABILIZED.
REMOVE TRASH AND DEBRIS ENCOUNTERED DURING CLEAR AND GRUB AND/OR EXCAVATION	HAUL TRASH AND DEBRIS TO APPROVED DISPOSAL SITE, MAINTAINING CONSTRUCTION ENTRANCES TO ENSURE NO OFF-SITE TRACKING OF SOIL.
INSTALL CULVERTS AND DRAINAGE DITCHES	DEWATER CUT AREAS AS NEEDED TO INSTALL CULVERTS IN DRY CONDITIONS.
CUT MATERIAL FROM FLOODPLAIN CREATION AREAS NORTH OF PUNALU'U STREAM AND PLACE FILL ON FILL AREAS, INCLUDING GREEN VALLEY ROAD PRISM.	HAUL CUT FROM NORTH AREAS TO FILL AREAS IN PUNALU'U BASIN, PLACE AND COMPACT MATERIALS IN LIFTS. MAINTAIN CONSTRUCTION ENTRANCES AND CLEAN VEHICLES TO ENSURE NO MATERIAL IS TRACKED OFF-SITE AND/OR ONTO KAMEHAMEHA HIGHWAY. IF TRACKING OCCURS, SWEEP OR VACUUM MATERIAL OFF ROADWAYS – WASHING OF ROADWAYS IS NOT PERMITTED. COVER FLOODPLAIN CUT AND FILL AREAS WITH MULCH OR SLASH AS FINAL GRADE IS ACHIEVED. ENSURE NO BARE SOIL IS VISIBLE AT COMPLETION OF MULCH OR SLASH APPLICATION.
AT COMPLETION OF FLOODPLAIN GRADING (NOT INCLUDING BUFFERS), CUT ESTUARY CHANNEL, DEWATERING ONLY IF NECESSARY TO EXCAVATE THE CHANNEL.	MAINTAIN EARTHEN BERM BETWEEN STATION 0+00 TO STATION 0+50 TO ISOLATE CHANNEL EXCAVATION FROM PUNALU'U STREAM. WHEN CHANNEL EXCAVATION FROM STATION 0+50 TO STATION 12+50 IS COMPLETE, INSTALL TURBIDITY CURTAIN ALONG PUNALU'U STREAM BETWEEN STATION 7+50 TO STATION 8+50 (100 LF), THEN REMOVE BERM TO COMPLETE CHANNEL EXCAVATION. REMOVE TURBIDITY CURTAIN WHEN TURBIDITY HAS SETTLED AND WATER HAS CLARIFIED IN ESTUARY CHANNEL.
CLEAR AND GRUB BUFFER AREAS ALONG PUNALU'U STREAM. CUT REMAINING MATERIAL FROM BUFFER AREAS TO ACHIEVE PROPOSED GRADE AND HAUL AND PLACE CUT MATERIAL ON FILL AREAS WITHIN PUNALU'U BASIN.	CHIP THE VEGETATION INTO SLASH (6" MAX DIAMETER, 12" MAX LENGTH) AND STOCKPILE FOR APPLICATION AS MULCH ON CLEARED LAND. CLEAR NO MORE THAN 1 ACRE AT A TIME, LEAVE EXPOSED SOILS BARE FOR NO MORE THAN 7 DAYS IN DRY MONTHS, 2 DAYS IN WET MONTHS BEFORE APPLYING SLASH OR MULCH TO BARE SOILS.
INSTALL WATER PIPELINE, INSTALL GEOTEXTILE, BASE COURSE AND TOP COURSE OF GREEN VALLEY ROAD	COMPACT SOILS OF GREEN VALLEY ROAD PRISM, STABILIZE ROAD SURFACE WITH GRAVEL
CUT KAHANA STORMWATER BASIN AND PLACE FILL ON ADJACENT KAHANA FILL AREA	LOCAL HAUL OF CUT WITHOUT TRANSPORT ON KAMEHAMEHA HWY. COMPACT ROAD PRISM AND TERRACE AREAS AS FILL LAYERS ARE INSTALLED. ISOLATE CUT FROM EXISTING DRAINAGE CHANNEL BY MAINTAINING PLUG OF SOIL MIN 50 FT WIDE UPSTREAM OF CULVERT IN BASIN AREA UNTIL BASIN GRADING IS COMPLETED. COVER FILL AREAS WITH MULCH OR SLASH AS FINAL GRADE IS ACHIEVED. ENSURE NO BARE SOIL IS VISIBLE AT COMPLETION OF MULCH OR SLASH APPLICATION.
EXCAVATE UPPER AND LOWER KAHANA DITCHES, PLACE FILL ON KAHANA FILL TERRACE AREAS	INSTALL AGGREGATE IN DITCH BOTTOM AS SHOWN TO STABILIZE DITCH BOTTOMS. COVER FILL AREAS WITH MULCH OR SLASH AS FINAL GRADE IS ACHIEVED. ENSURE NO BARE SOIL IS VISIBLE AT COMPLETION OF MULCH OR SLASH APPLICATION.
INSTALL STREAM CROSSING	BYPASS CHANNEL FLOWS AS SHOWN ON DRAWINGS TO INSTALL STREAM CROSSING OUTSIDE OF FLOWING WATER
INSTALL UPSTREAM BANK STABILIZATION	BYPASS CHANNEL FLOWS IN TEMPORARY BYPASS CHANNEL AS SHOWN ON DRAWINGS TO INSTALL BANK STABILIZATION OUTSIDE OF FLOWING WATER
EXCAVATE ESTUARY IN PUNALU'U STREAM	INSTALL 2005 LF TURBIDITY CURTAINS ALONG EDGE OF EXISTING STREAM CHANNEL. MAINTAIN BERM OF SOIL MIN 20' WIDE ALONG LENGTH OF BOTH SIDES OF STREAM. EXCAVATE ESTUARY GRADING BEHIND BERMS. UTILIZE EQUIPMENT MATS OR LAYERS OF VEGETATION AND/OR LOW-GROUND PRESSURE EQUIPMENT AS NEEDED TO PREVENT EQUIPMENT FROM BECOMING MIRED IN SATURATED SOILS. REMOVE BERM FROM NORTH SIDE OF STREAM. REMOVE NORTH TURBIDITY CURTAIN WHEN WATER BEHIND TURBIDITY CURTAIN CLEARS. RELOCATE SOUTH TURBIDITY CURTAIN NORTHWARD TO ALLOW FINAL ESTUARY DREDGING AND REMOVE SOUTH BERM . REMOVE SOUTH TURBIDITY CURTAIN WHEN WATER BEHIND TURBIDITY CURTAIN CLEARS.



MICHAEL E. HRACHOVEC
LICENSED PROFESSIONAL ENGINEER
No. 15237-C
HAWAII U.S.A.
THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.
Signature — Expiration Date of the License

KAMEHAMEHA SCHOOLS — IMUA
Natural Systems Design
ICF INTERNATIONAL

0 ½ 1
IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT PLOTTED TO ORIGINAL SCALE.

NAME OR INITIALS AND DATE	
DESIGNED	TA, MH, BB
CHECKED	TA, MH
DRAWN	GD, GM
CHECKED	MH

GEOGRAPHIC INFORMATION	
LATITUDE	21°34'29"N
LONGITUDE	157°52'58"W
TN/SC/RG	-/-/-
DATE	9/20/2013

PUNALU'U FLOOD MITIGATION AND STREAM RESTORATION

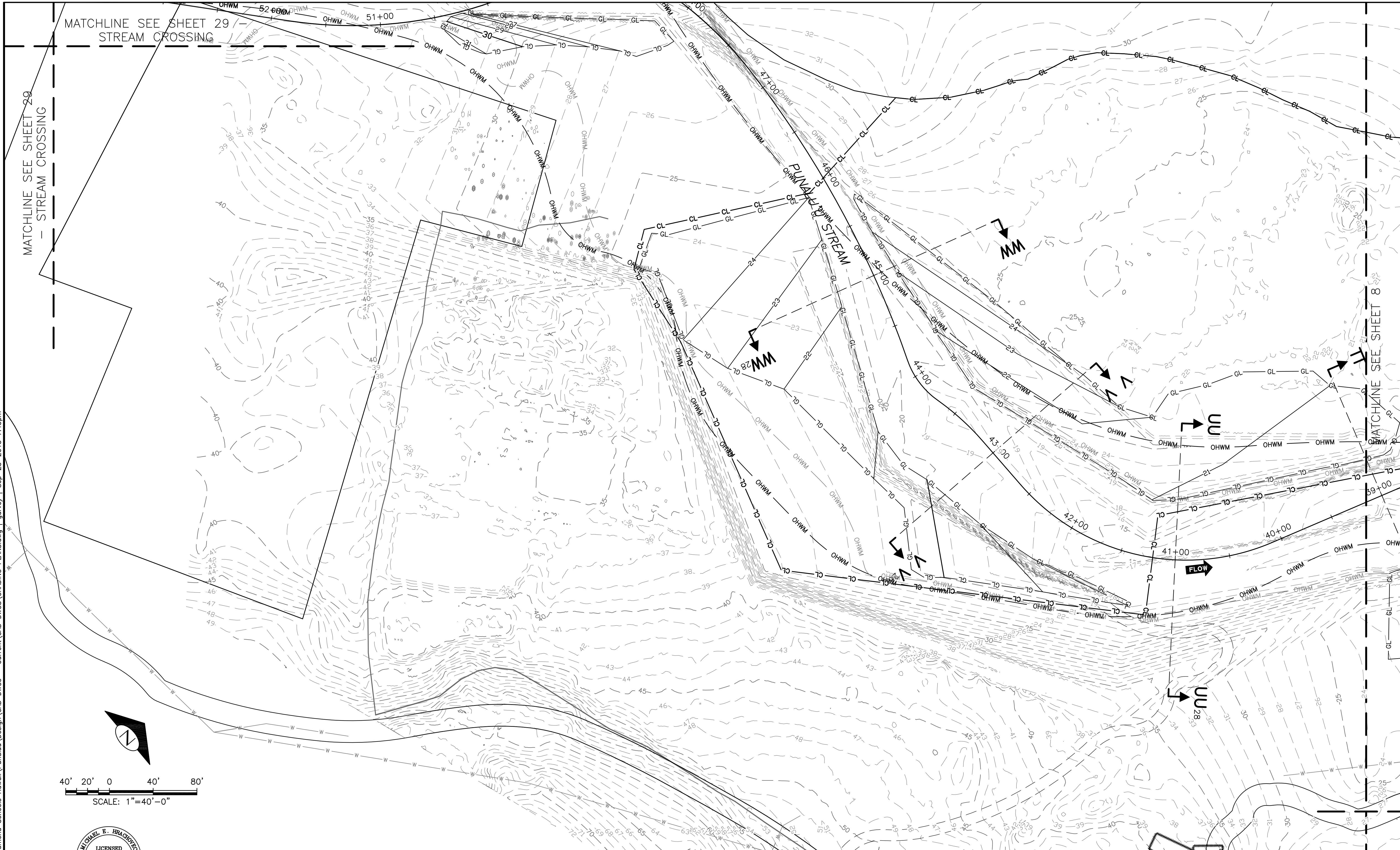
STAGING, ACCESS AND TESC 2

6

SHEET 6 OF 46

Sep-25-2013 90% DRAWINGS DRAFT

N:\Projects\Kamehameha Schools Hawaii\Punaluu\Design\CAD DWGs - Current\CAD DWGS\STAGING ACCESS AND TESC.dwg | garvey | Sep-25-2013 7:43pm



Sep-25-2013 90% DRAWINGS DRAFT

N:\Projects\Kamehameha Schools Hawaii\Punaluu\Design\CAD DWGs - Current\CAD DWGS\GRADING PLANS.dwg | garvey | Sep-25-2013 7:45pm

MICHAEL E. HRACHOVEC LICENSED PROFESSIONAL ENGINEER No. 15237-C HAWAII U.S.A.

THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.

Signature Expiration Date of the License

Kamehameha Schools · Natural Systems Design · ICF International

0 Ø 1 — IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT PLOTTED TO ORIGINAL SCALE.

NAME OR INITIALS AND DATE	
DESIGNED	TA, MH, BB
CHECKED	TA, MH
DRAWN	GD, GM
CHECKED	MH

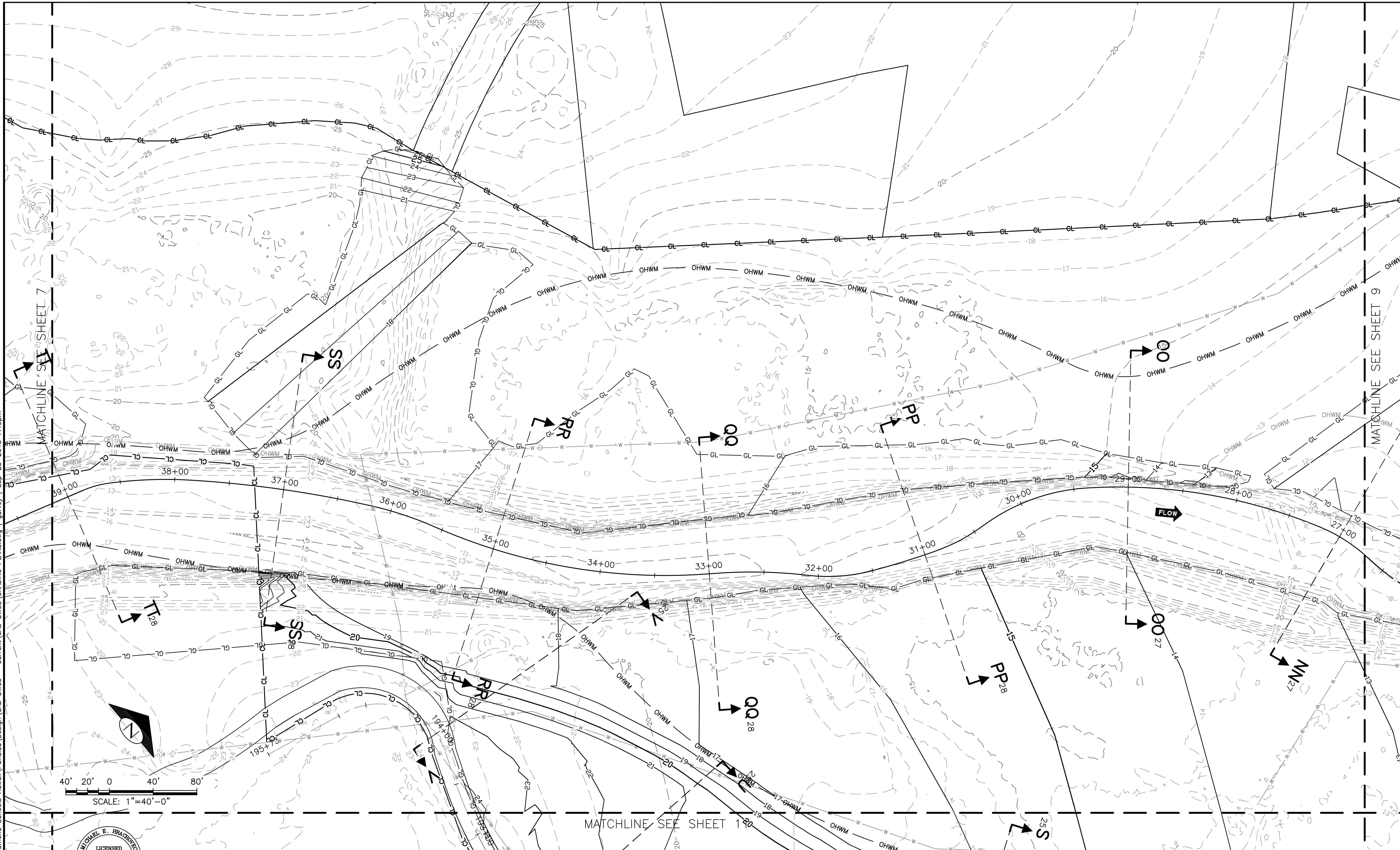
GEOGRAPHIC INFORMATION	
LATITUDE	21°34'29"N
LONGITUDE	157°52'58"W
TN/SC/RG	-/-/-
DATE	9/20/2013

PUNALU'U FLOOD MITIGATION AND STREAM RESTORATION

GRADING PLAN 1

7

SHEET 7 OF 46



MICHAEL E. HRACHOVEC
LICENSED PROFESSIONAL ENGINEER
No. 15237-C
HAWAII U.S.A.
THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.
Signature
Expiration Date of the License

Natural Systems Design

IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT PLOTTED TO ORIGINAL SCALE.

NAME OR INITIALS AND DATE	
DESIGNED	TA, MH, BB
CHECKED	TA, MH
DRAWN	GD, GM
CHECKED	MH

GEOGRAPHIC INFORMATION	
LATITUDE	21°34'29"N
LONGITUDE	157°52'58"W
TN/SC/RG	-/-/-
DATE	9/20/2013

PUNALU'U FLOOD MITIGATION AND STREAM RESTORATION

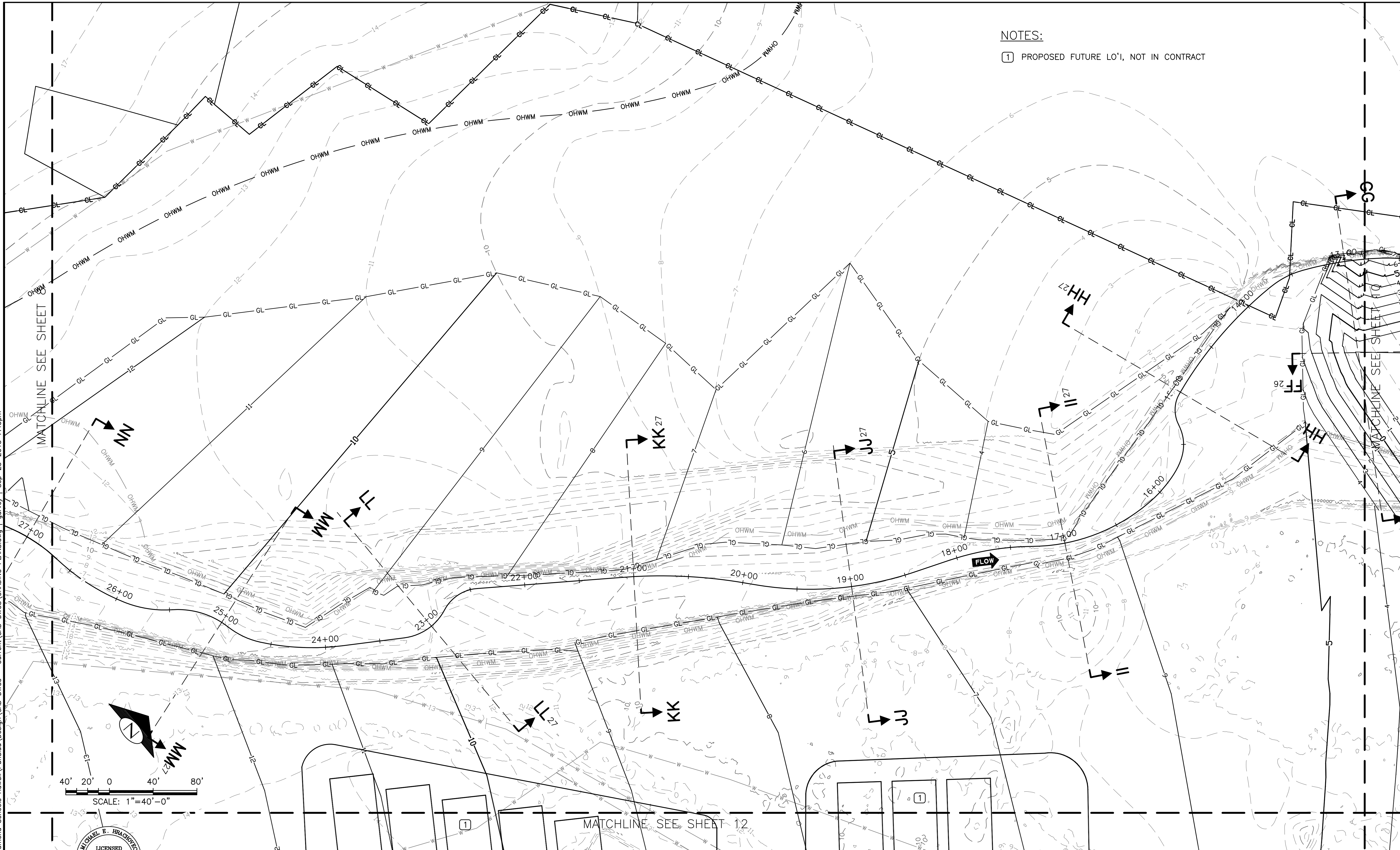
GRADING PLAN 2

8

SHEET 8 OF 46

Sep-25-2013 90% DRAWINGS DRAFT

N:\Projects\Kamehameha Schools Hawaii\Punaluu\Design\CAD DWGs - Current\CAD DWGS\GRADING PLANS.dwg | garvey | Sep-25-2013 7:45pm



NOTES:

1. PROPOSED FUTURE LO'I, NOT IN CONTRACT

MICHAEL E. HRACHOVEC
LICENSED PROFESSIONAL ENGINEER
No. 15237-C
HAWAII U.S.A.

THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.

Signature | Expiration Date of the License

KAMEHAMEHA SCHOOLS 1887 IMUA

Natural Systems Design

ICF INTERNATIONAL

0 Ø 1
IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT PLOTTED TO ORIGINAL SCALE.

NAME OR INITIALS AND DATE	
DESIGNED	TA, MH, BB
CHECKED	TA, MH
DRAWN	GD, GM
CHECKED	MH

GEOGRAPHIC INFORMATION	
LATITUDE	21°34'29"N
LONGITUDE	157°52'58"W
TN/SC/RG	-/-/-
DATE	9/20/2013

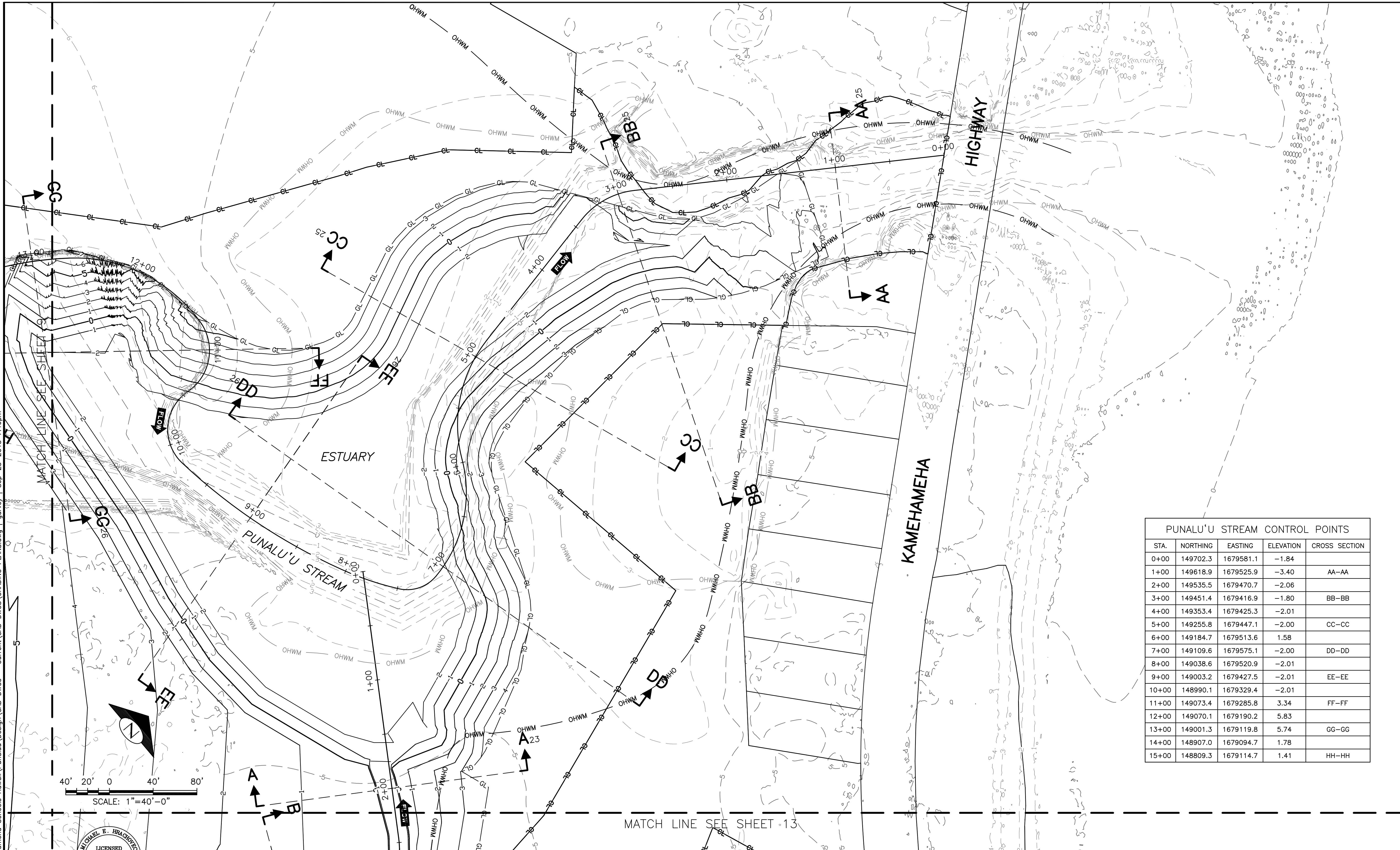
PUNALU'U FLOOD MITIGATION AND STREAM RESTORATION

GRADING PLAN 3

9

SHEET 9 OF 46

Sep-25-2013 90% DRAWINGS DRAFT



PUNALU'U STREAM CONTROL POINTS				
STA.	NORTHING	EASTING	ELEVATION	CROSS SECTION
0+00	149702.3	1679581.1	−1.84	
1+00	149618.9	1679525.9	−3.40	AA–AA
2+00	149535.5	1679470.7	−2.06	
3+00	149451.4	1679416.9	−1.80	BB–BB
4+00	149353.4	1679425.3	−2.01	
5+00	149255.8	1679447.1	−2.00	CC–CC
6+00	149184.7	1679513.6	1.58	
7+00	149109.6	1679575.1	−2.00	DD–DD
8+00	149038.6	1679520.9	−2.01	
9+00	149003.2	1679427.5	−2.01	EE–EE
10+00	148990.1	1679329.4	−2.01	
11+00	149073.4	1679285.8	3.34	FF–FF
12+00	149070.1	1679190.2	5.83	
13+00	149001.3	1679119.8	5.74	GG–GG
14+00	148907.0	1679094.7	1.78	
15+00	148809.3	1679114.7	1.41	HH–HH

Sep-25-2013 90% DRAWINGS DRAFT

N:\Projects\Kamehameha Schools Hawaii\Punaluu\Design\CAD DWGs – Current\CAD DWGS\GRADING PLANS.dwg | garvey | Sep-25-2013 7:46pm

MICHAEL E. HRACHOVEC
LICENSED PROFESSIONAL ENGINEER
No. 15237-C
HAWAII U.S.A.

THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.

Signature | Expiration Date of the License

KAMEHAMEHA SCHOOLS | IMUA

Natural Systems Design

ICF INTERNATIONAL

0 ½ 1
IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT PLOTTED TO ORIGINAL SCALE.

NAME OR INITIALS AND DATE	
DESIGNED	TA, MH, BB
CHECKED	TA, MH
DRAWN	GD, GM
CHECKED	MH

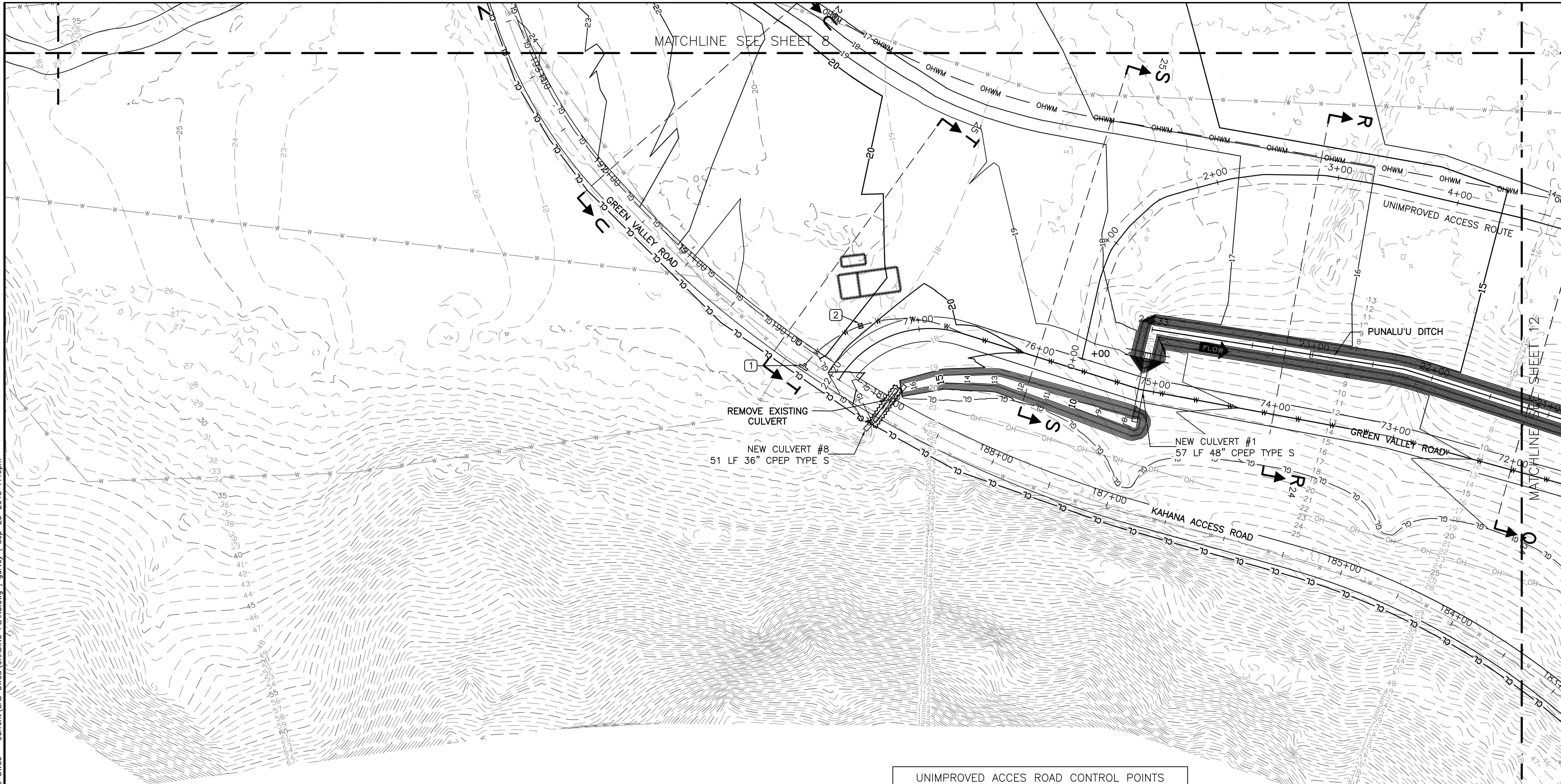
GEOGRAPHIC INFORMATION	
LATITUDE	21°34'29"N
LONGITUDE	157°52'58"W
TN/SC/RG	–/–/–
DATE	9/20/2013

PUNALU'U FLOOD MITIGATION AND STREAM RESTORATION

GRADING PLAN 4

10

SHEET 10 OF 46



NOTES:

1. LOCATE EXISTING WATER LINE, PROTECT FROM DAMAGE DURING AND AFTER LOCATION. CONNECT NEW 8" HDPE WATER LINE TO EXISTING 8" HDPE LINE AT N 47154.7 E 78565.1 WITH TEE (8" X 8" X 8") [BRAND, MODEL #].

2. ADD 8" [TYPE] VALVE IN [VAULT] AT N 147154.7 E 1678565.1 EL. 16.0

UNIMPROVED ACCES ROAD CONTROL POINTS

STA.	NORTHING	EASTING	ELEVATION	CROSS SECTION
0+00.0	147334.2	1678707.1	19.54	
1+00.0	147417.0	1678652.1	17.90	
2+83.3	147579.6	1678716.1	16.41	R–R
5+00.0	147711.2	1678888.0	14.43	Q–Q
6+78.8	147813.8	1679034.4	12.76	P–P
8+79.2	147934.9	1679194.1	10.69	O–O
11+26.6	148081.4	1679393.4	8.83	N–N
13+31.6	148208.7	1679553.1	7.93	M–M
14+24.0	148291.7	1679591.2	6.75	

MICHAEL E. HRACHOVEC
LICENSED PROFESSIONAL ENGINEER
No. 15237-C
HAWAII U.S.A.
THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.
Signature — Expiration Date of the License

Natural Systems Design — ICF INTERNATIONAL — KAMEHAMEHA SCHOOLS — IMUA

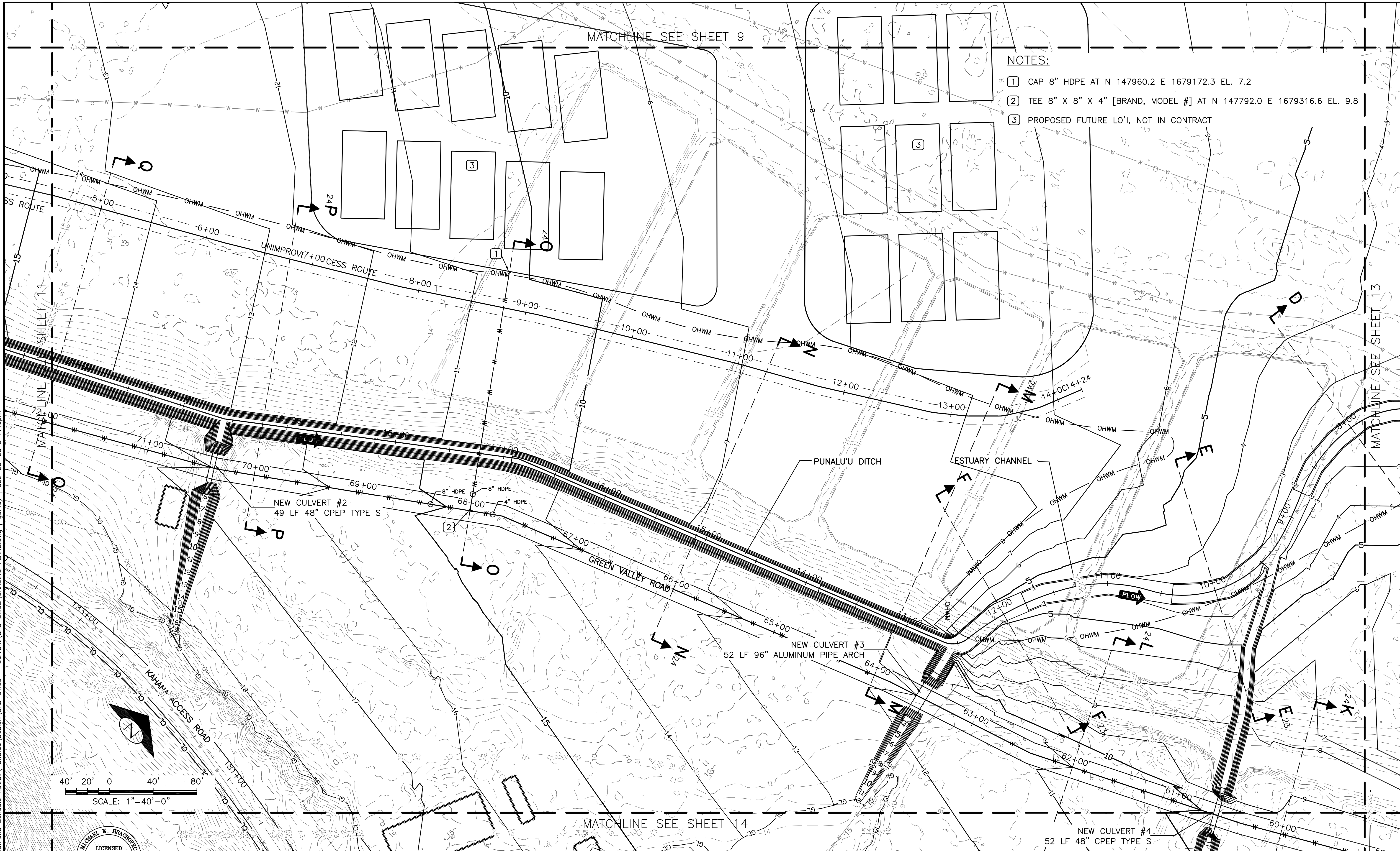
IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT PLOTTED TO ORIGINAL SCALE.

NAME OR INITIALS AND DATE	
DESIGNED	TA, MH, BB
CHECKED	TA, MH
DRAWN	GD, GM
CHECKED	MH

GEOGRAPHIC INFORMATION	
LATITUDE	21°34'29"N
LONGITUDE	157°52'58"W
TN/SC/RG	–/–/–
DATE	9/20/2013

PUNALU'U FLOOD MITIGATION AND STREAM RESTORATION

GRADING PLAN 5



N:\Projects\Kamehameha Schools Hawaii\Punaluu\Design\CAD DWGs – Current\CAD DWGS\GRADING PLANS.dwg | garvey | Sep-25-2013 7:46pm

MICHAEL E. HRACHOVEC LICENSED PROFESSIONAL ENGINEER No. 15237-C HAWAII U.S.A.

THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.

Signature — Expiration Date of the License

Natural Systems Design

ICF INTERNATIONAL

0 1

IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT PLOTTED TO ORIGINAL SCALE.

NAME OR INITIALS AND DATE	
DESIGNED	TA, MH, BB
CHECKED	TA, MH
DRAWN	GD, GM
CHECKED	MH

GEOGRAPHIC INFORMATION	
LATITUDE	21°34'29"N
LONGITUDE	157°52'58"W
TN/SC/RG	-/-/-
DATE	9/20/2013

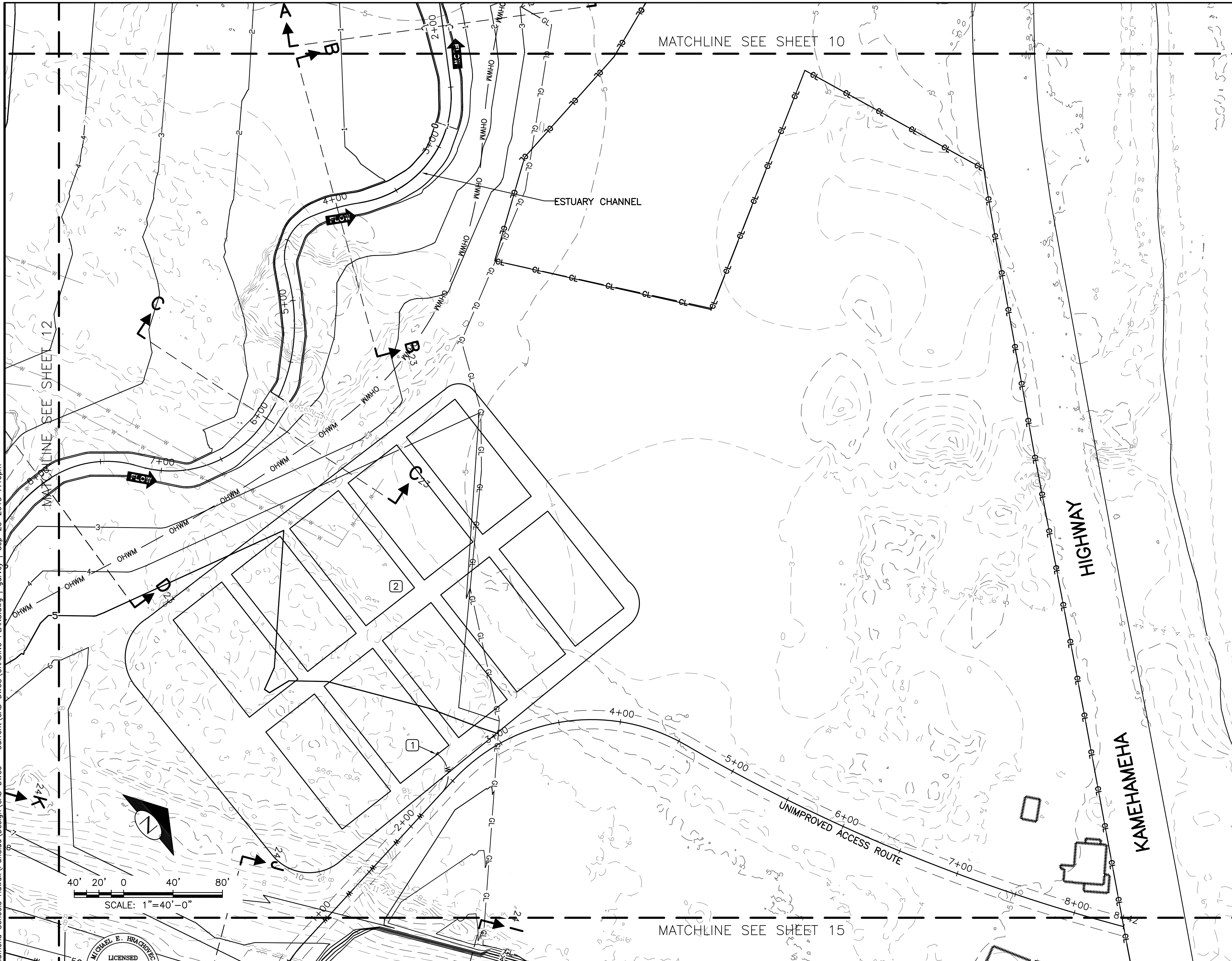
PUNALU'U FLOOD MITIGATION AND STREAM RESTORATION

GRADING PLAN 6

12

SHEET 12 OF 46

Sep-25-2013 90% DRAWINGS DRAFT



NOTES:

1. CAP 4" HDPE AT N 148561.0 E 1680148.7 EL. 0.3
2. PROPOSED FUTURE LO'I, NOT IN CONTRACT

UNIMPROVED ACCESS ROAD CONTROL POINTS			
STA.	NORTHING	EASTING	ELEVATION
0+00	148316.6	1680228.9	9.63
2+00	148506.9	1680180.5	5.56
4+00	148691.3	1680224.6	5.62
6+00	148775.0	1680405.4	3.91
8+42	148896.8	1680613.7	5.80

Sep-25-2013 90% DRAWINGS DRAFT

N:\Projects\Kamehameha Schools Hawaii\Punaluu\Design\CAD DWGs - Current\CAD DWGS\GRADING PLANS.dwg | garvey | Sep-25-2013 7:46pm

MICHAEL E. HRACHOVEC LICENSED PROFESSIONAL ENGINEER No. 15237-C HAWAII U.S.A.

THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.

Signature Expiration Date of the License

Natural Systems Design

ICF INTERNATIONAL

IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT PLOTTED TO ORIGINAL SCALE.

NAME OR INITIALS AND DATE	
DESIGNED	TA, MH, BB
CHECKED	TA, MH
DRAWN	GD, GM
CHECKED	MH

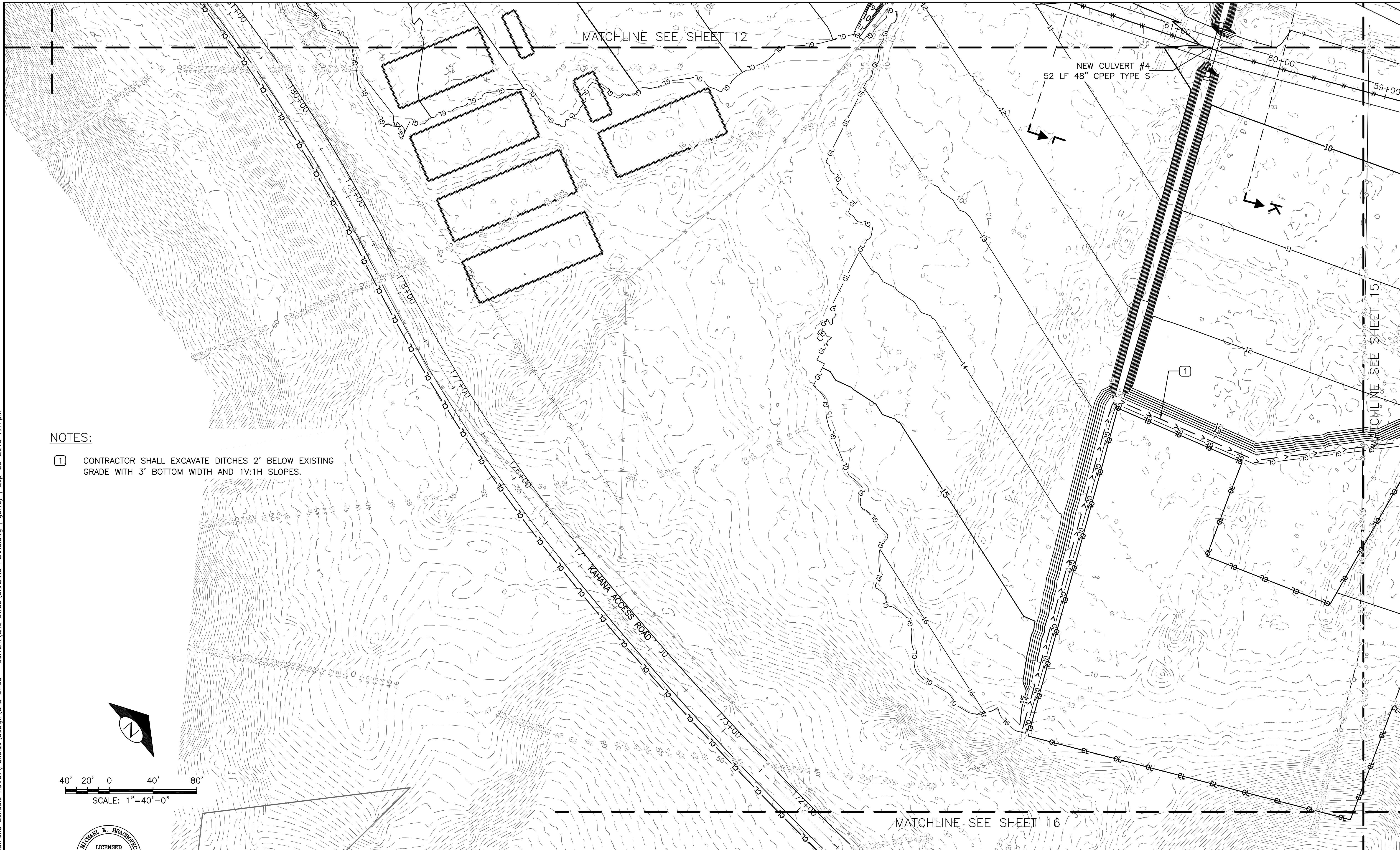
GEOGRAPHIC INFORMATION	
LATITUDE	21°34'29"N
LONGITUDE	157°52'58"W
TN/SC/RG	-/-/-
DATE	9/20/2013

PUNALU'U FLOOD MITIGATION AND STREAM RESTORATION

GRADING PLAN 7

13

SHEET 13 OF 46



NOTES:

1. CONTRACTOR SHALL EXCAVATE DITCHES 2' BELOW EXISTING GRADE WITH 3' BOTTOM WIDTH AND 1V:1H SLOPES.

N:\Projects\Kamehameha Schools Hawaii\Punaluu\Design\CAD DWGs - Current\CAD DWGS\GRADING PLANS.dwg | garvey | Sep-25-2013 7:47pm

Sep-25-2013 90% DRAWINGS DRAFT

MICHAEL E. HRACHOVEC LICENSED PROFESSIONAL ENGINEER No. 15237-C HAWAII U.S.A.

THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.

Signature — Expiration Date of the License

Natural Systems Design — ICF INTERNATIONAL — KAMEHAMEHA SCHOOLS IMUA

IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT PLOTTED TO ORIGINAL SCALE.

NAME OR INITIALS AND DATE	
DESIGNED	TA, MH, BB
CHECKED	TA, MH
DRAWN	GD, GM
CHECKED	MH

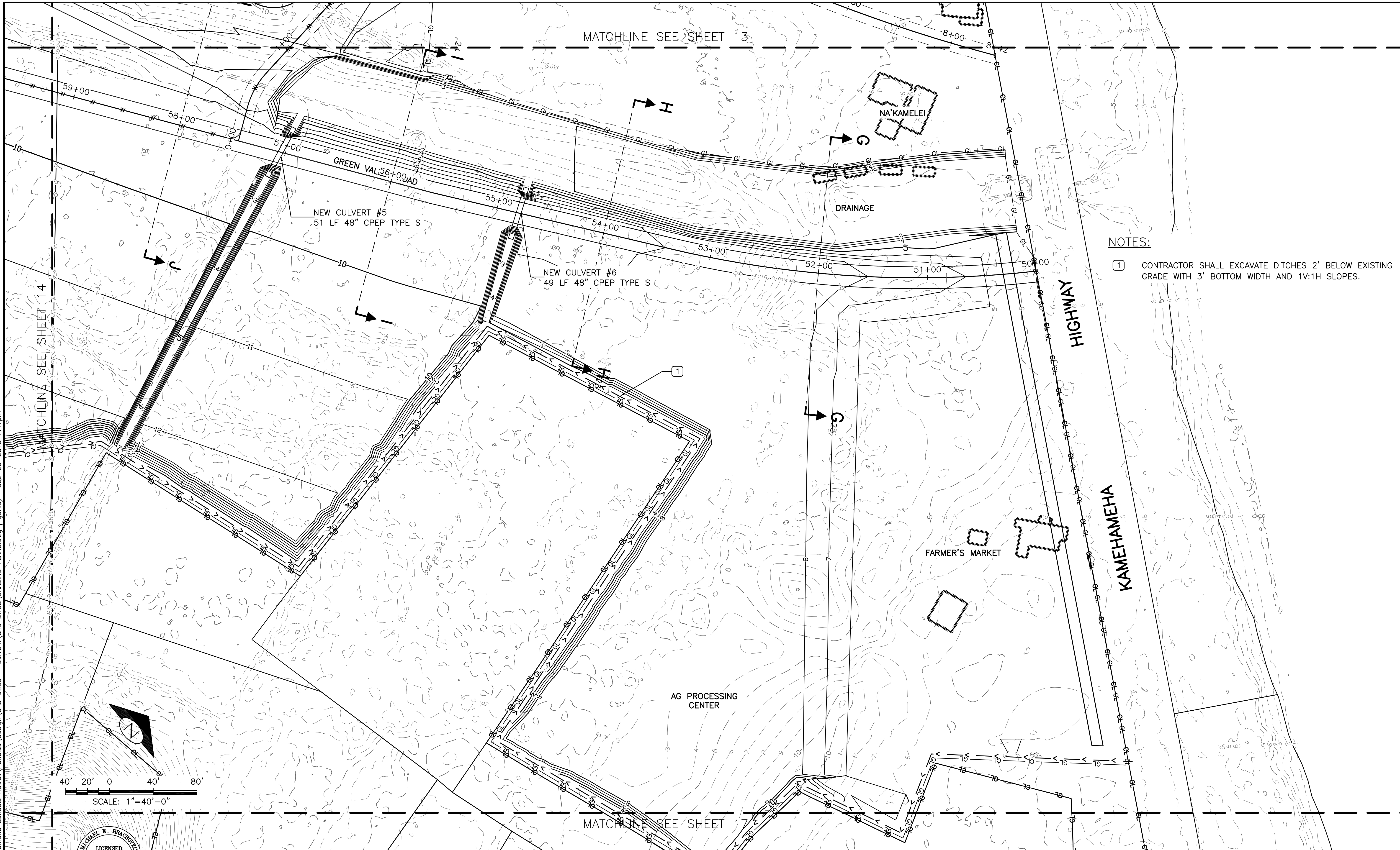
GEOGRAPHIC INFORMATION	
LATITUDE	21°34'29"N
LONGITUDE	157°52'58"W
TN/SC/RG	-/-/-
DATE	9/20/2013

PUNALU'U FLOOD MITIGATION AND STREAM RESTORATION

GRADING PLAN 8

14

SHEET 14 OF 46



NOTES:

1. CONTRACTOR SHALL EXCAVATE DITCHES 2' BELOW EXISTING GRADE WITH 3' BOTTOM WIDTH AND 1V:1H SLOPES.

Sep-25-2013 90% DRAWINGS DRAFT

N:\Projects\Kamehameha Schools Hawaii\Punaluu\Design\CAD DWGs – Current\CAD DWGS\GRADING PLANS.dwg | garvey | Sep-25-2013 7:47pm

MICHAEL E. HRACHOVEC
LICENSED PROFESSIONAL ENGINEER
No. 15237-C
HAWAII U.S.A.

THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.

Signature — Expiration Date of the License

Kamehameha Schools 1887 — IMUA

Natural Systems Design

ICF International

0 Ø 1

IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT PLOTTED TO ORIGINAL SCALE.

NAME OR INITIALS AND DATE	
DESIGNED	TA, MH, BB
CHECKED	TA, MH
DRAWN	GD, GM
CHECKED	MH

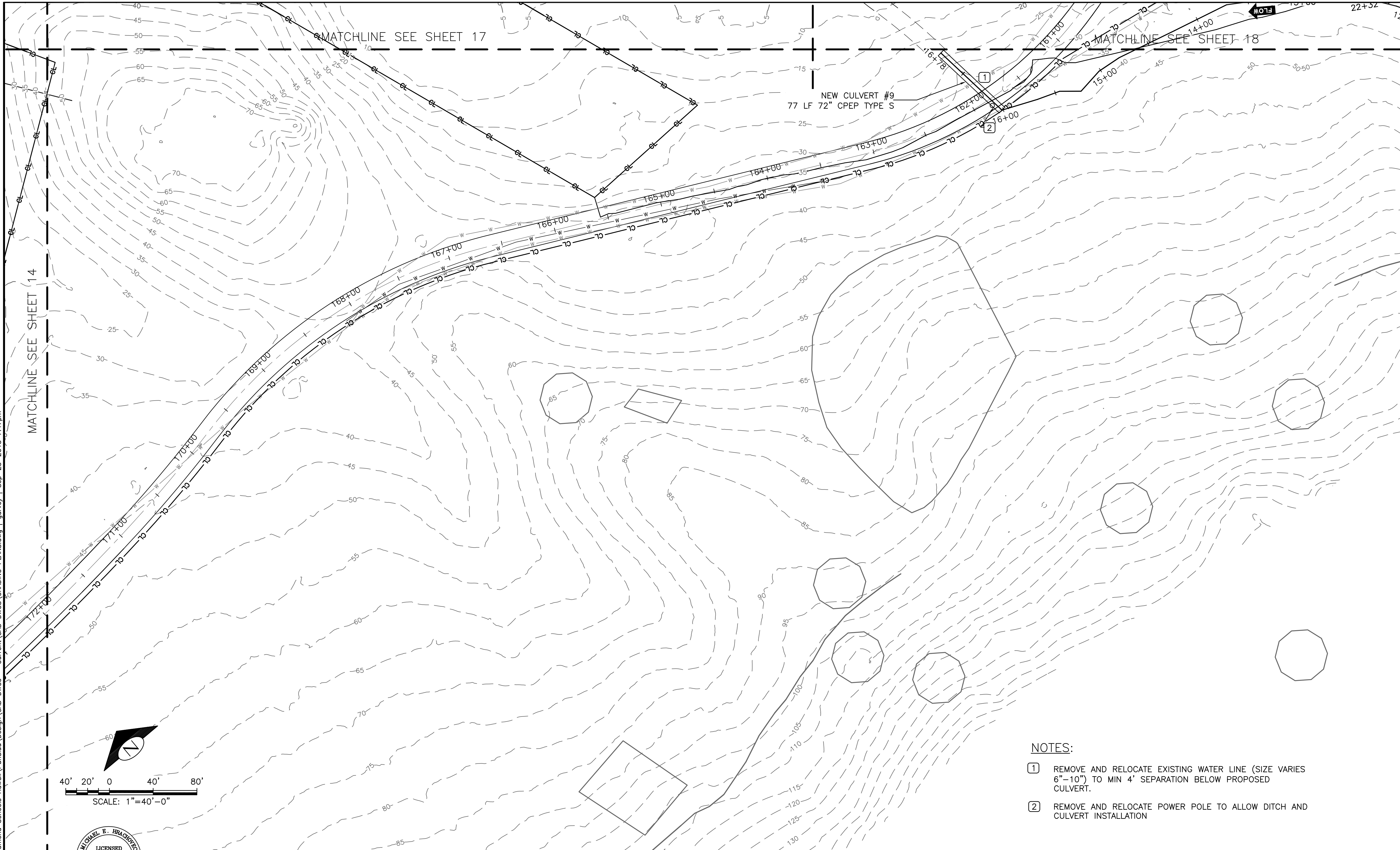
GEOGRAPHIC INFORMATION	
LATITUDE	21°34'29"N
LONGITUDE	157°52'58"W
TN/SC/RG	–/–/–
DATE	9/20/2013

PUNALU'U FLOOD MITIGATION AND STREAM RESTORATION

GRADING PLAN 9

15

SHEET 15 OF 46



NOTES:

1. REMOVE AND RELOCATE EXISTING WATER LINE (SIZE VARIES 6"–10") TO MIN 4' SEPARATION BELOW PROPOSED CULVERT.
2. REMOVE AND RELOCATE POWER POLE TO ALLOW DITCH AND CULVERT INSTALLATION

MICHAEL E. HRACHOVEC
LICENSED PROFESSIONAL ENGINEER
No. 15237-C
HAWAII U.S.A.

THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.

Signature — Expiration Date of the License

Kamehameha Schools 1887 IMUA

Natural Systems Design

ICF INTERNATIONAL

0 Ø 1

IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT PLOTTED TO ORIGINAL SCALE.

NAME OR INITIALS AND DATE	
DESIGNED	TA, MH, BB
CHECKED	TA, MH
DRAWN	GD, GM
CHECKED	MH

GEOGRAPHIC INFORMATION	
LATITUDE	21°34'29"N
LONGITUDE	157°52'58"W
TN/SC/RG	-/-/-
DATE	9/20/2013

PUNALU'U FLOOD MITIGATION AND STREAM RESTORATION

GRADING PLAN 10

16

Sep-25-2013 90% DRAWINGS DRAFT

N:\Projects\Kamehameha Schools Hawaii\Punaluu\Design\CAD DWGs - Current\CAD DWGS\GRADING PLANS.dwg | garvey | Sep-25-2013 7:47pm

Sep-25-2013 90% DRAWINGS DRAFT

MICHAEL E. HRACHOVEC
LICENSED PROFESSIONAL ENGINEER
No. 15237-C
HAWAII U.S.A.

THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.

Signature — Expiration Date of the License

0 Ø 1
IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT PLOTTED TO ORIGINAL SCALE.

NAME OR INITIALS AND DATE	
DESIGNED	TA, MH, BB
CHECKED	TA, MH
DRAWN	GD, GM
CHECKED	MH

GEOGRAPHIC INFORMATION	
LATITUDE	21°34'29"N
LONGITUDE	157°52'58"W
TN/SC/RG	-/-/-
DATE	9/20/2013

PUNALU'U FLOOD MITIGATION AND STREAM RESTORATION

GRADING PLAN 11

17

SHEET 17 OF 46

Sep-25-2013 90% DRAWINGS DRAFT

N:\Projects\Kamehameha Schools Hawaii\Punaluu\Design\CAD DWGs – Current\CAD DWGS\GRADING PLANS.dwg | garvey | Sep-25-2013 7:48pm

MICHAEL E. HRACHOVEC
LICENSED PROFESSIONAL ENGINEER
No. 15237-C
HAWAII U.S.A.

THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.

Signature | Expiration Date of the License

KAMEHAMEHA SCHOOLS 1887 IMUA

Natural Systems Design

ICF INTERNATIONAL

0 Ø 1
IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT PLOTTED TO ORIGINAL SCALE.

NAME OR INITIALS AND DATE	
DESIGNED	TA, MH, BB
CHECKED	TA, MH
DRAWN	GD, GM
CHECKED	MH

GEOGRAPHIC INFORMATION	
LATITUDE	21°34'29"N
LONGITUDE	157°52'58"W
TN/SC/RG	–/–/–
DATE	9/20/2013

PUNALU'U FLOOD MITIGATION AND STREAM RESTORATION

GRADING PLAN 12

18

SHEET 18 OF 46

MICHAEL E. HRACHOVEC
LICENSED PROFESSIONAL ENGINEER
No. 15237-C
HAWAII U.S.A.

THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.

Signature | Expiration Date of the License

KAMEHAMEHA SCHOOLS 1887 IMUA

Natural Systems Design

ICF INTERNATIONAL

0 Ø 1

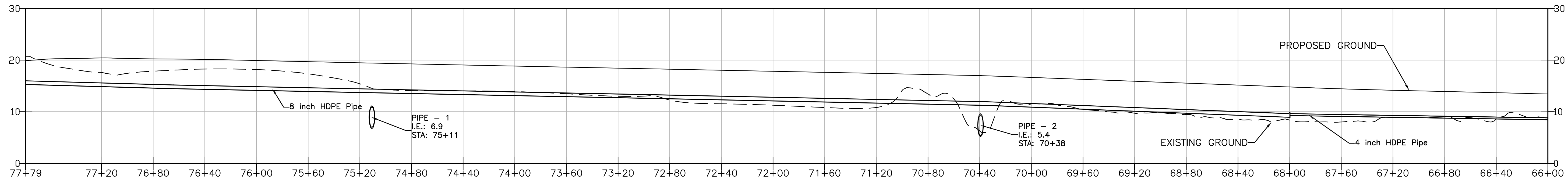
IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT PLOTTED TO ORIGINAL SCALE.

NAME OR INITIALS AND DATE	
DESIGNED	TA, MH, BB
CHECKED	TA, MH
DRAWN	GD, GM
CHECKED	MH

GEOGRAPHIC INFORMATION	
LATITUDE	21°34'29"N
LONGITUDE	157°52'58"W
TN/SC/RG	–/–/–
DATE	9/20/2013

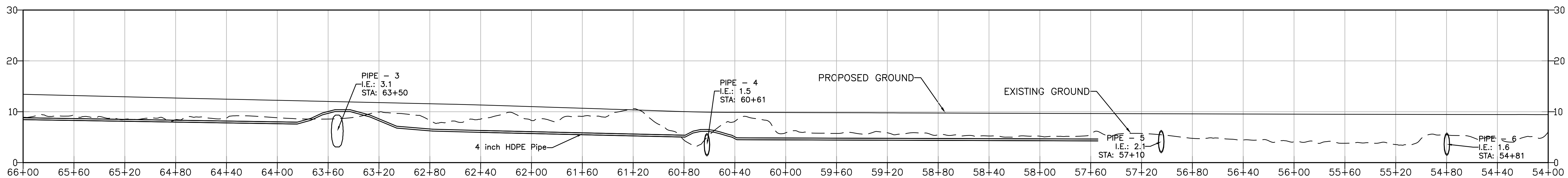
PUNALU'U FLOOD MITIGATION AND STREAM RESTORATION

GRADING PLAN 13



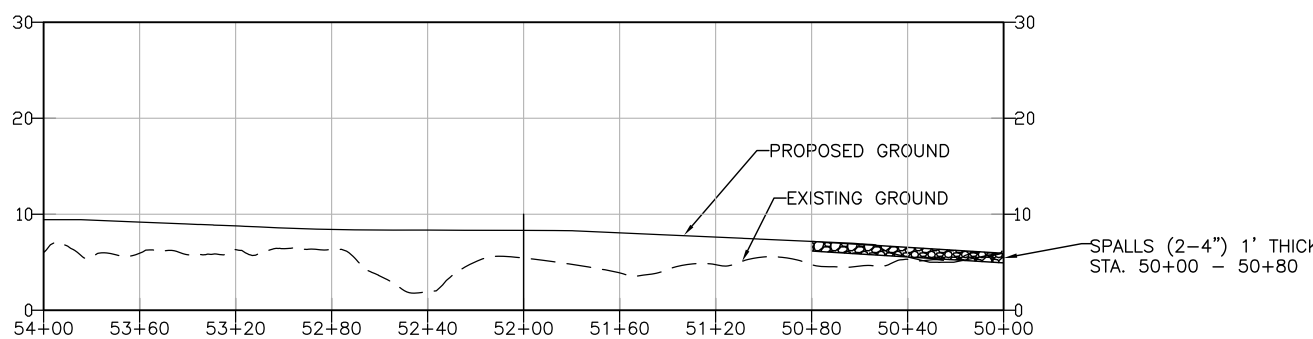
GREEN VALLEY ROAD

V: 1"=10', H: 1"=40'



GREEN VALLEY ROAD

V: 1"=10', H: 1"=40'



GREEN VALLEY ROAD

V: 1"=10', H: 1"=40'

GREEN VALLEY ROAD CONTROL POINTS				
STA.	ELEVATION	NORTHING	EASTING	CROSS SECTION
50+00	0.00	148798.8	1680789.0	
51+00	7.39	148718.8	1680729.7	
52+00	8.31	148645.0	1680662.4	G–G
53+00	8.58	148578.4	1680587.8	
54+00	9.43	148518.1	1680508.0	H–H
55+00	9.47	148458.3	1680427.9	
56+00	9.52	148399.5	1680347.0	I–I
57+00	9.60	148342.0	1680265.2	
58+00	9.67	148284.6	1680183.3	J–J
59+00	9.76	148227.2	1680101.4	
60+00	9.85	148169.8	1680019.6	K–K
61+00	10.20	148115.5	1679935.6	
62+00	11.00	148063.2	1679850.4	L–L
63+00	11.68	148018.7	1679761.1	
64+00	12.24	147978.6	1679669.6	M–M

GREEN VALLEY ROAD CONTROL POINTS				
STA.	ELEVATION	NORTHING	EASTING	CROSS SECTION
65+00	12.81	147933.4	1679580.3	
66+00	13.43	147888.3	1679491.1	N–N
67+00	14.05	147843.1	1679401.9	
68+00	14.80	147792.0	1679316.6	O–O
69+00	15.72	147726.9	1679240.7	
70+00	16.65	147661.8	1679164.9	P–P
71+00	17.32	147602.1	1679084.8	
72+00	17.83	147545.3	1679002.5	Q–Q
73+00	18.35	147488.5	1678920.2	
74+00	18.85	147425.3	1678842.7	R–R
75+00	19.36	147361.9	1678765.4	
76+00	19.94	147307.1	1678681.8	S–S
77+00	20.33	147247.7	1678602.2	
77+80.8	19.85	147170.5	1678591.9	

Sep-25-2013 90% DRAWINGS DRAFT

N:\Projects\Kamehameha Schools Hawaii\Punalu'u\Design\CAD DWGs – Current\CAD DWGS\PROFILES.dwg | garvey | Sep-25-2013 7:49pm

MICHAEL E. HRACHOVEC
LICENSED PROFESSIONAL ENGINEER
No. 15237-C
HAWAII U.S.A.

THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.

Signature — Expiration Date of the License

KAMEHAMEHA SCHOOLS — IMUA

Natural Systems Design

ICF INTERNATIONAL

0 Ø 1
IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT PLOTTED TO ORIGINAL SCALE.

NAME OR INITIALS AND DATE	
DESIGNED	TA, MH, BB
CHECKED	TA, MH
DRAWN	GD, GM
CHECKED	MH

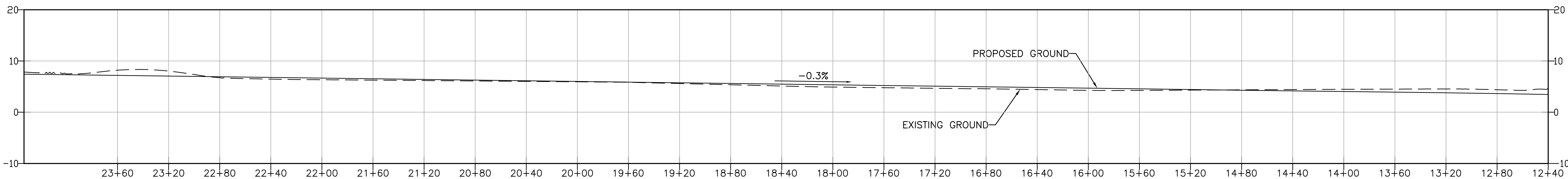
GEOGRAPHIC INFORMATION	
LATITUDE	21°34'29"N
LONGITUDE	157°52'58"W
TN/SC/RG	–/–/–
DATE	9/20/2013

PUNALU'U FLOOD MITIGATION AND STREAM RESTORATION

PROFILES 1

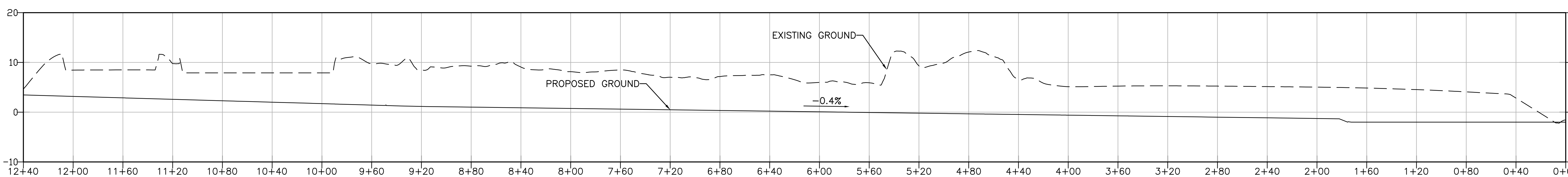
20

SHEET 20 OF 46



PUNALU'U DITCH PROFILE

V: 1"=10', H: 1"=40'



ESTUARY CHANNEL PROFILE

V: 1"=10', H: 1"=40'

ESTUARY/PUNALU'U DITCH CONTROL POINTS

STA.	ELEVATION	NORTHING	EASTING	CROSS SECTION
0+00	-2.01	149050.5	1679531.4	
2+00	-1.27	148943.5	1679700.3	A-A
4+00	-0.60	148783.4	1679758.1	B-B
6+00	0.07	148629.8	1679852.3	C-C
8+00	0.75	148457.9	1679776.2	D-D
10+00	1.71	148267.1	1679810.4	E-E
12+00	3.16	148104.9	1679702.8	F-F
13+09.4	3.75	148025.9	1679645.6	M-M
15+09.4	4.40	147936.1	1679466.9	N-N
17+22.5	5.10	147832.4	1679282.0	O-O
19+22.5	5.76	147697.8	1679134.0	P-P
21+17.8	6.40	147588.3	1678972.8	Q-Q
23.226	7.07	147466.6	1678808.8	R-R
24+33	7.43	147393.9	1678725.4	

Sep-25-2013 90% DRAWINGS DRAFT

MICHAEL E. HRACHOVEC LICENSED PROFESSIONAL ENGINEER No. 15237-C HAWAII U.S.A.

THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.

Signature Expiration Date of the License

Natural Systems Design

ICF INTERNATIONAL

0 Ø 1

IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT PLOTTED TO ORIGINAL SCALE.

NAME OR INITIALS AND DATE	
DESIGNED	TA, MH, BB
CHECKED	TA, MH
DRAWN	GD, GM
CHECKED	MH

GEOGRAPHIC INFORMATION	
LATITUDE	21°34'29"N
LONGITUDE	157°52'58"W
TN/SC/RG	-/-/-
DATE	9/20/2013

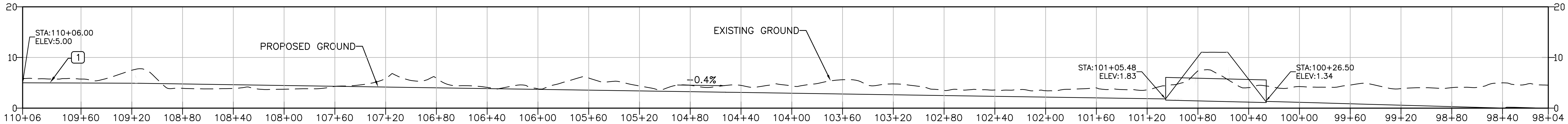
PUNALU'U FLOOD MITIGATION AND STREAM RESTORATION

PROFILES 2

21

SHEET 21 OF 46

N:\Projects\Kamehameha Schools Hawaii\Punaluu\Design\CAD DWGs - Current\CAD DWGS\PROFILES.dwg | garvey | Sep-25-2013 7:49pm

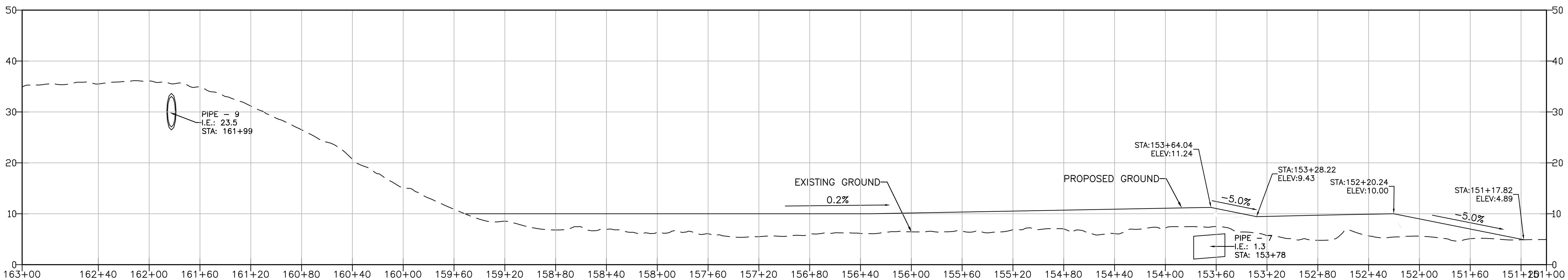


SOUTH SITE PROFILE

V: 1"=10', H: 1"=40'

SOUTH SITE PROFILE NOTES:

1. CONTINUE DITCH PROFILE GRADING EXTENTS UNTIL EXISTING GROUND EL.=5'



KAHANA ACCESS ROAD

V: 1"=10', H: 1"=40'

KAHANA ACCESS ROAD NOTES:

1. ROAD PRISM GRADING SHALL BE AT 3H:1V FROM ROAD EXTENTS TO SURROUNDING GRADE.

SOUTH SITE CONTROL POINTS

STA.	ELEVATION	NORTHING	EASTING	CROSS SECTION
98+04	0.02	147753.1	1681772.3	
99+00	0.45	147676.8	1681830.7	
100+03.9	1.18	147594.3	1681893.9	XX-XX
101+00	3.61	147518.0	1681952.3	
102+00	2.19	147438.6	1682013.1	
103+00	2.57	147359.2	1682073.9	
104+00	2.95	147279.8	1682134.7	
105+03.9	3.35	147197.3	1682197.9	YY-YY
106+00	3.71	147121.0	1682256.3	
107+00	4.09	147041.6	1682317.1	
108+00	4.47	146962.2	1682377.9	
109+00	4.86	146882.8	1682438.7	
110+00	5.90	146803.4	1682499.5	

KAHANA ACCESS ROAD CONTROL POINTS

STA.	ELEVATION	NORTHING	EASTING
150+00	6.09	147722.2	1682249.0
151+00	4.95	147670.5	1682163.3
152+00	8.99	147618.9	1682077.7
153+00	9.60	147567.9	1681991.7
154+00	11.08	147531.6	1681898.7
155+00	10.61	147504.5	1681802.5
156+00	10.15	147477.5	1681706.2
157+00	10.00	147432.8	1681617.6
158+00	10.00	147358.9	1681550.5
159+00	10.00	147284.9	1681483.5
160+00	15.13	147231.2	1681399.6
161+00	28.77	147203.7	1681303.8
162+00	36.11	147204.5	1681204.2

N:\Projects\Kamehameha Schools Hawaii\Punaluu\Design\CAD DWGs - Current\CAD DWGS\PROFILES.dwg | garvey | Sep-25-2013 7:49pm

Sep-25-2013 90% DRAWINGS DRAFT

MICHAEL E. HRACHOVEC
LICENSED PROFESSIONAL ENGINEER
No. 15237-C
HAWAII U.S.A.

THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.

Signature — Expiration Date of the License

KAMEHAMEHA SCHOOLS — IMUA

Natural Systems Design

ICF INTERNATIONAL

0 Ø 1
IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT PLOTTED TO ORIGINAL SCALE.

NAME OR INITIALS AND DATE	
DESIGNED	TA, MH, BB
CHECKED	TA, MH
DRAWN	GD, GM
CHECKED	MH

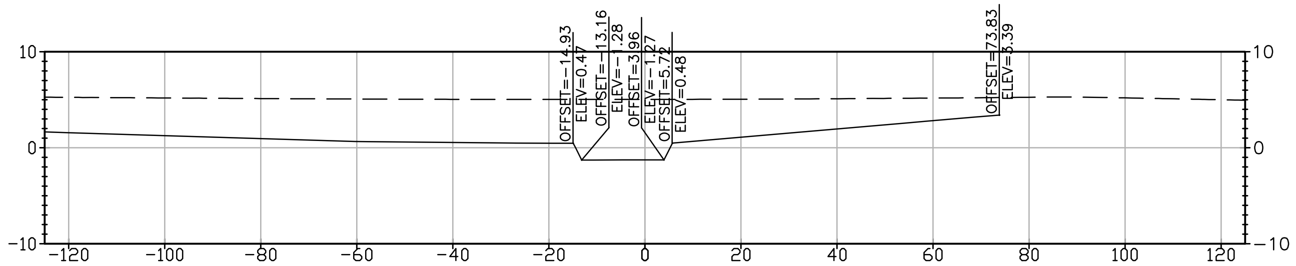
GEOGRAPHIC INFORMATION	
LATITUDE	21°34'29"N
LONGITUDE	157°52'58"W
TN/SC/RG	-/-/-
DATE	9/20/2013

PUNALU'U FLOOD MITIGATION AND STREAM RESTORATION

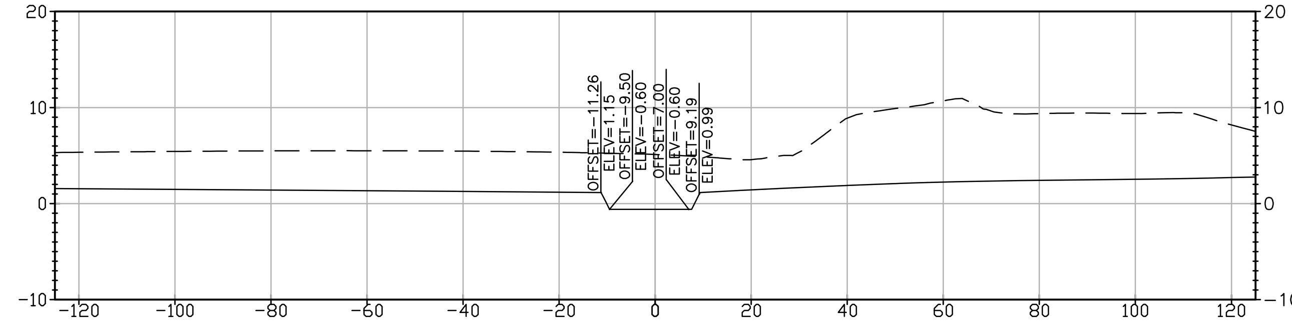
PROFILES 3

22

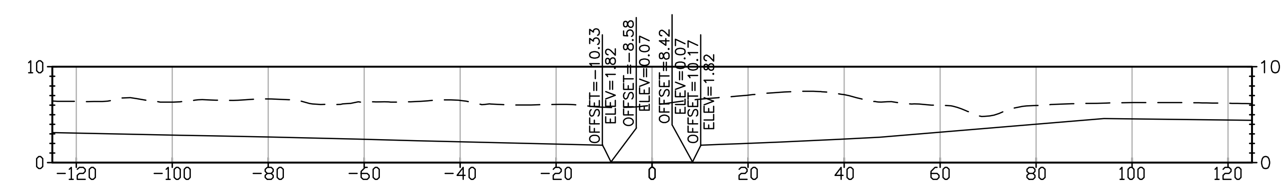
SHEET 22 OF 46



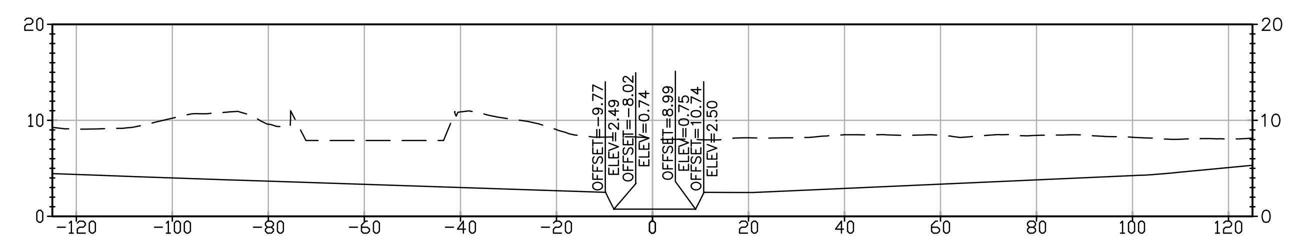
SECTION A–A 10
V: 1" = 10', H: 1" = 20'



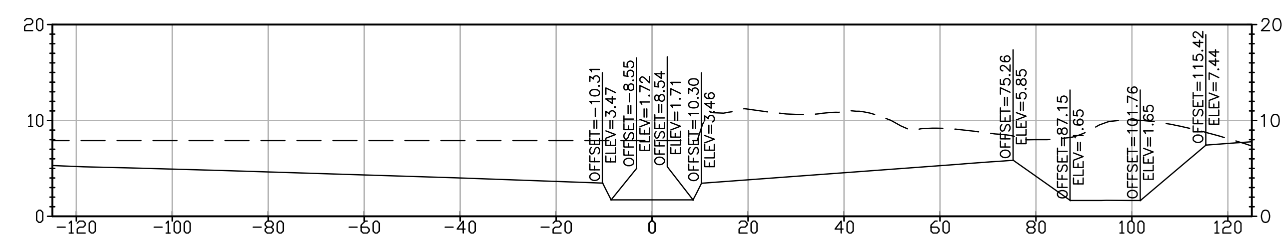
SECTION B–B 13
V: 1" = 10', H: 1" = 20'



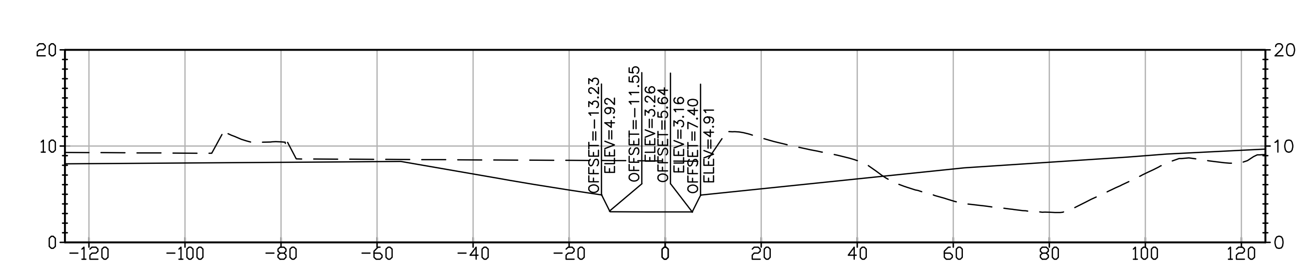
SECTION C–C 13
V: 1" = 10', H: 1" = 20'



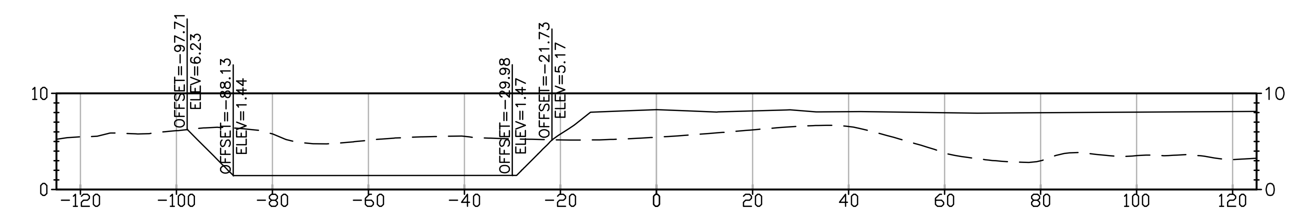
SECTION D–D 12, 13
V: 1" = 10', H: 1" = 20'



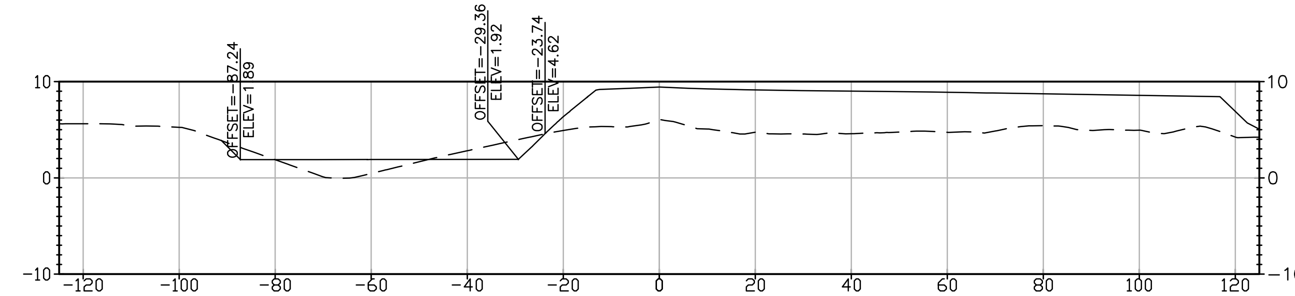
SECTION E–E 12
V: 1" = 10', H: 1" = 20'



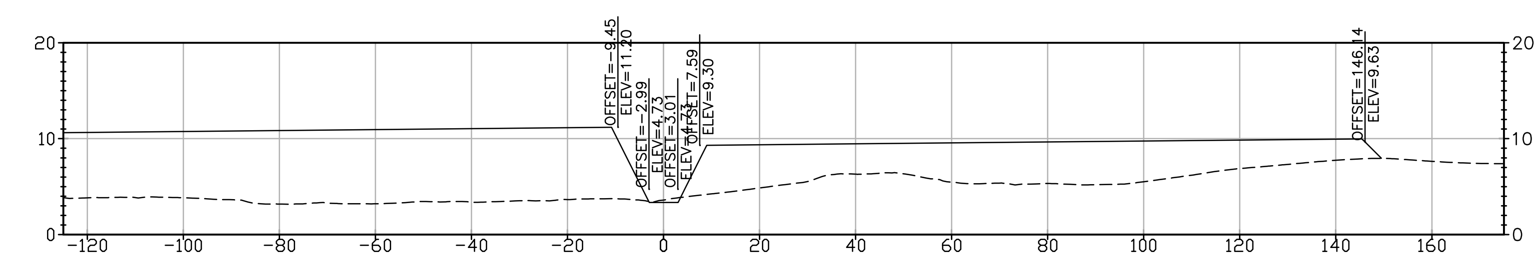
SECTION F–F 12
V: 1" = 10', H: 1" = 20'



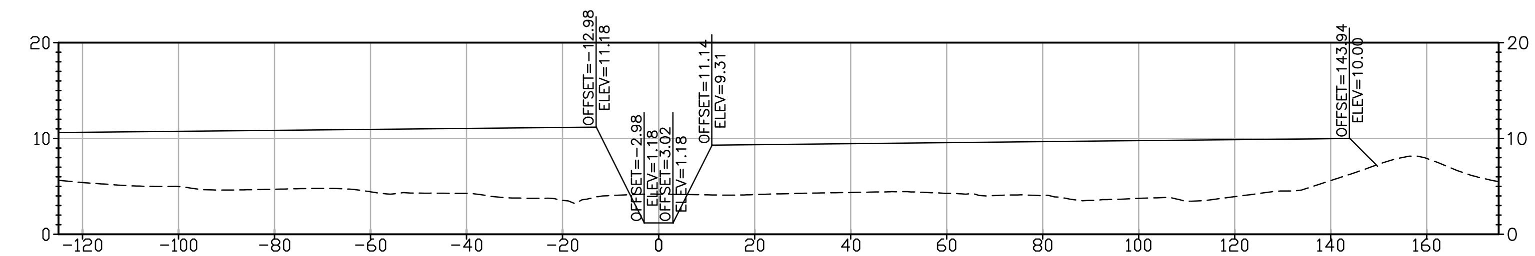
SECTION G–G 15
V: 1" = 10', H: 1" = 20'



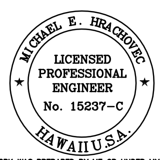
SECTION H–H 15
V: 1" = 10', H: 1" = 20'



SECTION YY–YY 19
V: 1" = 10', H: 1" = 20'



SECTION XX–XX 18
V: 1" = 10', H: 1" = 20'



THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.

Signature — Expiration Date of the License

Natural Systems Design

ICF INTERNATIONAL

0 Ø 1
IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT PLOTTED TO ORIGINAL SCALE.

NAME OR INITIALS AND DATE	
DESIGNED	TA, MH, BB
CHECKED	TA, MH
DRAWN	GD, GM
CHECKED	MH

GEOGRAPHIC INFORMATION	
LATITUDE	21°34'29"N
LONGITUDE	157°52'58"W
TN/SC/RG	-/-/-
DATE	9/20/2013

PUNALU'U FLOOD MITIGATION AND STREAM RESTORATION

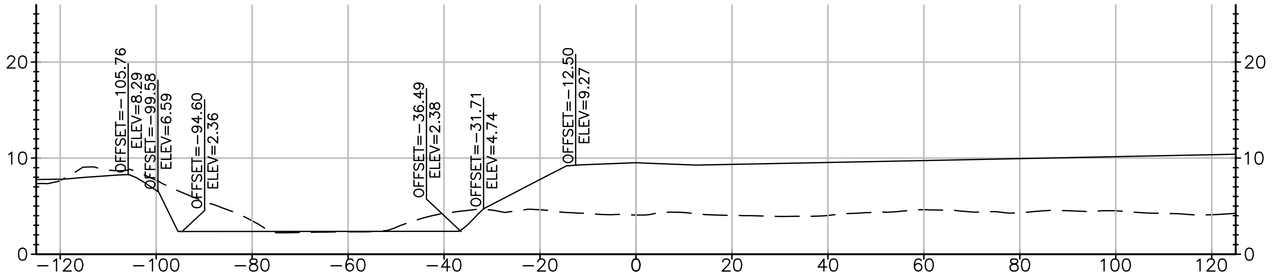
CROSS-SECTIONS 1

23

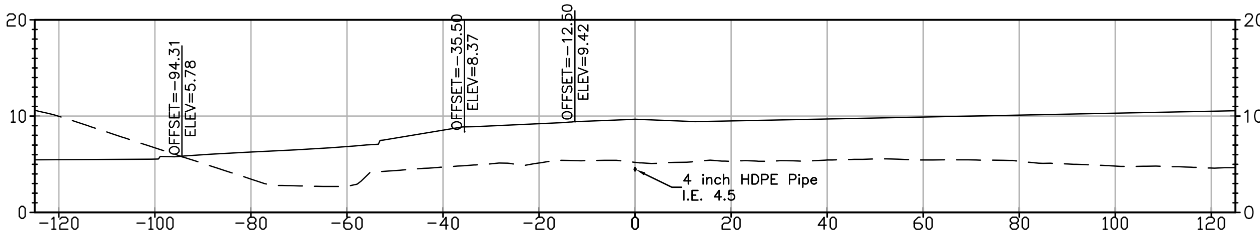
SHEET 23 OF 46

N:\Projects\Kamehameha Schools Hawaii\Punaluu\Design\CAD DWGs - Current\CAD DWGS\CROSS-SECTIONS.dwg | garvey | Sep-25-2013 7:50pm

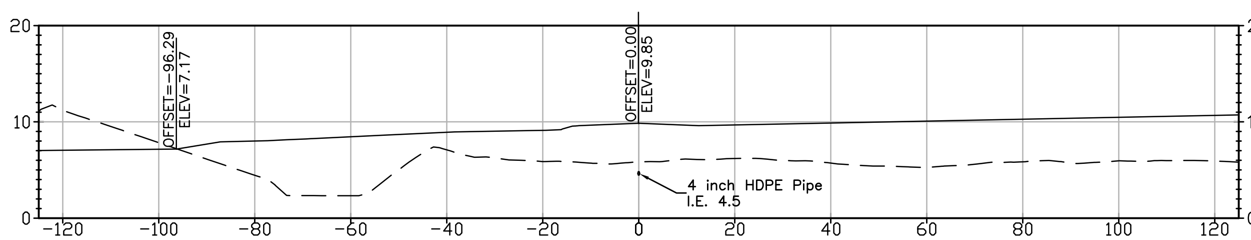
Sep-25-201390% DRAWINGS DRAFT



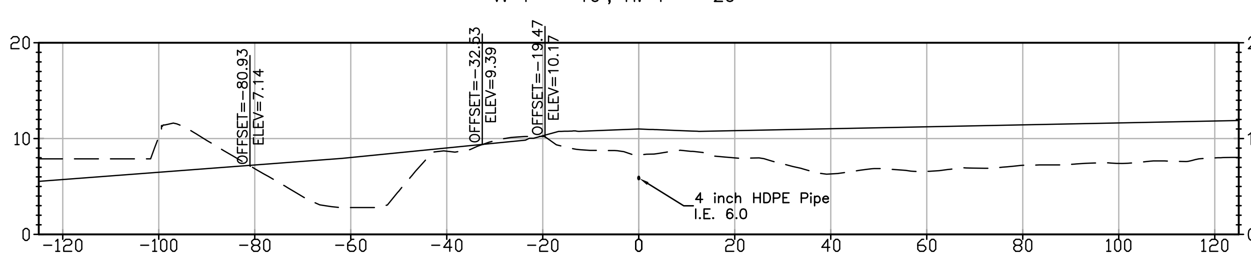
SECTION I–I 15
V: 1" = 10', H: 1" = 20'



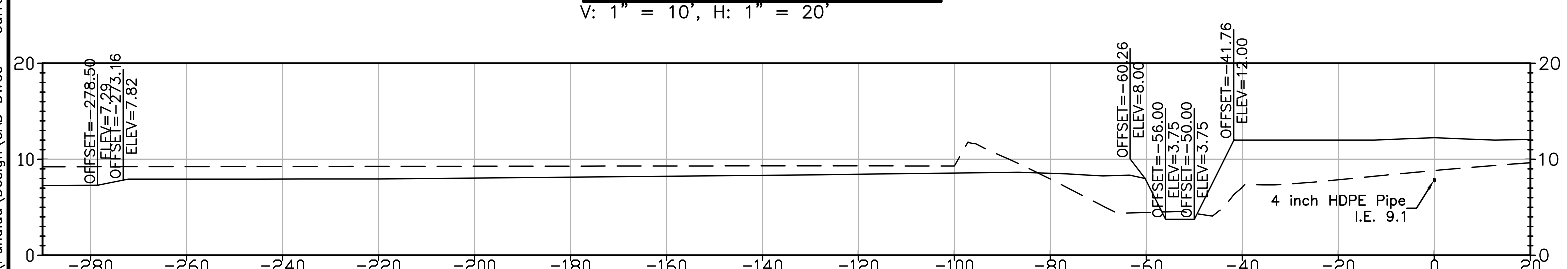
SECTION J–J 13, 15
V: 1" = 10', H: 1" = 20'



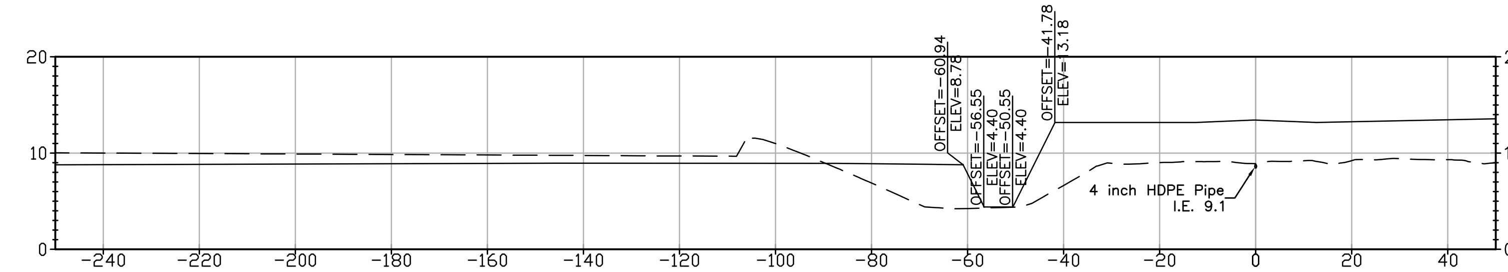
SECTION K–K 12, 14
V: 1" = 10', H: 1" = 20'



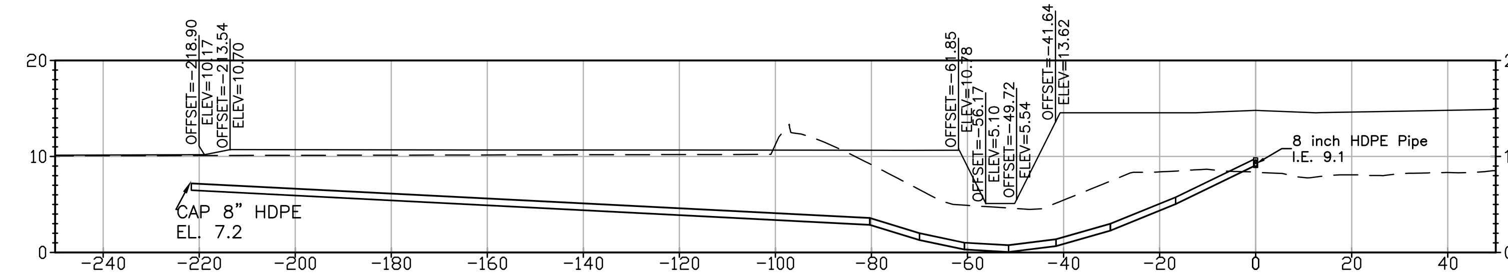
SECTION L–L 12, 14
V: 1" = 10', H: 1" = 20'



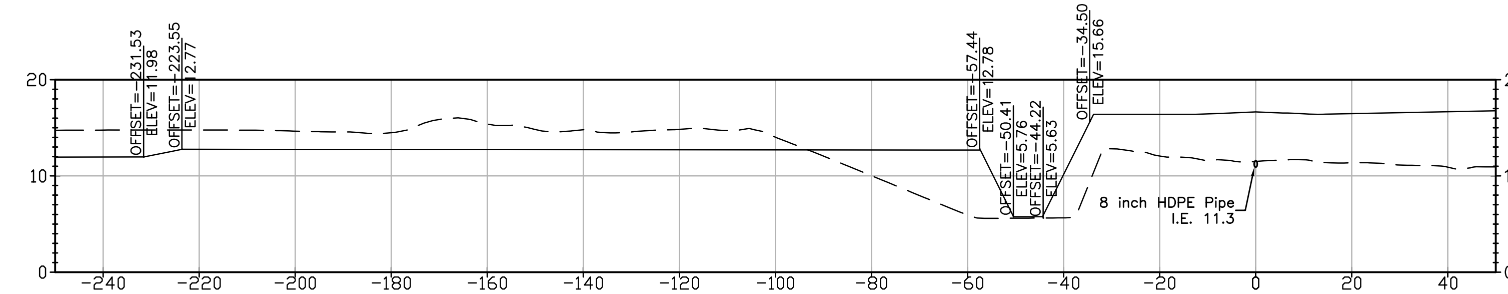
SECTION M–M 12
V: 1" = 10', H: 1" = 20'



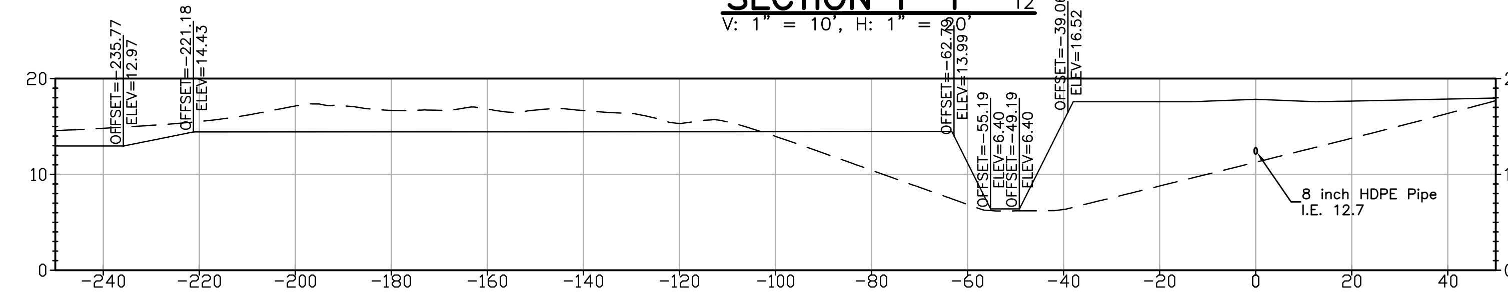
SECTION N–N 12
V: 1" = 10', H: 1" = 20'



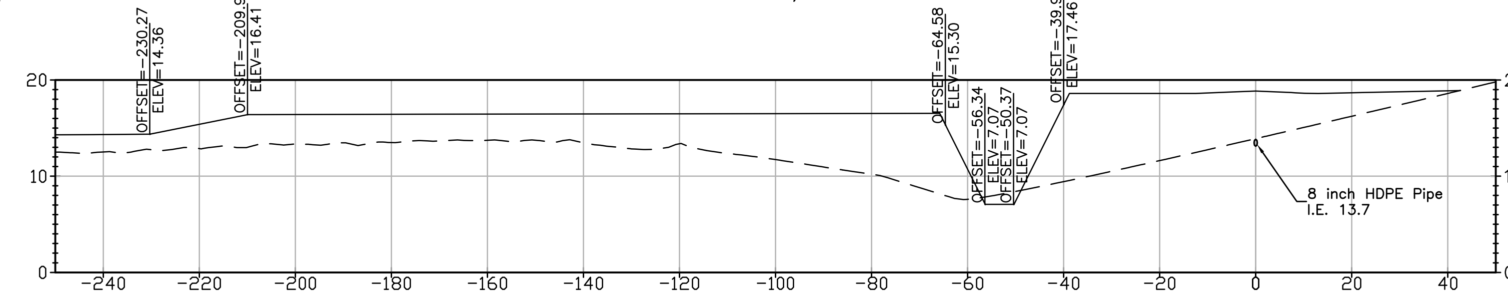
SECTION O–O 12
V: 1" = 10', H: 1" = 20'



SECTION P–P 12
V: 1" = 10', H: 1" = 20'



SECTION Q–Q 12
V: 1" = 10', H: 1" = 20'



SECTION R–R 11
V: 1" = 10', H: 1" = 20'

MICHAEL E. HRACHOVEC
LICENSED PROFESSIONAL ENGINEER
No. 15237-C
HAWAII U.S.A.

THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.

Signature — Expiration Date of the License

KAMEHAMEHA SCHOOLS — IMUA

Natural Systems Design

ICF INTERNATIONAL

IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT PLOTTED TO ORIGINAL SCALE.

NAME OR INITIALS AND DATE	
DESIGNED	TA, MH, BB
CHECKED	TA, MH
DRAWN	GD, GM
CHECKED	MH

GEOGRAPHIC INFORMATION	
LATITUDE	21°34'29"N
LONGITUDE	157°52'58"W
TN/SC/RG	-/-/-
DATE	9/20/2013

PUNALU'U FLOOD MITIGATION AND STREAM RESTORATION

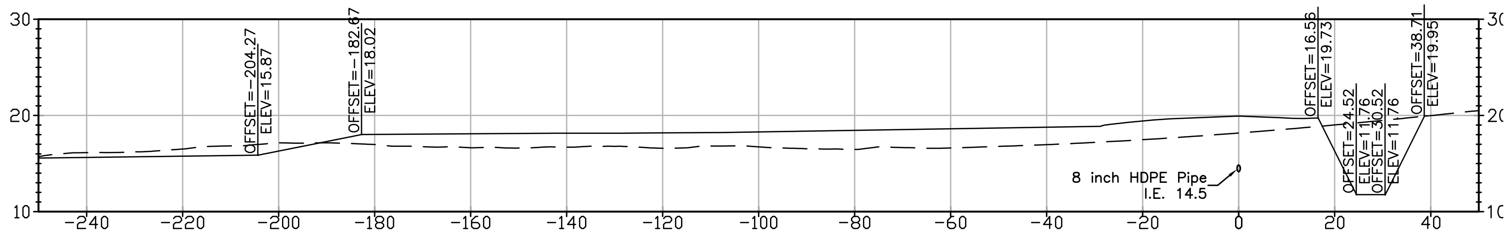
CROSS-SECTIONS 2

24

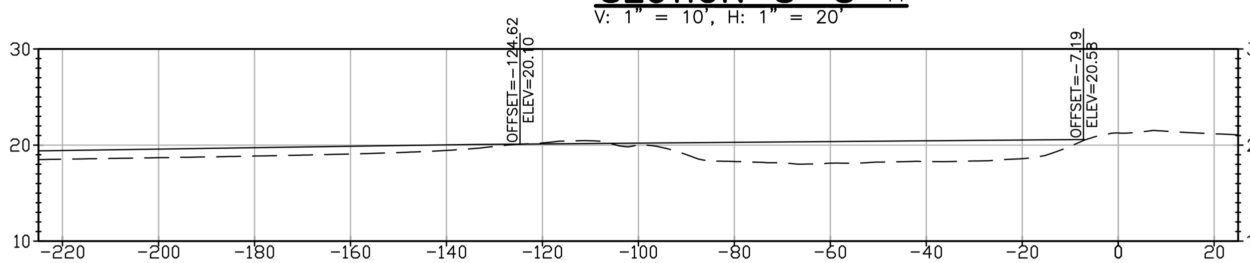
SHEET 24 OF 46

Sep-25-2013 90% DRAWINGS DRAFT

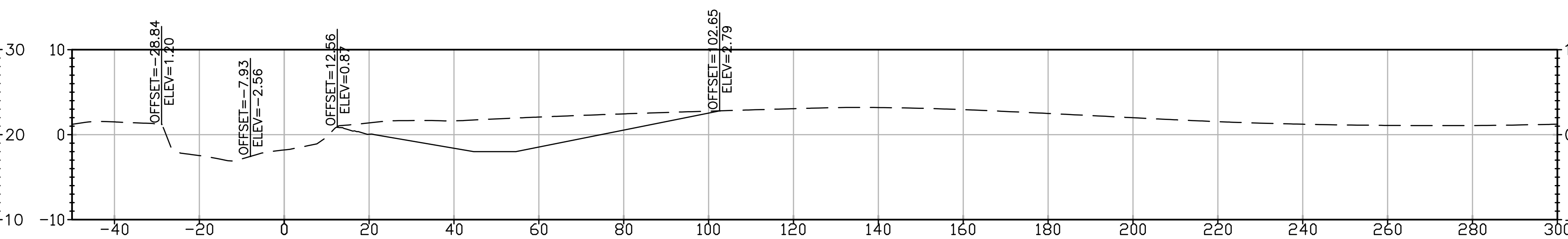
N:\Projects\Kamehameha Schools Hawaii\Punaluu\Design\CAD DWGs – Current\CAD DWGS\CROSS-SECTIONS.dwg | garvey | Sep-25-2013 7:50pm



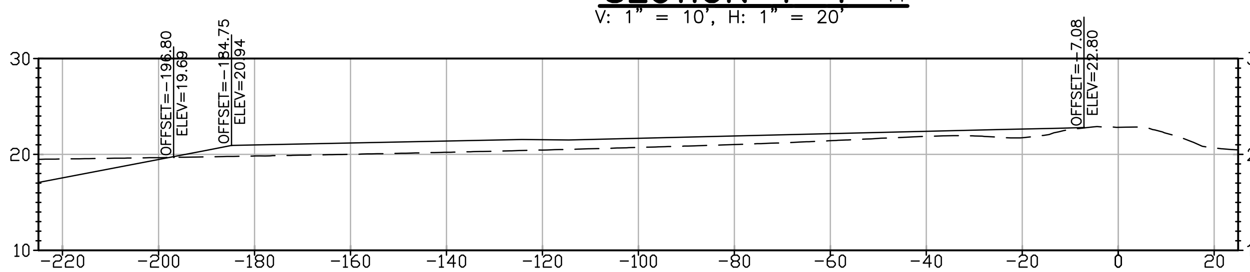
SECTION S–S 11
V: 1" = 10', H: 1" = 20'



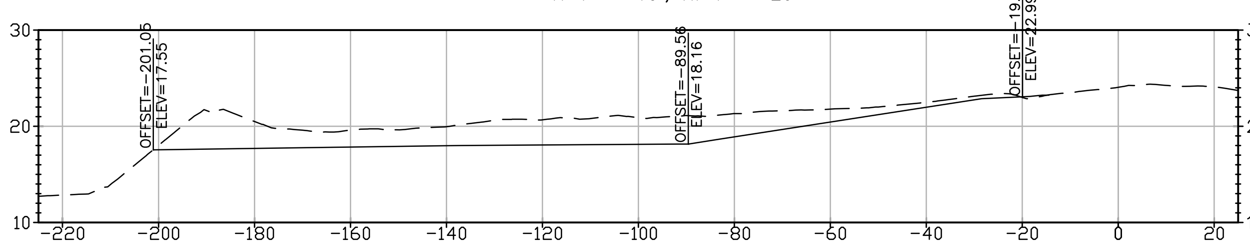
SECTION T–T 11
V: 1" = 10', H: 1" = 20'



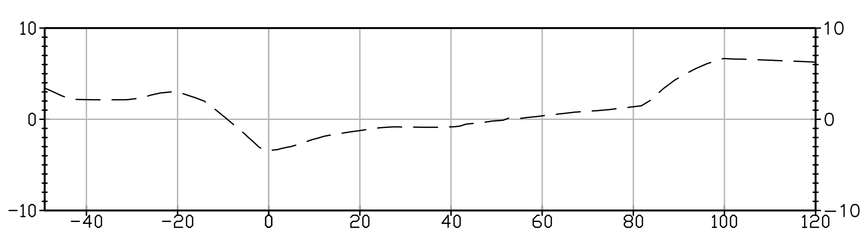
SECTION BB–BB 10
V: 1" = 10', H: 1" = 20'



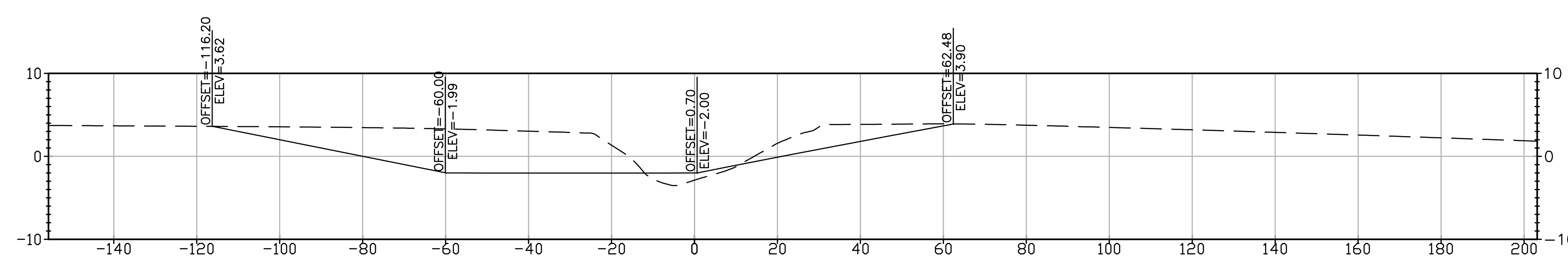
SECTION U–U 8, 11
V: 1" = 10', H: 1" = 20'



SECTION V–V 8, 11
V: 1" = 10', H: 1" = 20'



SECTION AA–AA 10
V: 1" = 10', H: 1" = 20'



SECTION CC–CC 10
V: 1" = 10', H: 1" = 20'

MICHAEL E. HRACHOVEC
LICENSED PROFESSIONAL ENGINEER
No. 15237-C
HAWAII U.S.A.

THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.

Signature — Expiration Date of the License

KAMEHAMEHA SCHOOLS — IMUA

Natural Systems Design

ICF INTERNATIONAL

0 Ø 1
IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT PLOTTED TO ORIGINAL SCALE.

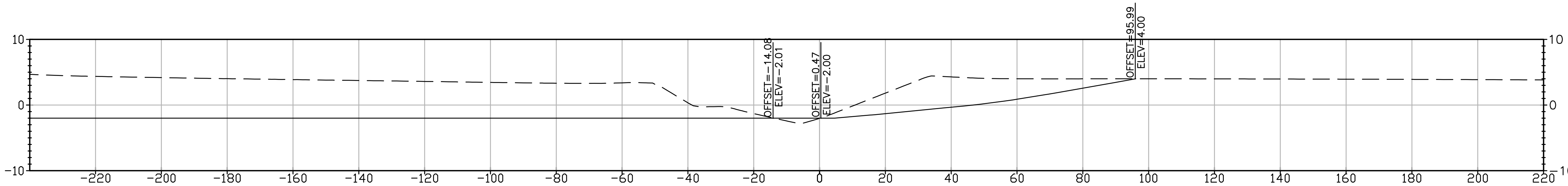
NAME OR INITIALS AND DATE	
DESIGNED	TA, MH, BB
CHECKED	TA, MH
DRAWN	GD, GM
CHECKED	MH

GEOGRAPHIC INFORMATION	
LATITUDE	21°34'29"N
LONGITUDE	157°52'58"W
TN/SC/RG	-/-/-
DATE	9/20/2013

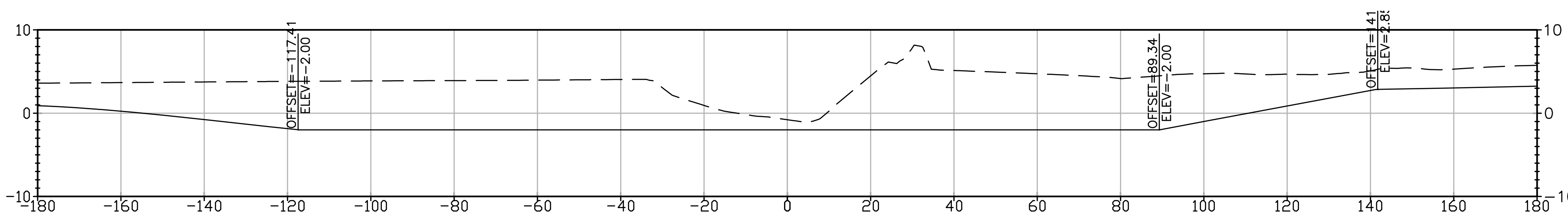
PUNALU'U FLOOD MITIGATION AND STREAM RESTORATION

CROSS-SECTIONS 3

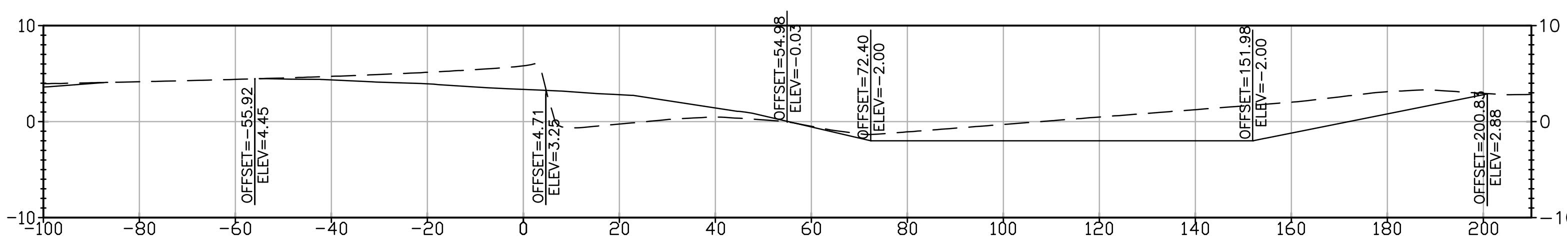
Sep-25-2013 90% DRAWINGS DRAFT



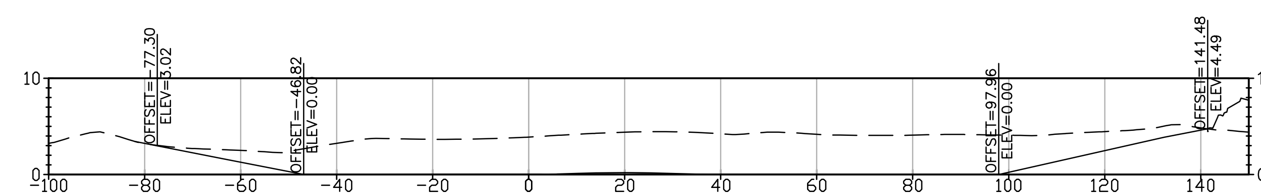
SECTION DD-DD 10
V: 1" = 10', H: 1" = 20'



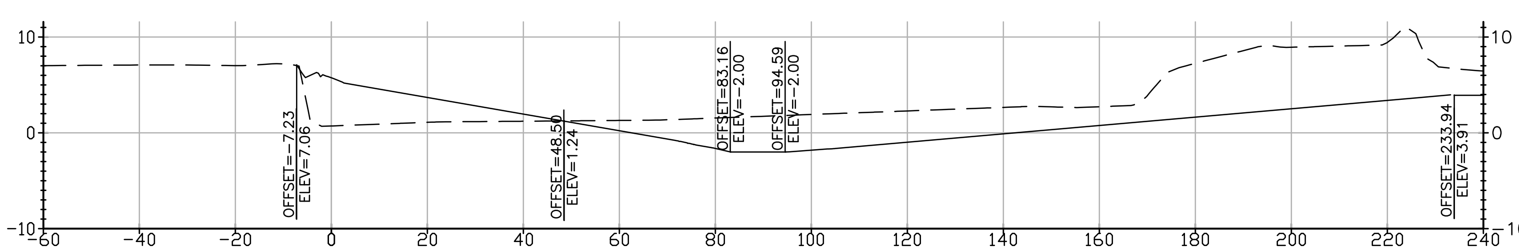
SECTION EE-EE 10
V: 1" = 10', H: 1" = 20'



SECTION FF-FF 9, 10
V: 1" = 10', H: 1" = 20'



SECTION ZZ-ZZ 18
V: 1" = 10', H: 1" = 20'



SECTION GG-GG 9, 10
V: 1" = 10', H: 1" = 20'

N:\Projects\Kamehameha Schools Hawaii\Punaluu\Design\CAD DWGs - Current\CAD DWGS\CROSS-SECTIONS.dwg | garvey | Sep-25-2013 7:50pm

Sep-25-2013 90% DRAWINGS DRAFT

MICHAEL E. HRACHOVEC
LICENSED PROFESSIONAL ENGINEER
No. 15237-C
HAWAII U.S.A.

THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.

Signature | Expiration Date of the License

KAMEHAMEHA SCHOOLS 1887 IMUA

Natural Systems Design

ICF INTERNATIONAL

0 Ø 1
IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT PLOTTED TO ORIGINAL SCALE.

NAME OR INITIALS AND DATE	
DESIGNED	TA, MH, BB
CHECKED	TA, MH
DRAWN	GD, GM
CHECKED	MH

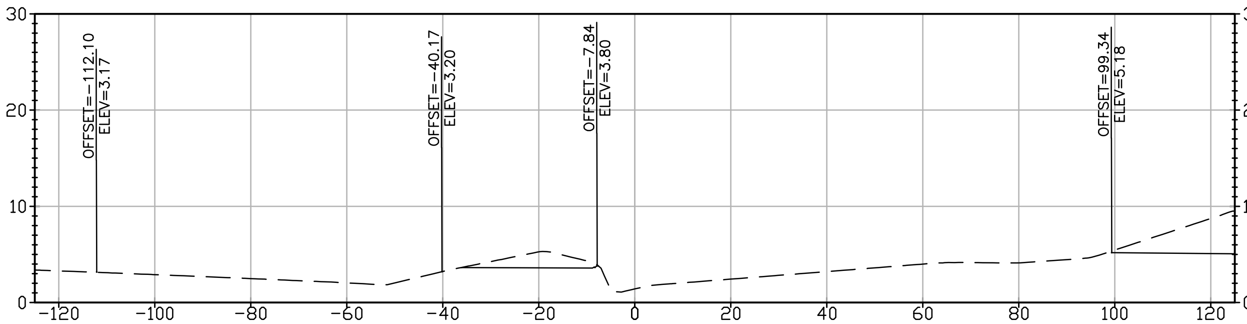
GEOGRAPHIC INFORMATION	
LATITUDE	21°34'29"N
LONGITUDE	157°52'58"W
TN/SC/RG	-/-/-
DATE	9/20/2013

PUNALU'U FLOOD MITIGATION AND STREAM RESTORATION

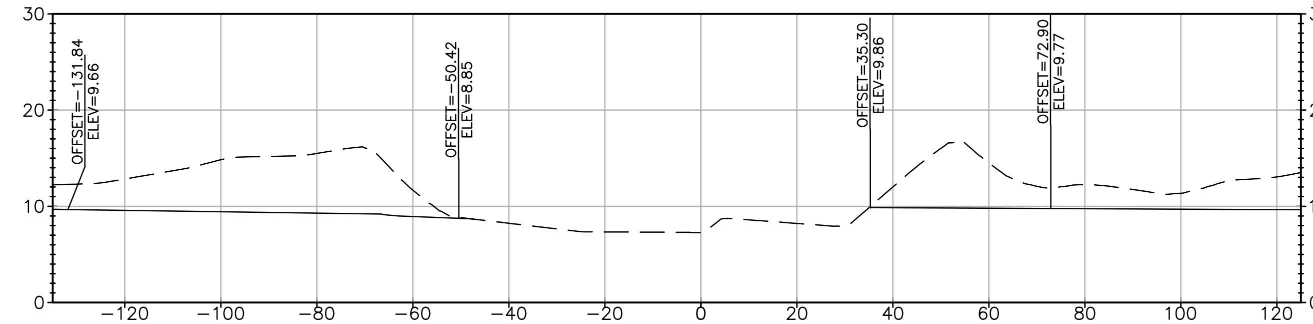
CROSS-SECTIONS 4

26

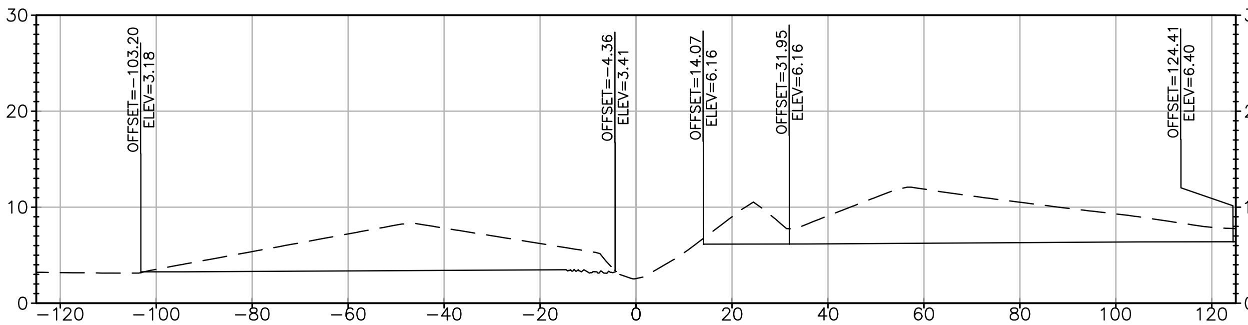
SHEET 26 OF 46



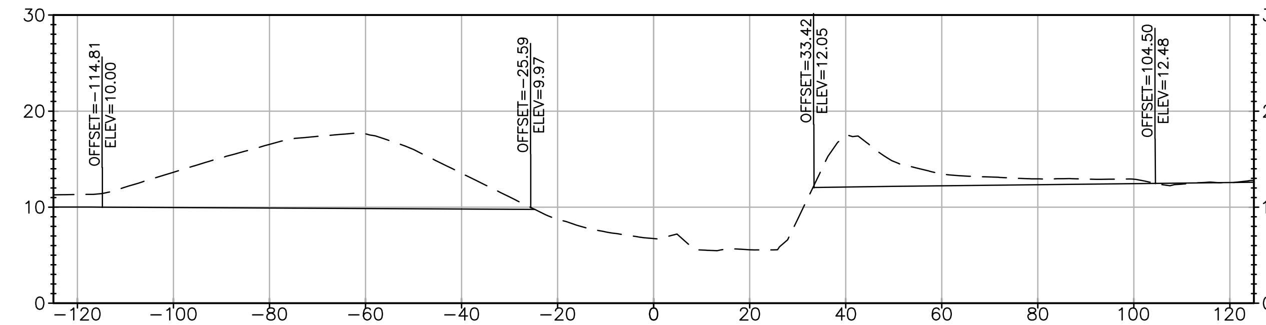
SECTION HH-HH 9
V: 1" = 10', H: 1" = 20'



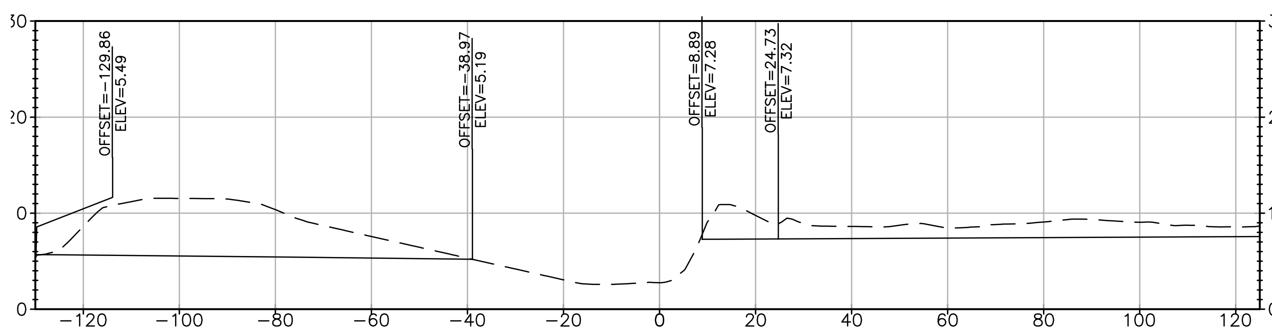
SECTION LL-LL 9
V: 1" = 10', H: 1" = 20'



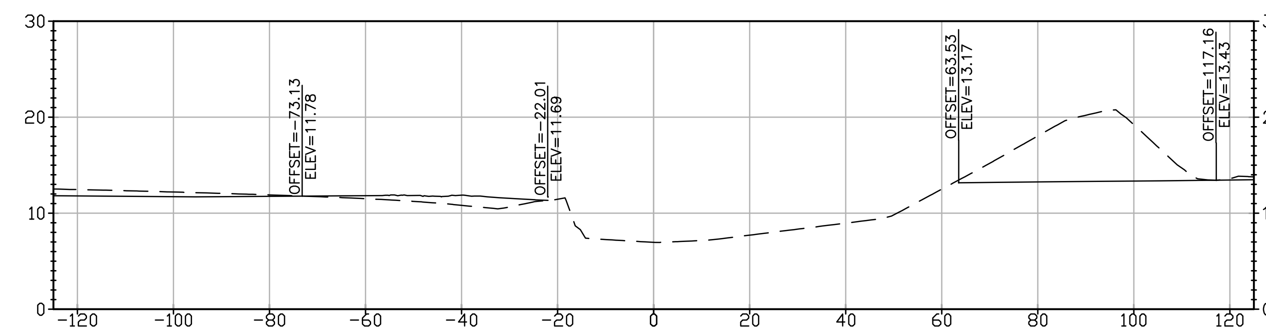
SECTION II-II 9
V: 1" = 10', H: 1" = 20'



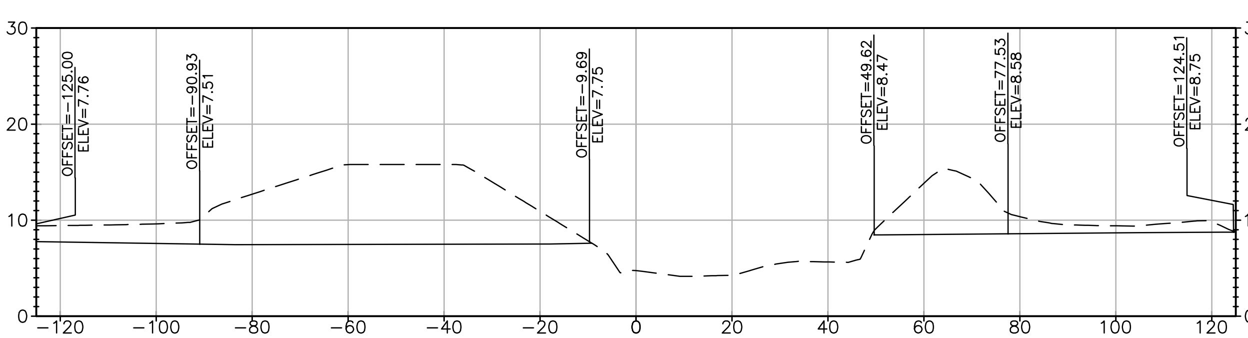
SECTION MM-MM 9
V: 1" = 10', H: 1" = 20'



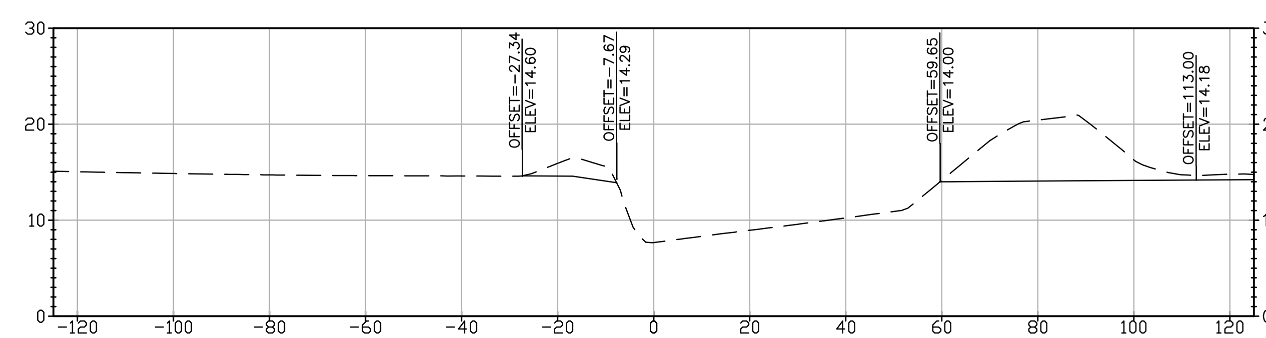
SECTION JJ-JJ 9
V: 1" = 10', H: 1" = 20'



SECTION NN-NN 8, 9
V: 1" = 10', H: 1" = 20'



SECTION KK-KK 9
V: 1" = 10', H: 1" = 20'



SECTION OO-OO 8
V: 1" = 10', H: 1" = 20'

MICHAEL E. HRACHOVEC
LICENSED PROFESSIONAL ENGINEER
No. 15237-C
HAWAII U.S.A.

THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.

Signature — Expiration Date of the License

Natural Systems Design

0 — 1
IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT PLOTTED TO ORIGINAL SCALE.

NAME OR INITIALS AND DATE	
DESIGNED	TA, MH, BB
CHECKED	TA, MH
DRAWN	GD, GM
CHECKED	MH

GEOGRAPHIC INFORMATION	
LATITUDE	21°34'29"N
LONGITUDE	157°52'58"W
TN/SC/RG	-/-/-
DATE	9/20/2013

PUNALU'U FLOOD MITIGATION AND STREAM RESTORATION

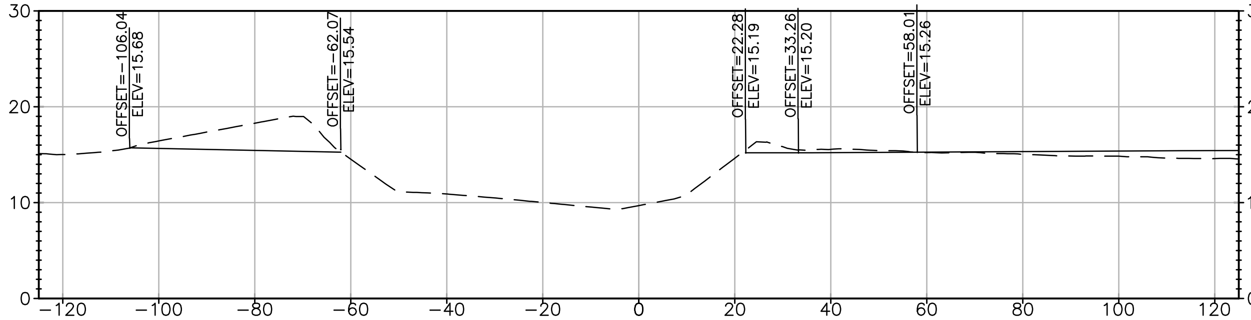
CROSS-SECTIONS 5

27

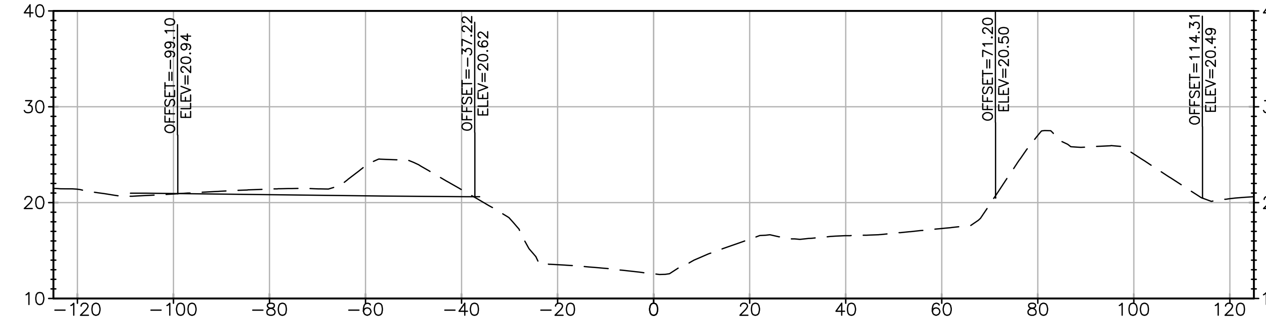
SHEET 27 OF 46

N:\Projects\Kamehameha Schools Hawaii\Punaluu\Design\CAD DWGs - Current\CAD DWGS\CROSS-SECTIONS.dwg | garvey | Sep-25-2013 7:51pm

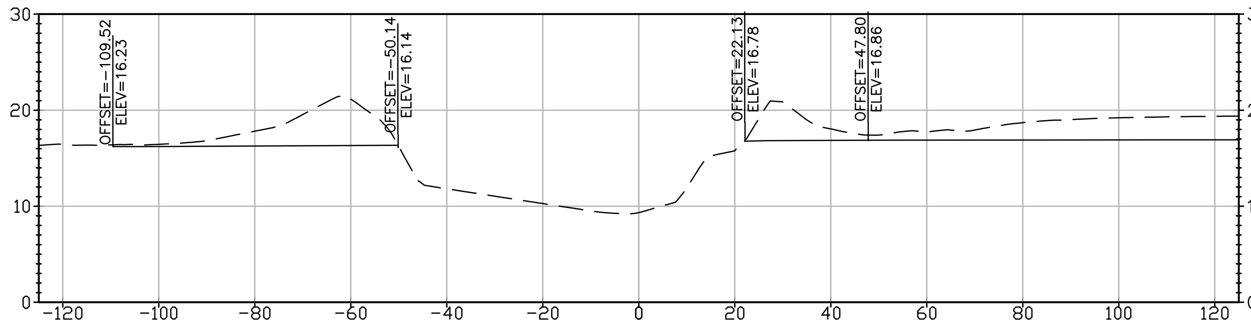
Sep-25-2013 90% DRAWINGS DRAFT



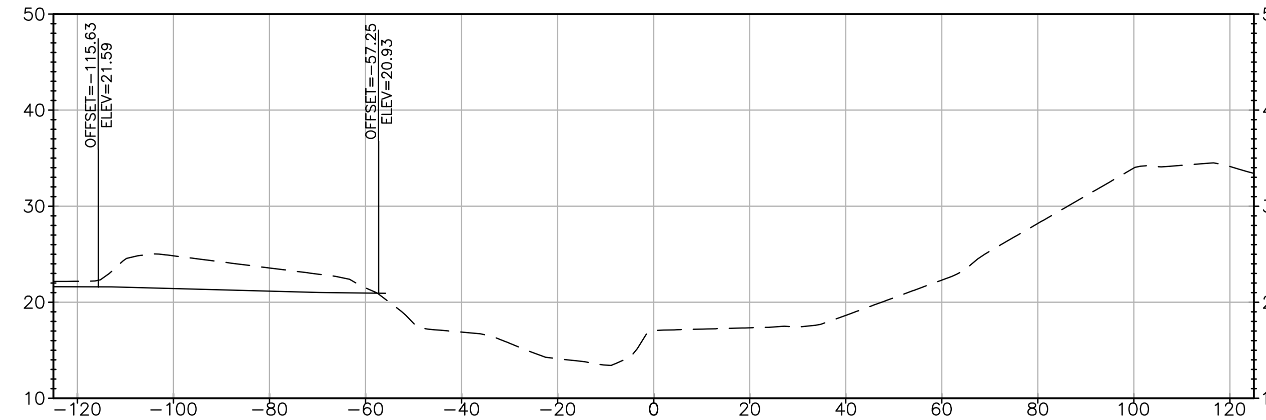
SECTION PP-PP 8
V: 1" = 10', H: 1" = 20'



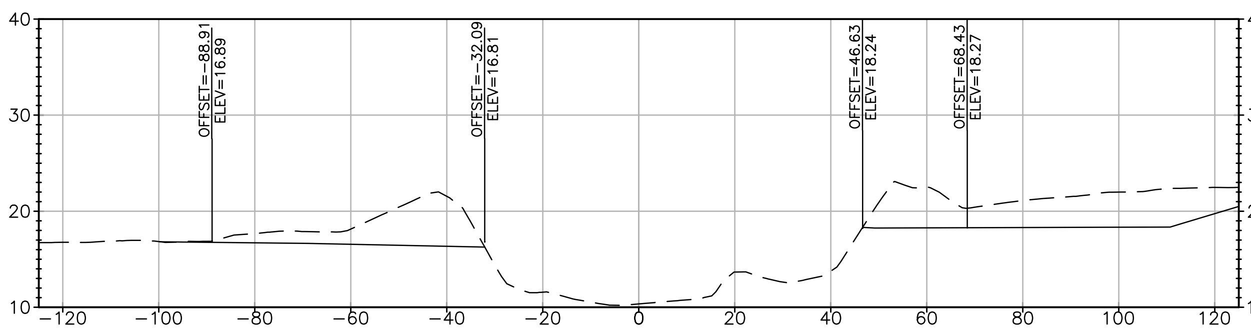
SECTION TT-TT 7, 8
V: 1" = 10', H: 1" = 20'



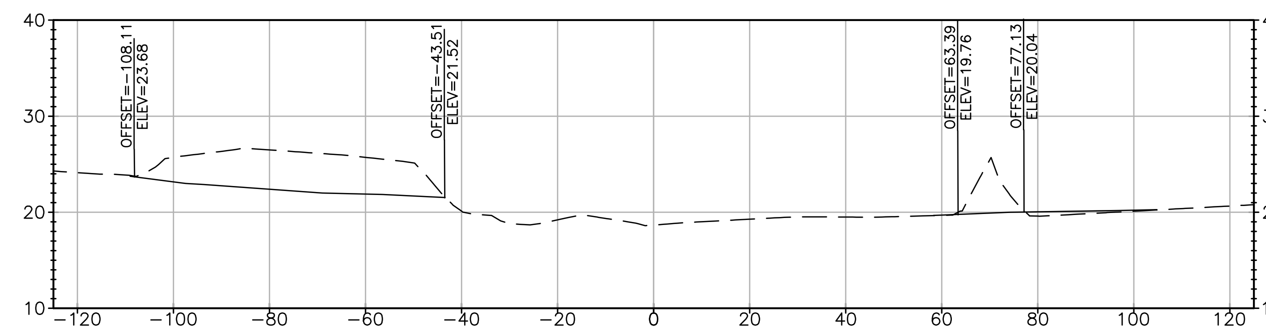
SECTION QQ-QQ 8
V: 1" = 10', H: 1" = 20'



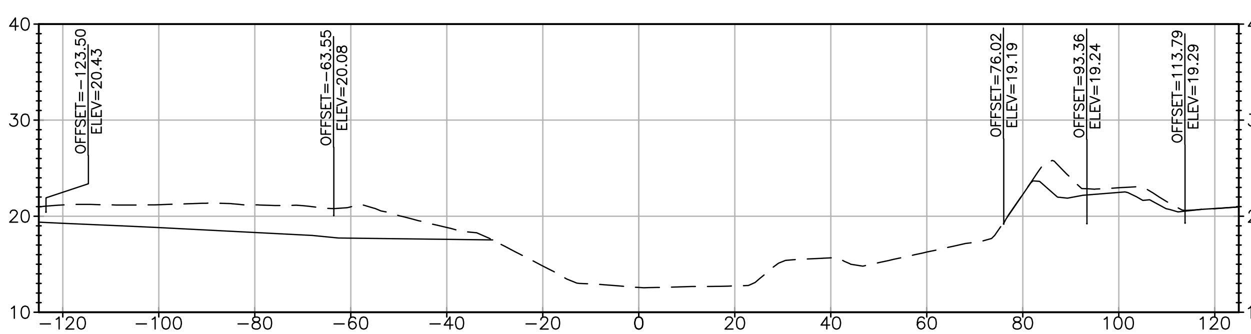
SECTION UU-UU 7
V: 1" = 10', H: 1" = 20'



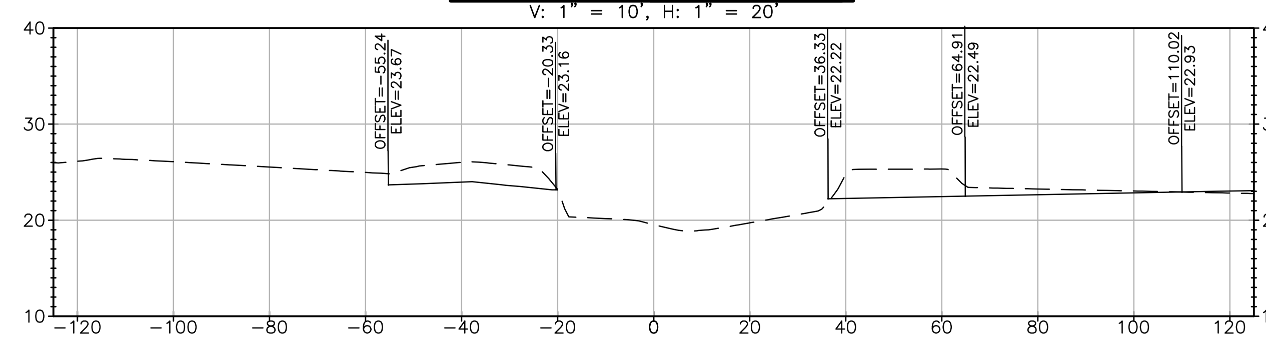
SECTION RR-RR 8
V: 1" = 10', H: 1" = 20'



SECTION V V-V V 7
V: 1" = 10', H: 1" = 20'



SECTION SS-SS 8
V: 1" = 10', H: 1" = 20'



SECTION WW-WW 7
V: 1" = 10', H: 1" = 20'

MICHAEL E. HRACHOVEC
LICENSED PROFESSIONAL ENGINEER
No. 15237-C
HAWAII U.S.A.
THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.
Signature   Expiration Date of the License

Natural Systems Design

ICF INTERNATIONAL

IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT PLOTTED TO ORIGINAL SCALE.

NAME OR INITIALS AND DATE	
DESIGNED	TA, MH, BB
CHECKED	TA, MH
DRAWN	GD, GM
CHECKED	MH

GEOGRAPHIC INFORMATION	
LATITUDE	21°34'29"N
LONGITUDE	157°52'58"W
TN/SC/RG	-/-/-
DATE	9/20/2013

PUNALU'U FLOOD MITIGATION AND STREAM RESTORATION

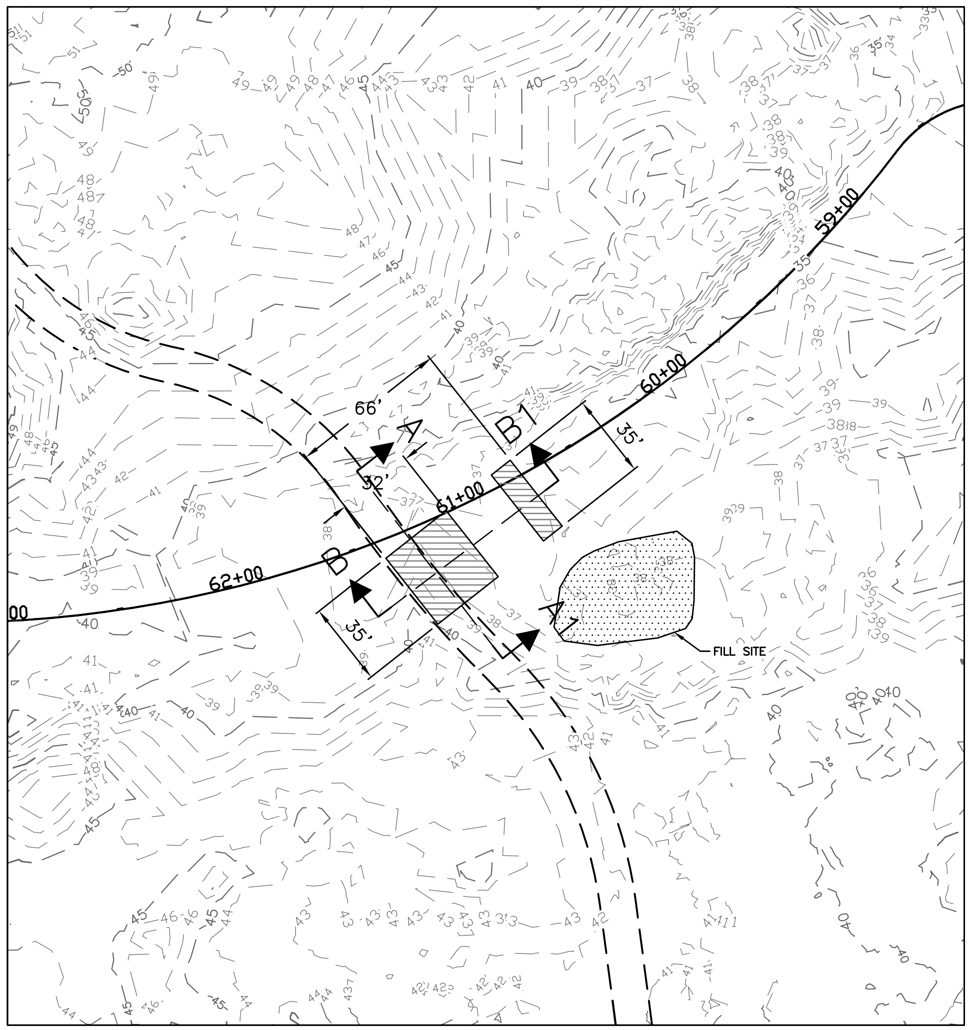
CROSS-SECTIONS 6

28

SHEET 28 OF 46

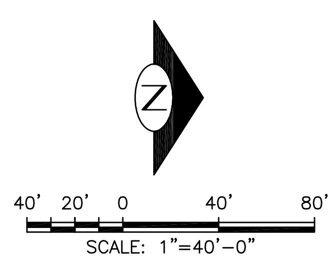
N:\Projects\Kamehameha Schools Hawaii\Punaluu\Design\CAD DWGs - Current\CAD DWGS\CROSS-SECTIONS.dwg | garvey | Sep-25-2013 7:51pm

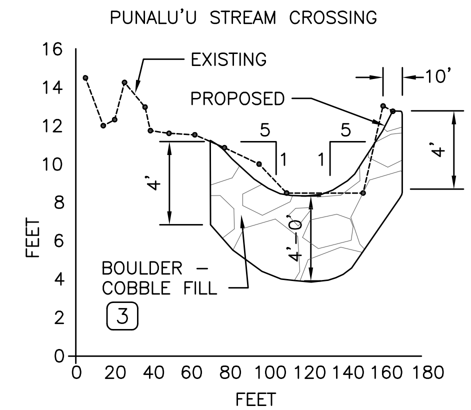
Sep-25-2013 90% DRAWINGS DRAFT



STREAM CROSSING PLAN

SCALE: 1" = 40'

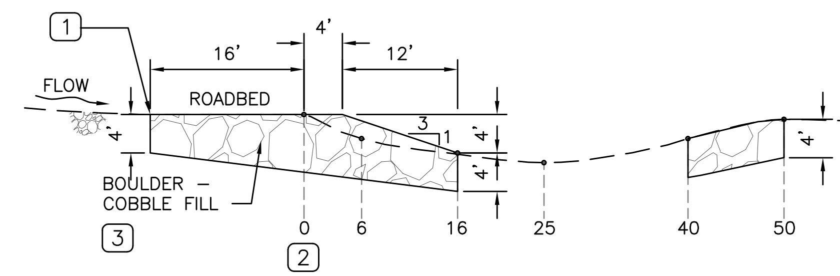




STATION	RELATIVE EL
(FT)	(FT)
5.5	14.5
13.5	12
20.5	12.3
25.5	14.4
35.5	13
38.5	11.7
49.5	11.5
65.5	11.4
77.5	10.8
95.5	10
110.5	8.6
148	8.6
156.5	13.1
163	12.8
ASSUMED DATUM	15

STREAM CROSSING SECTION A–A1

SCALE: AS NOTED



STREAM	DATA
STATION	EXISTING EL.
0	0
6	–2.5
16	–4.0
25	–5.0
40	–2.5
50	–0.5

STREAM CROSSING SECTION B–B1

SCALE: 1" = 10'

NOTES

1. MATCH EXISTING ELEVATION OF STREAM CROSSSING.
2. STATION 0 SHALL BE MEASURED AT DOWNSTREAM EDGE OF EXISTING ROAD CROSSING.
3. EXCAVATE AS SHOWN. PLACE 3–4 MAN BOULDERS AS FIRST LIFT AND FILL VOIDS WITH EXCAVATED MATERIAL. PLACE ADDITIONAL 3–4 MAN BOULDERS TO PROPOSED GRADE AND FILL VOIDS WITH EXCAVATED MATERIAL TO PROVIDE SMOOTH DRIVING SURFACE. DISPOSE OF EXCESS CUT AS DIRECTED ADJACENT TO STREAM CROSSING.

N:\Projects\Kamehameha Schools Hawaii\Punaluu\Design\CAD DWGs – Current\CAD DWGS\STREAM CROSSING.dwg | garvey | Sep–25–2013 7:52pm

Sep-25-2013 90% DRAWINGS DRAFT

MICHAEL E. HRACHOVEC
LICENSED PROFESSIONAL ENGINEER
No. 15237–C
HAWAII U.S.A.
THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.
Signature — Expiration Date of the License

KAMEHAMEHA SCHOOLS 1887 IMUA

Natural Systems Design

ICF INTERNATIONAL

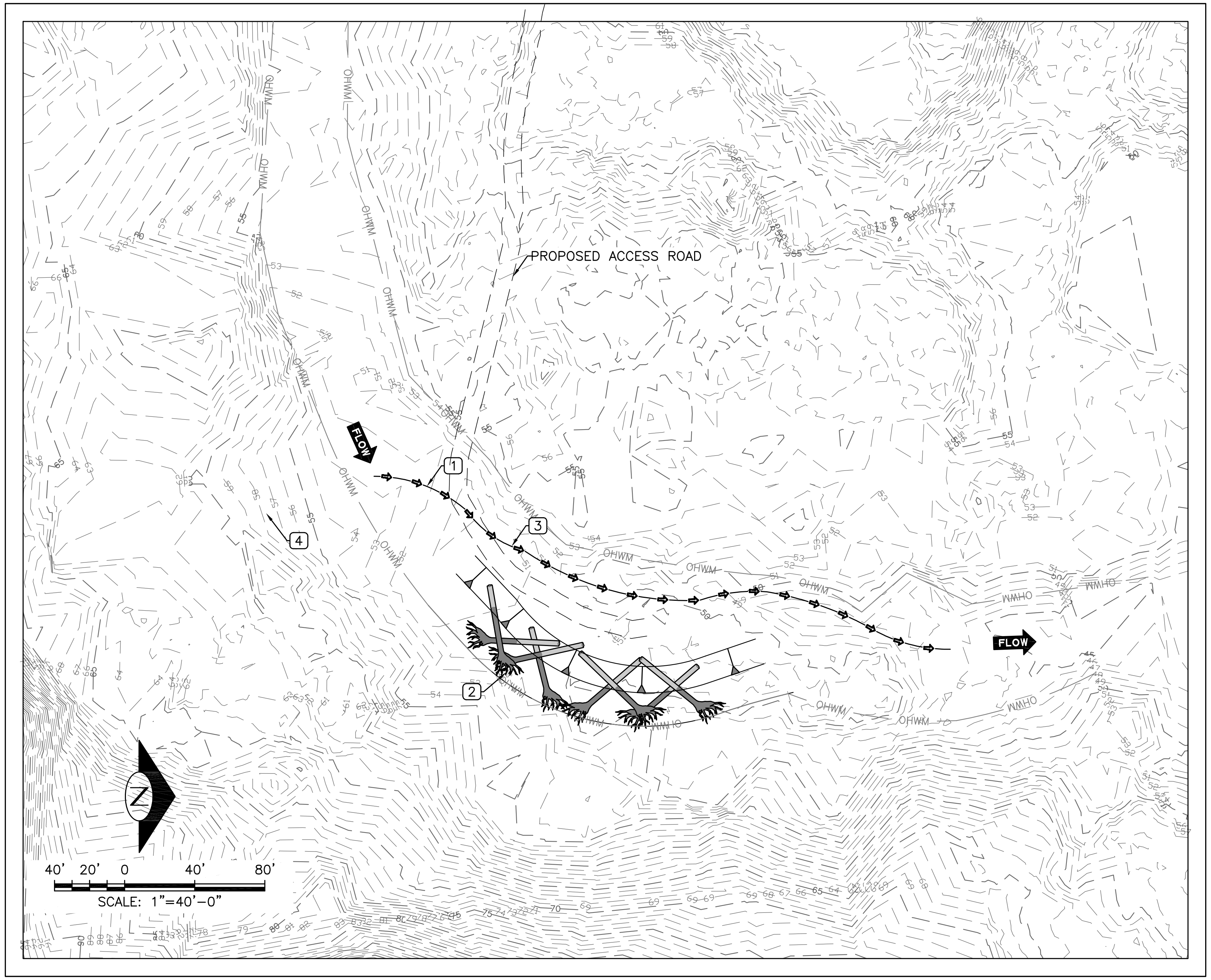
0 Ø 1
IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT PLOTTED TO ORIGINAL SCALE.

NAME OR INITIALS AND DATE	
DESIGNED	TA, MH, BB
CHECKED	TA, MH
DRAWN	GD, GM
CHECKED	MH

GEOGRAPHIC INFORMATION	
LATITUDE	21°34'29"N
LONGITUDE	157°52'58"W
TN/SC/RG	–/–/–
DATE	9/20/2013

PUNALU'U FLOOD MITIGATION AND STREAM RESTORATION

STREAM CROSSING

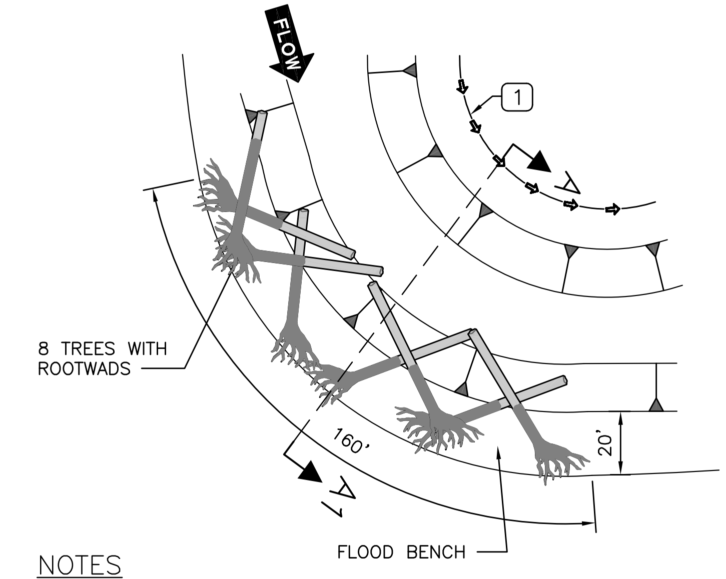


LOWER BANK STABILIZATION PLAN

SCALE: 1"= 40'

NOTES:

1. CUT BYPASS CHANNEL (APPROX. 5' WIDE BOTTOM, 4' DEEP, 1:1 SIDE SLOPES) TO BYPASS STREAM FLOWS AROUND WORK AREA. CONSTRUCT BYPASS CHANNEL STARTING AT BOTTOM AND PROCEEDING UPSTREAM. SORT CUT MATERIALS AS NEEDED TO SELECT BOULDERS FOR BANK STABILIZATION.
2. OWNER TO IDENTITY TREES TO BE HARVESTED LOCALLY FOR BANK STABILIZATION. ALL MATERIALS USED FOR BANK STABILIZATION TO BE OBTAINED IN VICINITY OF WORK.
3. ADJUST BYPASS CHANNEL LOCATION AND SIZING TO PERMIT EQUIPMENT CROSSING. MINIMIZE NUMBER OF CROSSINGS TO MINIMIZE TURBIDITY.
4. TOPOGRAPHICAL DATA OBTAINED FROM LIDAR. ACTUAL ELEVATIONS WILL DIFFER FROM THOSE SHOWN.

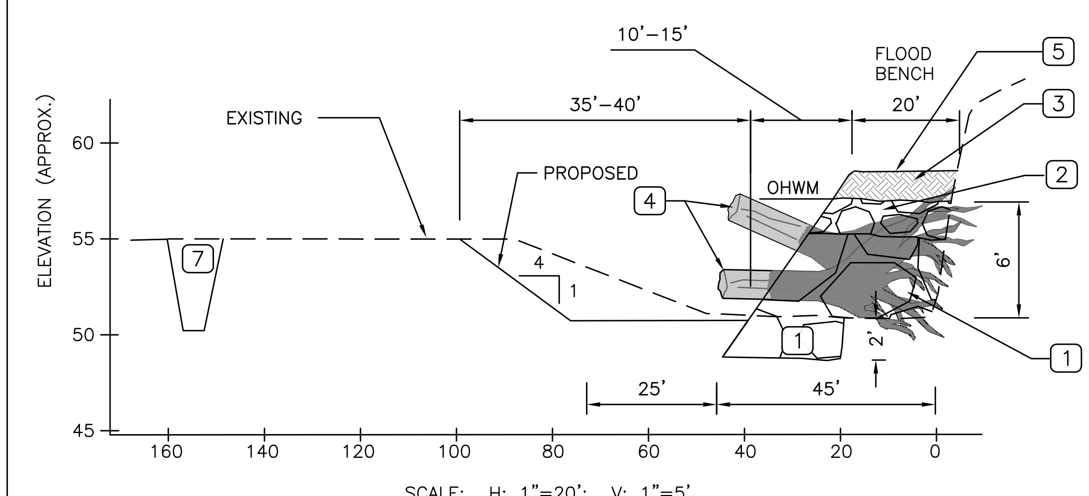


NOTES

1. BYPASS CHANNEL

PLAN DETAIL

SCALE: 1"= 30'



NOTES

1. >36"ø BOULDERS SELECTED FROM CUT MATERIALS. PLACE AFTER TREES ARE INSTALLED.
2. >18" BOULDERS SELECTED FROM CUT MATERIAL.
3. PLANT NATIVE TREES IN 24" TOPSOIL SELECTED FROM CUT MATERIALS OR ADJACENT AREA.
4. TREE WITH ROOTS; DBH ≥ 18", L=50', ROOTWAD DIAMETER ≥ 8', BRANCHES INTACT.
5. ADJUST FLOOD BENCH GRADING TO ACCOMODATE UPSLOPE DRAINAGE AS DIRECTED.
6. EXCAVATION AND PLACEMENT OF MATERIALS IS APPROXIMATE AND SHALL BE FIELD DIRECTED BY ENGINEER.
7. BYPASS CHANNEL – ADJUST LOCATION AND SIZING TO ACCOMMODATE BANK STABILIZATION AND PROVIDE SUFFICIENT FLOW CAPACITY.

SECTION A–A1

SCALE: AS NOTED

MICHAEL E. HRACHOVEC LICENSED PROFESSIONAL ENGINEER No. 15237-C HAWAII U.S.A.

THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.

Signature — Expiration Date of the License

KAMEHAMEHA SCHOOLS 1887 IMUA

Natural Systems Design

ICF INTERNATIONAL

0 Ø 1

IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT PLOTTED TO ORIGINAL SCALE.

NAME OR INITIALS AND DATE	
DESIGNED	TA, MH, BB
CHECKED	TA, MH
DRAWN	GD, GM
CHECKED	MH

GEOGRAPHIC INFORMATION	
LATITUDE	21°34'29"N
LONGITUDE	157°52'58"W
TN/SC/RG	-/-/-
DATE	9/20/2013

PUNALU'U FLOOD MITIGATION AND STREAM RESTORATION

LOWER BANK PROTECTION

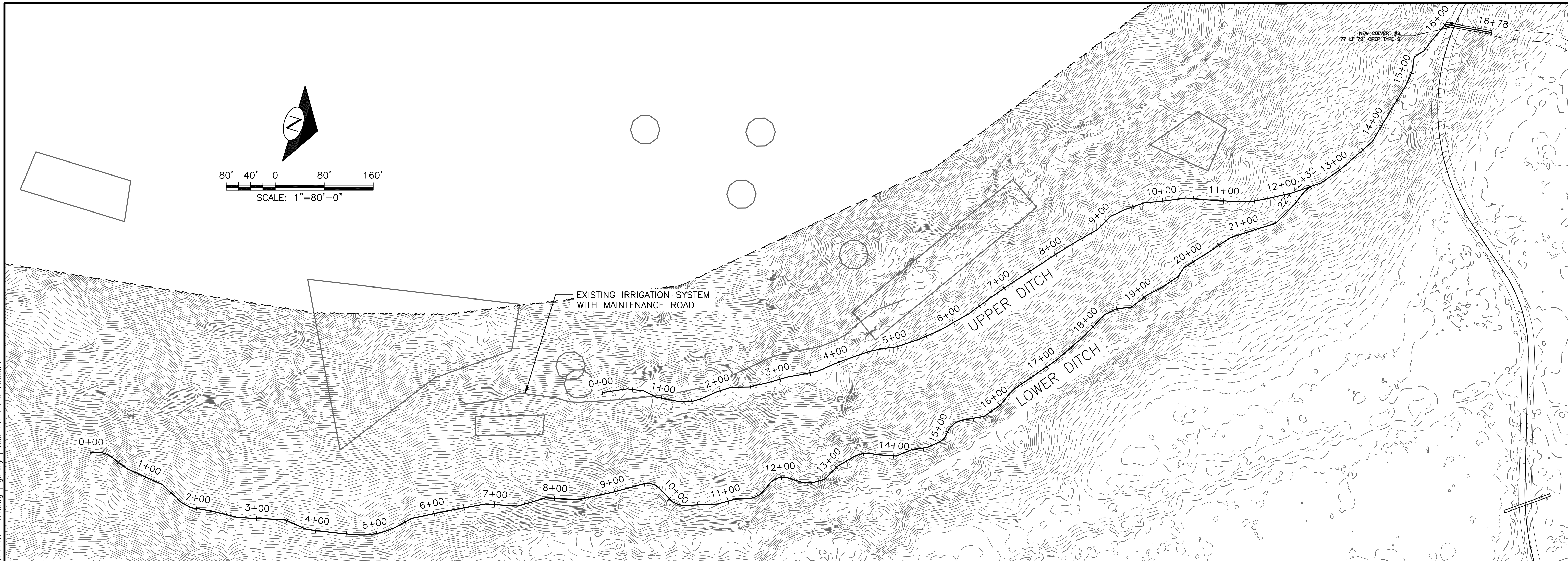
30

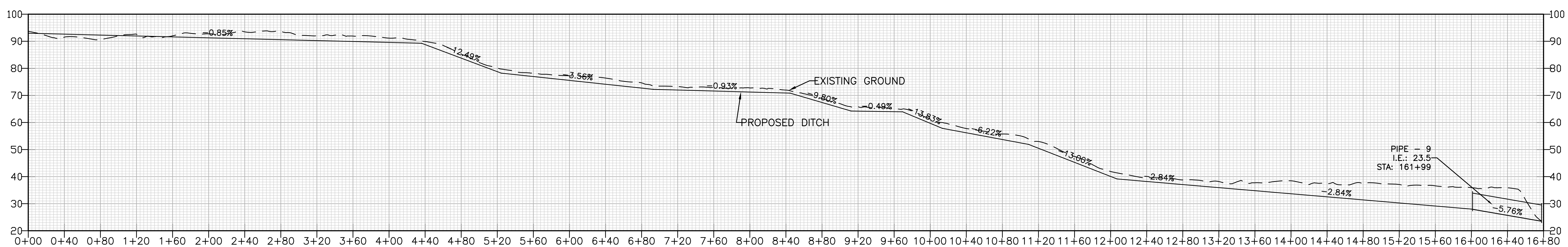
SHEET 30 OF 46

Sep-25-2013 90% DRAWINGS DRAFT

N:\Projects\Kamehameho Schools Hawaii\Punaluu\Design\CAD DWGs - Current\CAD DWGS\LOWER BANK PROTECTION.dwg | garvey | Sep-25-2013 7:52pm

N:\Projects\Kamehameha Schools Hawaii\Punaluu\Design\CAD DWGs – Current\CAD DWGS\SOUTHEAST DRAINAGE IMPROVEMENT PLAN.dwg | garvey | Sep-25-2013 7:53pm





UPPER DITCH PROFILE

V: 1"=20', H: 1"=60'

Sep-25-2013 **90% DRAWINGS DRAFT**

MICHAEL E. HRACHOVEC
LICENSED PROFESSIONAL ENGINEER
No. 15237-C
HAWAII U.S.A.

THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.

Signature Expiration Date of the License

KAMEHAMEHA SCHOOLS 1887 IMUA

Natural Systems Design

ICF INTERNATIONAL

0 Ø 1

IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT PLOTTED TO ORIGINAL SCALE.

NAME OR INITIALS AND DATE	
DESIGNED	TA, MH, BB
CHECKED	TA, MH
DRAWN	GD, GM
CHECKED	MH

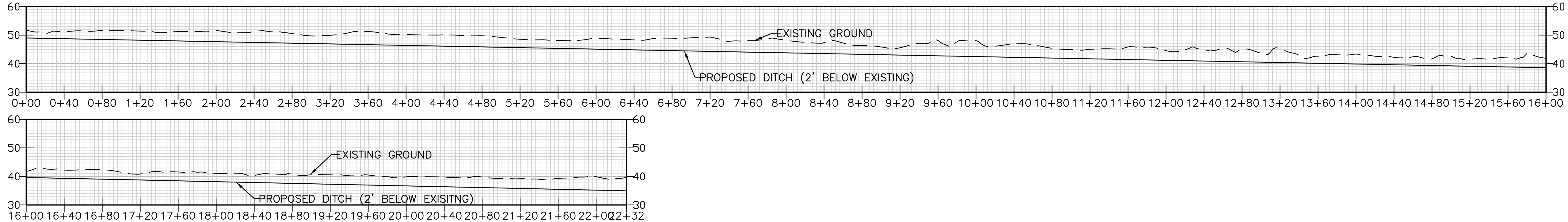
GEOGRAPHIC INFORMATION	
LATITUDE	21°34'29"N
LONGITUDE	157°52'58"W
TN/SC/RG	-/-/-
DATE	9/20/2013

PUNALU'U FLOOD MITIGATION AND STREAM RESTORATION

SOUTHEAST DRAINAGE IMPROVEMENT PLAN 1

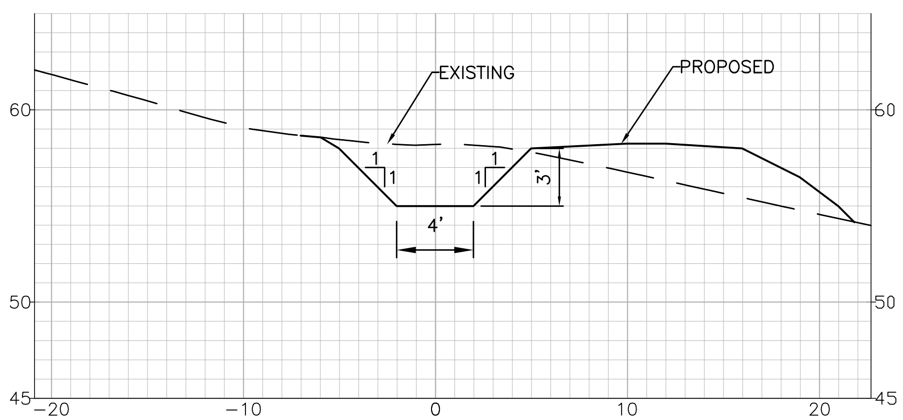
31

SHEET 31 OF 46

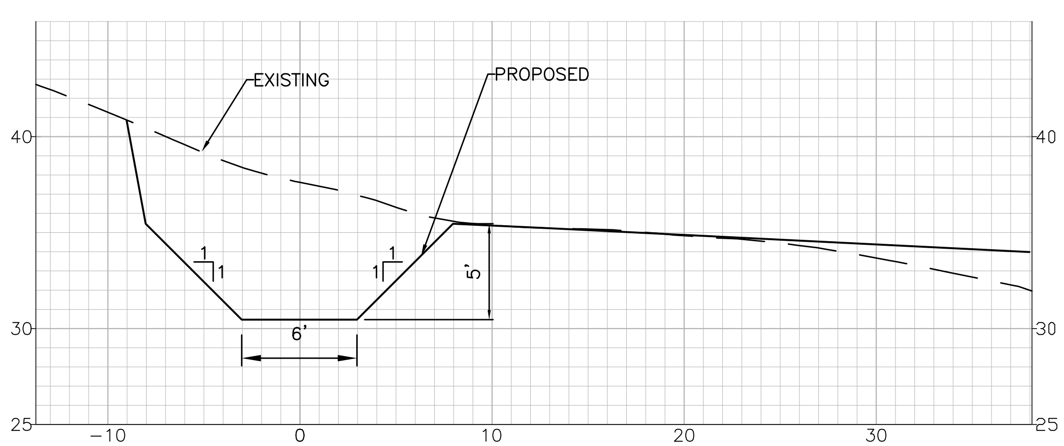


LOWER DITCH PROFILE

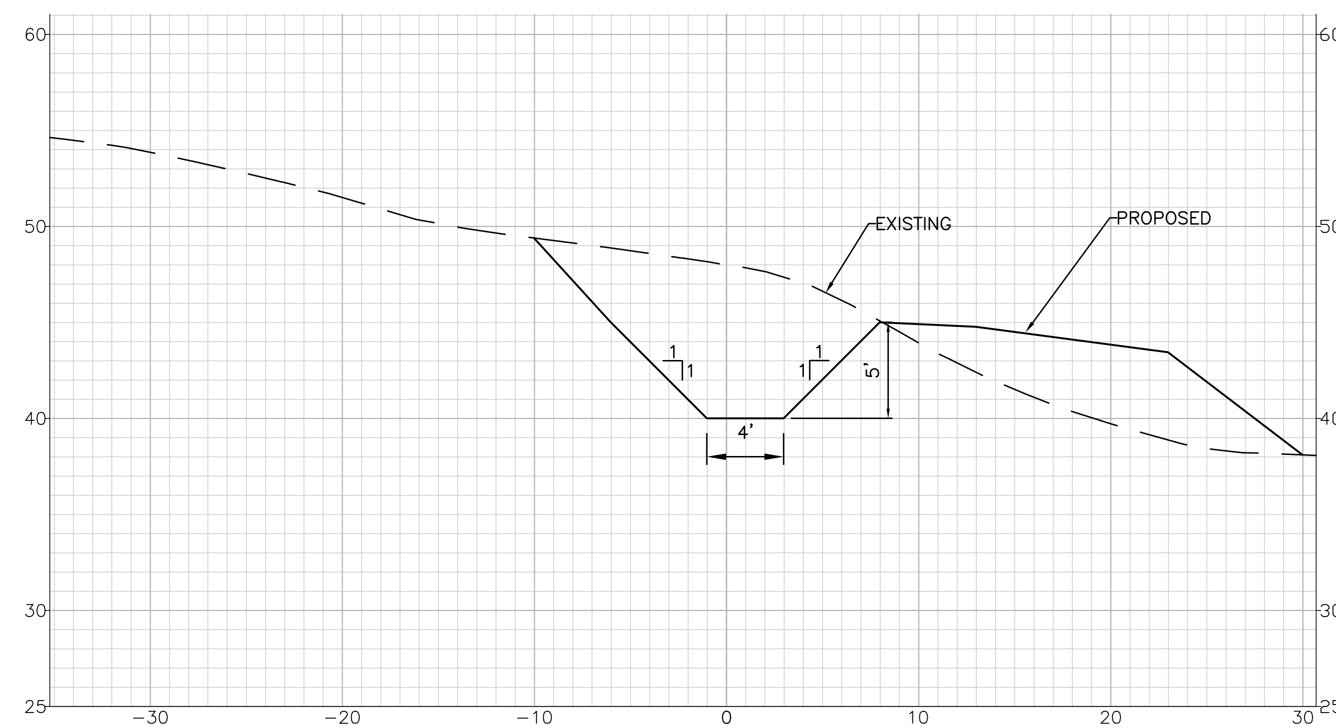
V: 1"=20', H: 1"=60'



UPPER DRAINAGE CHANNEL A



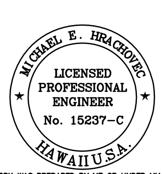
UPPER DRAINAGE CHANNEL B



LOWER DRAINAGE CHANNEL

PROPOSED DITCH CROSS SECTIONS

SCALE: 1"=5'



THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.

Signature — Expiration Date of the License

Natural Systems Design

ICF INTERNATIONAL

0 Ø 1
IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT PLOTTED TO ORIGINAL SCALE.

NAME OR INITIALS AND DATE		GEOGRAPHIC INFORMATION	
DESIGNED	TA, MH, BB	LATITUDE	21°34'29"N
CHECKED	TA, MH	LONGITUDE	157°52'58"W
DRAWN	GD, GM	TN/SC/RG	-/-/-
CHECKED	MH	DATE	9/20/2013

PUNALU'U FLOOD MITIGATION AND STREAM RESTORATION

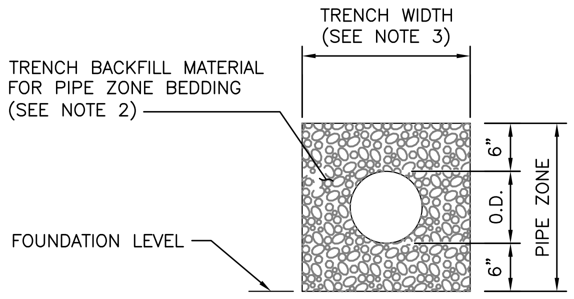
SOUTHEAST DRAINAGE IMPROVEMENT PLAN 2

32

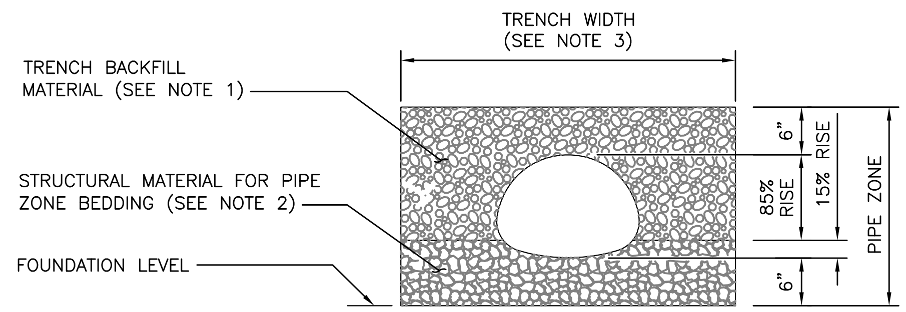
SHEET 32 OF 46

N:\Projects\Kamehameha Schools Hawaii\Punaluu\Design\CAD DWGs – Current\CAD DWGS\SOUTHEAST DRAINAGE IMPROVEMENT PLAN.dwg | garvey | Sep-25-2013 7:53pm

Sep-25-2013 90% DRAWINGS DRAFT



THERMOPLASTIC PIPE

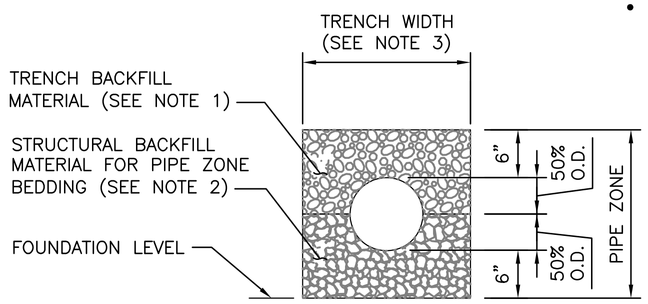


PIPE ARCHES

NOTES

1. SEE SPECIFICATION SECTION 703.21 FOR TRENCH BACKFILL MATERIAL.
2. SEE SPECIFICATIONS SECTION 703.20 FOR STRUCTURE BACKFILL MATERIAL.
3. TRENCH WIDTHS SHALL BE AS FOLLOWS:

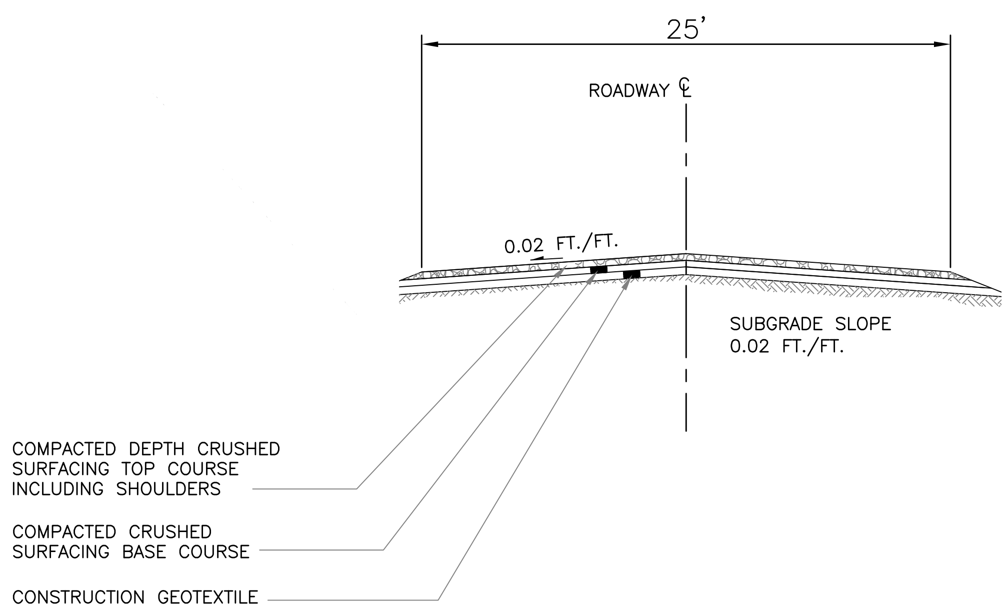
- PIPES < 15", WIDTH = PIPE I.D. + 12"
- PIPES ≥ 18", WIDTH = PIPE I.D. +18"
- WATER SUPPLY PIPES, WIDTH SHALL BE PIPE I.D. + 12" OR 24", WHICHEVER IS GREATER.



METAL PIPE

PIPE ZONE BEDDING AND BACKFILL (1/4)

SCALE: 1" = 1'



ROAD SURFACE (2/45)

SCALE: NTS

MICHAEL E. HRACHOVEC
LICENSED PROFESSIONAL ENGINEER
No. 15237-C
HAWAII U.S.A.

THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.

Signature — Expiration Date of the License

Natural Systems Design

ICF INTERNATIONAL

0 Ø 1
IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT PLOTTED TO ORIGINAL SCALE.

NAME OR INITIALS AND DATE	
DESIGNED	TA, MH, BB
CHECKED	TA, MH
DRAWN	GD, GM
CHECKED	MH

GEOGRAPHIC INFORMATION	
LATITUDE	21°34'29"N
LONGITUDE	157°52'58"W
TN/SC/RG	-/-/-
DATE	9/20/2013

PUNALU'U FLOOD MITIGATION AND STREAM RESTORATION

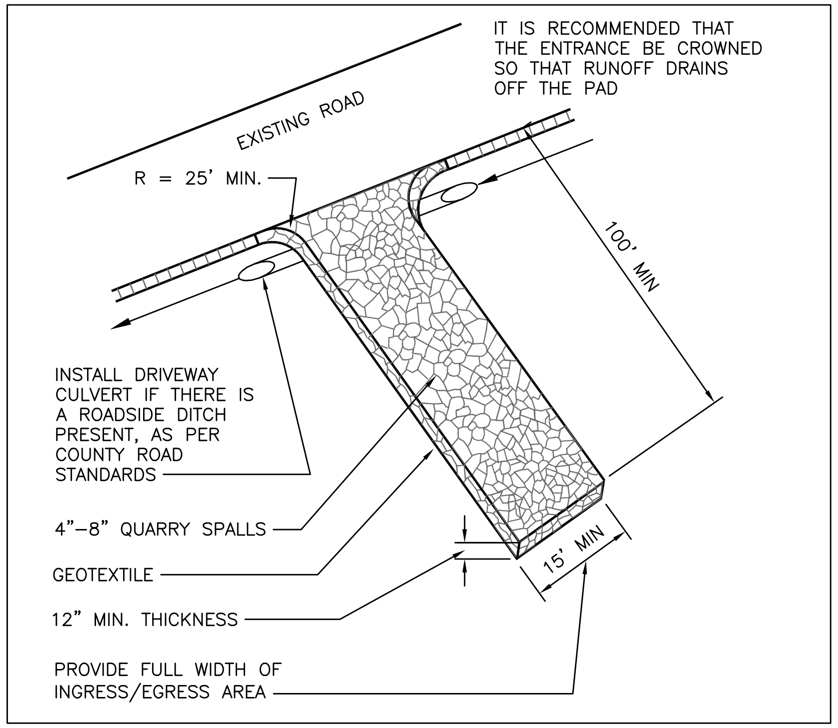
CONSTRUCTION DETAILS 1

45

SHEET 45 OF 46

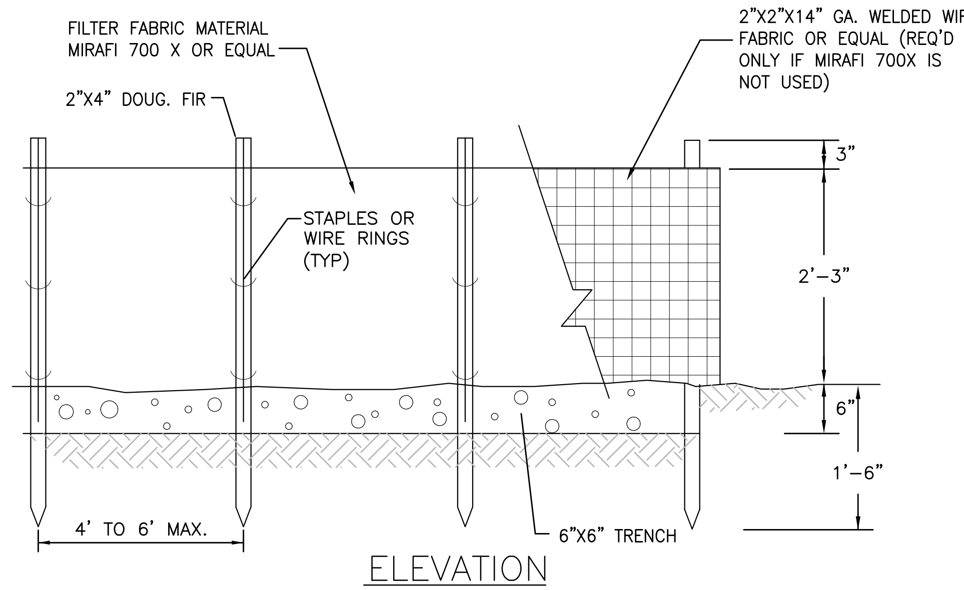
Sep-25-2013 90% DRAWINGS DRAFT

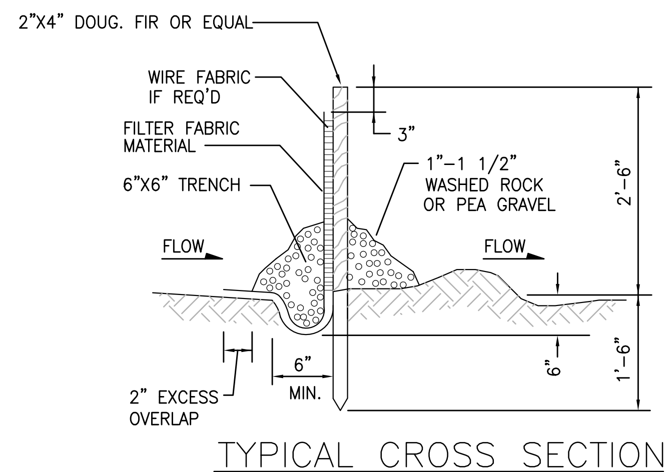
N:\Projects\Kamehameha Schools Hawaii\Punaluu\Design\CAD DWGs - Current\CAD DWGS\CONSTRUCTION DETAILS 1.dwg | garvey | Sep-25-2013 7:55pm



STABILIZED CONSTRUCTION ENTRANCE (1/5) (1/6)

SCALE: NTS



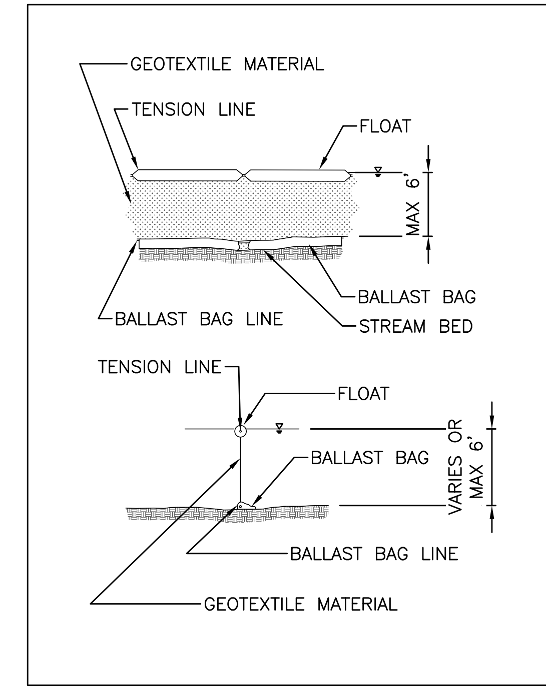


SILT FENCE INSTALLATION NOTES

1. THE SILT FENCE FILTER FABRIC SHALL BE PURCHASED IN A CONTINUOUS ROLL CUT TO THE LENGTH OF THE BARRIER TO AVOID USE OF JOINTS. WHEN JOINTS ARE NECESSARY FILTER FABRIC SHALL BE SPLICED TOGETHER ONLY AT A SUPPORT POST WITH A MINIMUM SIX (6) INCH OVERLAP AND BOTH ENDS OF THE SPLICE SHALL BE SECURELY FASTENED TO THE POST. THE MIRAFI 700X FILTER FABRIC SHALL BE STAPLED OR WIRED TO THE FENCE WITH AT LEAST TWENTY (20) INCHES OF FABRIC LAID IN THE SHALLOW SWALE. THE FENCE SHALL NOT EXCEED THIRTY–SIX (36) INCHES ABOVE THE ORIGINAL GROUND. THE SILT FENCE SHALL BE INSTALLED TO FOLLOW THE CONTOURS WHERE FEASIBLE AND SHALL NOT BE STAPLED TO TREES.
2. WHEN FILTER FABRIC OF LESS STRENGTH AS MIRAFI 700X IS APPROVED FOR USE, A WIRE MESH SUPPORT FENCE SHALL BE FASTENED SECURELY TO THE UPSLOPE SIDE OF THE POSTS USING HEAVY–DUTY WIRE STAPLES AT LEAST ONE (1) INCH LONG, TIE WIRES OR HOG RINGS. THE WIRE MESH SHALL EXTEND INTO THE SHALLOW SWALE IN MINIMUM OF FOUR (4) INCHES AND SHALL NOT EXTEND MORE THAN THIRTY–SIX (36) INCHES ABOVE THE ORIGINAL GROUND SURFACE.
3. THE SHALLOW SWALE AND BOTH SIDES OF THE SILT FENCE SHALL BE BACKFILLED WITH ONE (1) INCH TO ONE AND ONE HALF (1–1/2) INCHES DIAMETER WASHED GRAVEL.
4. SILT FENCES SHALL BE REMOVED WHEN THEY HAVE SERVED THEIR USEFUL PURPOSE AFTER THE UPSLOPE AREA HAS BEEN PERMANENTLY STABILIZED. THE NEWLY DISTURBED AREAS RESULTING FROM SILT FENCE REMOVAL SHALL BE IMMEDIATELY SEEDED AND MULCHED OR STABILIZED AS APPROVED BY THE CITY.
5. SILT FENCES SHALL BE INSPECTED IMMEDIATELY AFTER EACH RAINFALL AND AT LEAST DAILY DURING PROLONGED RAINFALL. ANY REQUIRED REPAIRS SHALL BE MADE IMMEDIATELY.

SILT FENCE (2/5) (2/6)

SCALE: NTS



TURBIDITY CURTAIN (3/5)

SCALE: NTS

Sep-25-2013 90% DRAWINGS DRAFT

N:\Projects\Kamehameha Schools Hawaii\Punaluu\Design\CAD DWGs – Current\CAD DWGS\CONSTRUCTION DETAILS 1.dwg | garvey | Sep–25–2013 7:55pm

MICHAEL E. HRACHOVEC LICENSED PROFESSIONAL ENGINEER No. 15237–C HAWAII U.S.A.
THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.
Signature Expiration Date of the License

Natural Systems Design | ICF INTERNATIONAL

0 Ø 1 — IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT PLOTTED TO ORIGINAL SCALE.

NAME OR INITIALS AND DATE		GEOGRAPHIC INFORMATION	
DESIGNED	TA, MH, BB	LATITUDE	21°34'29"N
CHECKED	TA, MH	LONGITUDE	157°52'58"W
DRAWN	GD, GM	TN/SC/RG	–/–/–
CHECKED	MH – –	DATE	9/20/2013

PUNALU'U FLOOD MITIGATION AND STREAM RESTORATION

CONSTRUCTION DETAILS 2

46

SHEET 46 OF 46

Appendix B

Wetlands Delineation on TMK: 5-3-003:001 por. and 041 por. for Kamehameha Schools Punaluʻu Agricultural Lands, Punaluʻu, Oʻahu

Wetlands delineation on TMK: 5-3-003:001 por. and 041 por. for Kamehameha Schools Punaluʻu Agricultural Lands Punaluʻu, Oʻahu

December 30, 2014 *AECOS* No. 1402

Susan Burr and Eric B. Guinther
AECOS, Inc.
45-939 Kamehameha Hwy, Suite 104
Kāneʻohe, Hawaiʻi 96744
Phone: (808) 234-7770 Fax: (808) 234-7775 Email: aecos@aecos.com

Introduction

Development of a stream stewardship and flood mitigation plan is identified as a priority in the Kamehameha Schools (KS) Punaluʻu Ahupuaʻa Plan (Townscape, 2010). ICF International (ICFI) has developed a conceptual plan ("Plan") for KS that involves creating a dedicated floodway, improving drainage, restoring native vegetation and wetland agriculture within the floodway, and improving habitats for native waterbirds and stream fauna. In September 2014, *AECOS* scientists delineated wetlands in the 200-ac Plan Area ("Plan Area") within Punaluʻu Ahupuaʻa (Figure 1). Wetland data sheets and geospatial information for the delineation process are presented in this report.

Site Description

The watershed of Punaluʻu Stream (state code No. 31016) is relatively large, comprising some 17.2 km^2 (6.6 mi^2; Parham et al., 2008). Punaluʻu Stream is a continuously flowing, perennial stream (HCPSU, 1990), with a relatively short *muliwai* or estuary inland from the ocean mouth. Annual rainfall in Punaluʻu watershed in the Plan Area is on the order of 1554 mm (61 in; (Giambelluca et. al., 2013).

The land and water of Punaluʻu watershed has been used for hundreds of years to grow *kalo*, *ʻawa*, and rice (McElroy and Eminger, 2012). Somewhat later, much of the valley bottom was covered in sugar cane. An existing irrigation ditch system that diverts water from Punaluʻu Stream was constructed in the

1920s for sugarcane production and used more recently to supply water for cultivation of taro and vegetable crops, ornamental plants, livestock, and aquaculture operations in the valley. The irrigation system consists of open ditches, 12 tunnels, and a flume. An application to reconstruct the diversion was approved in 2008 (HDLNR-COWRM, 2008) and has since been completed. Recent improvements also include the installation of pipes to convey water that flowed through open ditches.

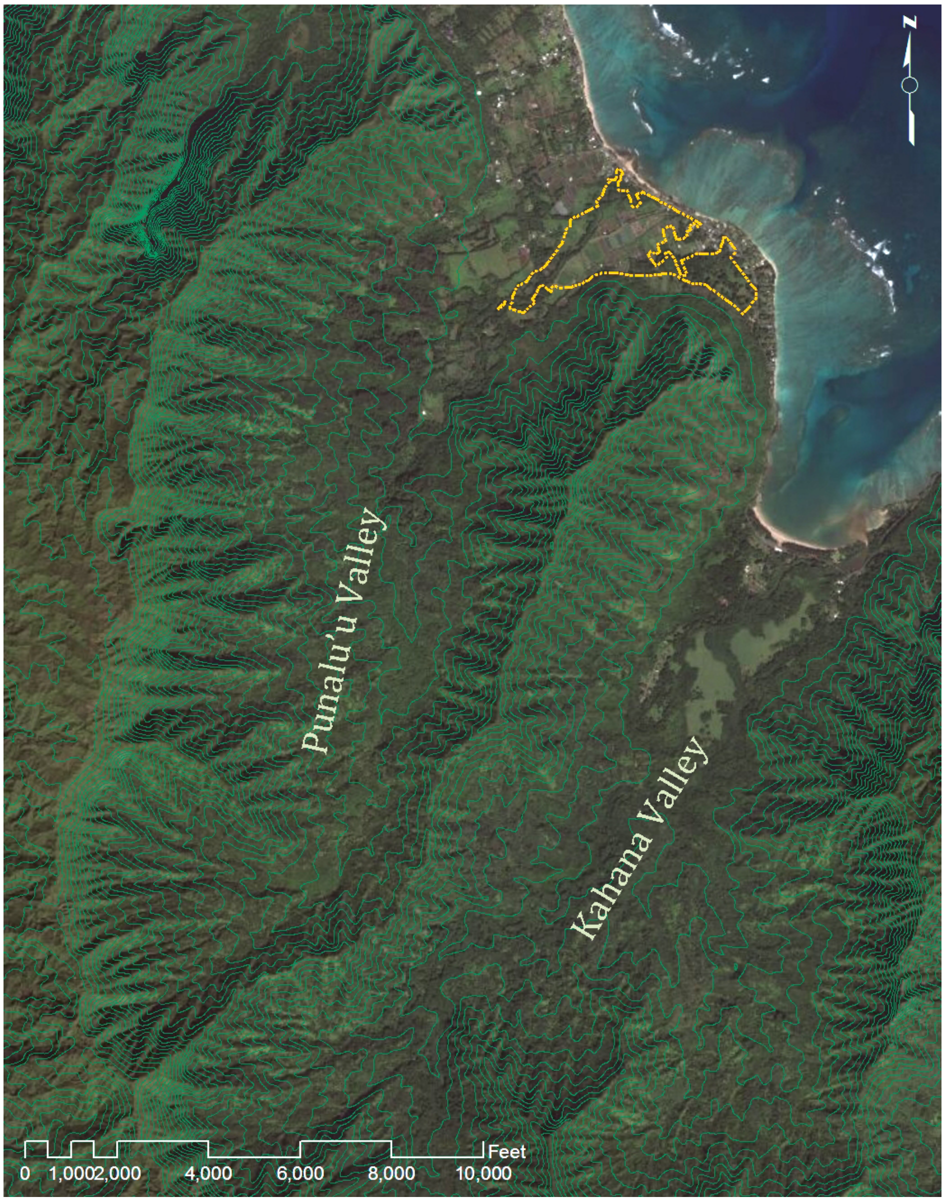


Fig. 1. Punaluʻu Watershed, windward Oʻahu. Plan Area is outlined in yellow.

Wetlands

Wetlands are typically found at the interface of aquatic and terrestrial ecosystems. Certain wetlands are regulated by the federal government under the auspices of the Clean Water Act (CWA) and are defined as (USACE, 1986; USEPA, 2004):

> …those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas.

The U.S. Army Corps of Engineers (USACE) developed a manual ("Manual") for use in the CWA Section 404 regulatory program to identify and delineate wetlands[1] (USACE, 1987) and has updated this information with a regional supplement (USACE, 2012a). The approach required by the Manual and regional supplement requires positive evidence of hydrophytic vegetation, hydric soils, and wetland hydrology (all three must be present) for a jurisdictional wetland determination. However, not all areas that meet the definition of wetlands in the Manual are *jurisdictional* wetlands considered "waters of the United States" under the CWA. Further, jurisdiction over aquatic features also extends to flowing (streams) and tidal (ocean) waters, determined by processes or criteria different from those described in the Manual.

USACE and U.S. Environmental Protection Agency (USEPA) have recently proposed a rule to clarify the definition of "waters of the United States" (USACE and USEPA, 2014). The intent of the proposed rule is to codify guidance previously provided in a memorandum (USEPA and USACE, 2008) written to ensure actions implemented by USACE districts and USEPA regions are consistent with two Supreme Court decisions (*Rapanos vs. United States* and *Carabell vs. United States*). According to the USEPA (McCarthy, 2014), the proposed rule does not expand jurisdiction, but instead clarifies and standardizes existing practices for determining jurisdiction. The proposed rule specifies that all wetlands adjacent to waters otherwise specified as waters of the U.S. (e.g., tidal waters, perennial streams) and all waters, including wetlands, that have a *significant nexus* to waters of the U.S. are themselves waters of the

[1] The process of determining that line on the ground (and shown on maps) separating jurisdictional waters from upland is termed "delineation". Although *AECOS* can "delineate" wetlands, jurisdictional determination is the purview of the U.S. Army Corps of Engineers, and the Corps must concur with our delineation for it to become official.

U.S. The proposed rule specifically excludes certain waters from the definition of waters of the U.S., including ditches that are excavated wholly in uplands, drain only uplands, and have less than perennial flow, and ditches that do not contribute flow to waters of the U.S.

The U.S. Fish and Wildlife Service (USFWS) definition of wetlands is different than that used to regulate wetlands under the CWA—only a single wetland characteristic (hydrophytic vegetation, hydric soils, or wetland hydrology) is required by USFWS for an area to be considered a wetland. The National Wetlands Inventory (NWI; USFWS, 2006), a mapping of all aquatic environments (not just wetlands), indicates aquatic features are present within the Plan Area of Punaluʻu watershed (Figure 2).

Figure 2. Aquatic features identified on National Wetlands Inventory (NWI) map in Plan Area of Punaluʻu watershed. Note that the NWI includes marine areas.

The NWI assigns a classification code to each aquatic feature that corresponds to a classification nomenclature that best describes the habitat (Cowardin, et al., 1974). The aquatic features identified as present in the Plan Area are listed in Table 1. While NWI aquatic features are not necessarily jurisdictional under the CWA (and many are misidentified), the NWI is a helpful starting point to identify where wetlands might occur in an area. As we shall describe below, our efforts in the Plan Area determined that a number of areas designated as wetlands on the NWI map are uplands (that is, not wetlands) and other areas not mapped as aquatic on the NWI map are wetlands as defined by the regulatory agency (USACE, 1987).

Table 1. Aquatic features identified on National Wetlands Inventory (NWI) map within the Plan Area of Punaluʻu watershed.

Code	Description
M2USn	Intertidal marine system with unconsolidated bottom.
E1UBL	Subtidal estuarine system with unconsolidated bottom.
E2EM1N	Regularly flooded intertidal estuarine system with broad-leaved evergreen vegetation.
E2FO3N	Regularly flooded intertidal estuarine system forested with broad-leaved evergreen vegetation.
R3UBH	Permanently flooded, upper perennial stream system with unconsolidated bottom.
PFO3C	Seasonally flooded, forested palustrine wetland with broad-leaved evergreen vegetation.
PFO3A	Temporary flooded, forested palustrine wetland with broad-leaved evergreen vegetation.
PEM1C	Seasonally flooded palustrine wetland with persistent emergent vegetation.
PEM1Cx	Seasonally flooded palustrine wetland that has been excavated and consists of persistent emergent vegetation.
PEM1KH	Diked and/or impounded palustrine wetland that is semipermanently, artificially flooded and supports persistent emergent vegetation.

Soils – Punaluʻu watershed is in the Major Land Resource Area (MLRA; NRCS, 2006) of "humid oxidic soils on low and intermediate rolling mountain slopes". The dominant soils in this MLRA are Utisols, Oxisols, and Inceptisols; alluvial sediments occur on bottom lands. The soil survey (NRCS, 2014a) maps the majority of the valley floor as Hanalei silty clay, 0 to 2% slopes (HnA); Hanalei stony silty clay, 2 to 6% slopes (HoB); Kaloko clay, noncalcareous variant (Kfb); and Pearl Harbor clay (Ph; Figure 3). Each of these soil map units is on the list of hydric soils for Oʻahu (NRCS, 2014b). Hydric soils are soils that are sufficiently wet in the upper part to develop anaerobic conditions; that is, soils that could be associated with wetlands. Soil saturation with water is what differentiates wetland soils from upland soils, as saturation greatly reduces the oxygen present between soil particles. In determining whether a soil is hydric, we look for evidence of this saturation; the soil need not be saturated at the time of inspection.

Figure 3. Soil survey including the Plan Area of Punaluʻu watershed. Hydric soils (in blue type; named in text) are HnA, HoB, Kfb, and Ph.

Most of the area mapped as wetlands in the NWI in the Plan Area is also mapped as having hydric soils. However, the area mapped as having hydric soil is far more extensive than the NWI wetlands, particularly the area mapped as Pearl Harbor clay (Ph) and the *mauka* area mapped as Hanalei silty clay, 0 to 2% slopes (HnA) on the left side of Punaluʻu Stream. These additional areas of mapped hydric soils are worth investigating as potential wetlands.

Hydrology– Punaluʻu Valley, located on the windward side of Oʻahu, receives abundant annual rainfall, ranging from 5591 mm (220 in) from the top of the watershed at 856 m (2808 ft) elevation above sea level to 1554 mm (61 in) of rainfall at the coastline (Giambelluca et. al., 2013). Because most of the rainfall in the upper slopes is due to orographic lifting, the higher elevations receive abundant rainfall throughout the year, but the rainfall near the coast is more seasonally distributed, with the majority of the rain falling between October and March.

In 2014 (through September), rainfall in Punaluʻu watershed was above average. A rain gage near the coast (Punaluu Pump or PUNH1) received 1558 mm (61 in) year to date, 139% of average, and Punaluu Stream (Sta. PNSH 1) gage, farther up the watershed, received 2475 mm (97in) year to date, 110% of average (NOAA-NWS, 2014). Thus, our wetlands investigation of the area conducted in the 2014 dry season would not yield different results than an investigation conducted in a typical wet season.

Another contributor to wetlands hydrology is a high groundwater table. The Koʻolau rift zone, located along windward Oʻahu, contains a dike-impounded aquifer (Nichols, et al., 1996). This groundwater influences surface water through contribution to the base flow of Punaluʻu Stream (and other windward Oʻahu streams) and also through discharge at springs.

Flooding from Punaluʻu Stream may also contribute to wetland hydrology conditions within the Plan Area. Daily mean discharge from Punaluʻu Stream measured at USGS Sta. No. 16301050 varies annually from a recorded low of 14.3 cfs (in 1984) to a high of 39.3 cfs (in 1965), with an average of 24.3 cfs. The annual statistic of daily mean discharge for 2013 was 18.2 cfs (USGS, 2014a). Flow in Punaluʻu is quite flashy, resulting in an average peak discharge more than two orders of magnitude higher than daily discharge.

The lower valley is protected from flooding by levees constructed along both banks. An attempt to further confine Punaluʻu Stream to a fixed channel within the floodplain was made in 1988 when the lower segment of Punaluʻu Stream was realigned and channelized (Figure 4; USACE, 1988; HDLNR-DWLD, 1988). The Army Corps required that the stream be restored to a more meandering course because the work was not authorized. Restoration was determined to be completed in 1991 (USACE, 1991), though only a slight bend was constructed and the lower stream is still channelized. Levees following the natural course through the Plan Area are still intact.

Vegetation – We identified the following vegetation types using satellite images and ground-truthing across the property (see Figure 5 and Table 2): cultivated cropland (Ag), pasture and grassland (Gl), mixed forest (Fo), *hau* forest wetland

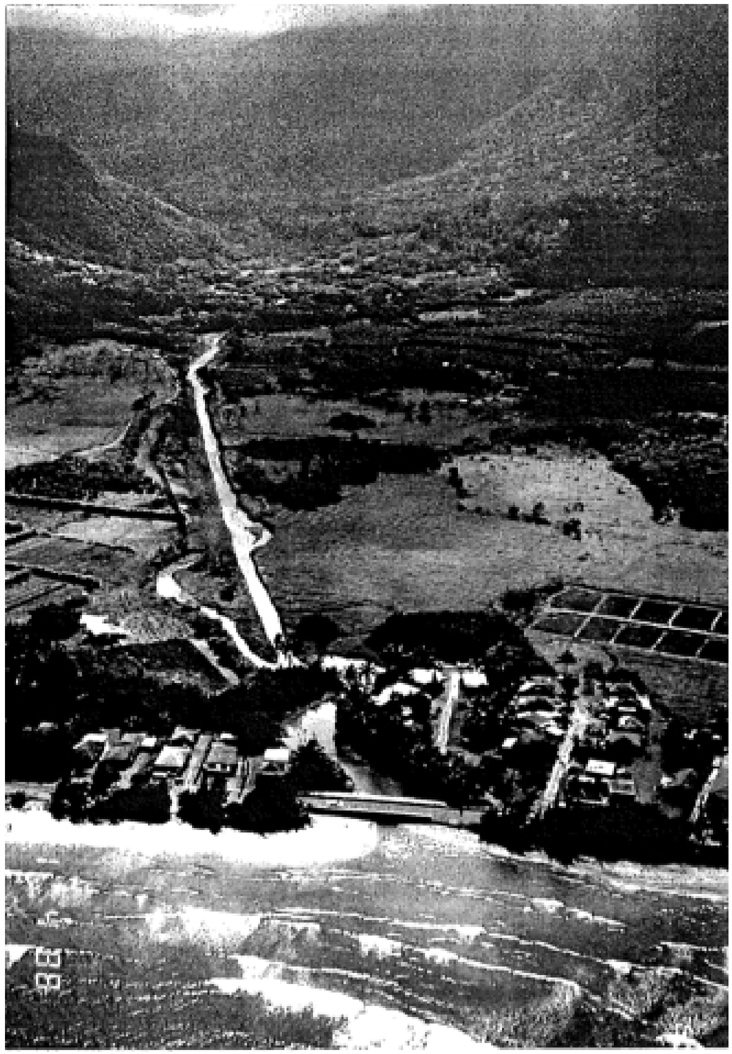


Figure 4. 1988 oblique aerial photo of the lower reach of Punaluʻu Stream, redirected to a straightened channel.

(Hw), and urban use/planted or disturbed forest (UFo). The majority of the Plan Area is in agricultural use: cropping and pasture lands. At the present time, much of the agriculture land is fallow, and grasslands are not in use as pastures, an exception being cattle pasture in the southeast corner of the Plan Area. These grasslands tend to be mosaics of monotypic stands of either Guinea grass (*Urochloa maxima*), California grass (*Urochloa mutica*), or especially abundant, elephant grass (*Cenchrus purpureus*). If not tilled and tended, fallow agriculture fields convert to grassland, so grasslands in our map may represent former crop lands and not necessarily abandoned or presently unused pastures.

Mixed forest is mostly found as a riparian zone along Punaluʻu Stream, and is nearly everywhere at this elevation dominated by gunpowder tree (*Trema orientalis*). Much of what appears to be forest in the southeastern part of the area has or is in the process of being cleared (in accordance with an approved conservation plan), and no longer resembles the dense tree cover seen in the satellite image. *Hau* (*Hibiscus tiliaceus*) forms monotypic forests, and some, but not all, are wetlands. The designation for urban use/planted or disturbed forest is used as a catchall for all developed house lots, landscaped areas, and highly disturbed forest lands. The latter are areas of abandoned development or agriculture that has come back into shrubland or forest, with some trees that were likely part of former landscaping.

Table 2. Vegetation code legend for maps in this report.

Ag	Agriculture, fallow or not, excluding pastureland.	Hw	*Hau* forest; wetland.
Fo	Forest; mixed naturalized trees, dominated here by gunpowder tree.	UFo	Urban and "landscape forest" mixed; includes abandoned developed lands.
Gl	Grassland; mostly pasture in use or not; in some cases, long fallow crop land. Three grass species dominate.		

Other than cultivated crops, the vegetation in Punaluʻu Valley consists largely of plants adapted to generally wet conditions. The National Wetland Plant List (NWPL) is a list administered by the USACE that assigns a wetland indicator status rating to each species of plant on a regional basis (USACE, 2012b, Lichvar, et al., 2014). Table 3 provides descriptions of each status indicator. Unfortunately, the status of introduced plant species found in wet windward valleys has somewhat limited utility in determining wetlands vs. uplands because most of the plants fall in the facultative (FAC) category, meaning they commonly occur both in wetlands and uplands.

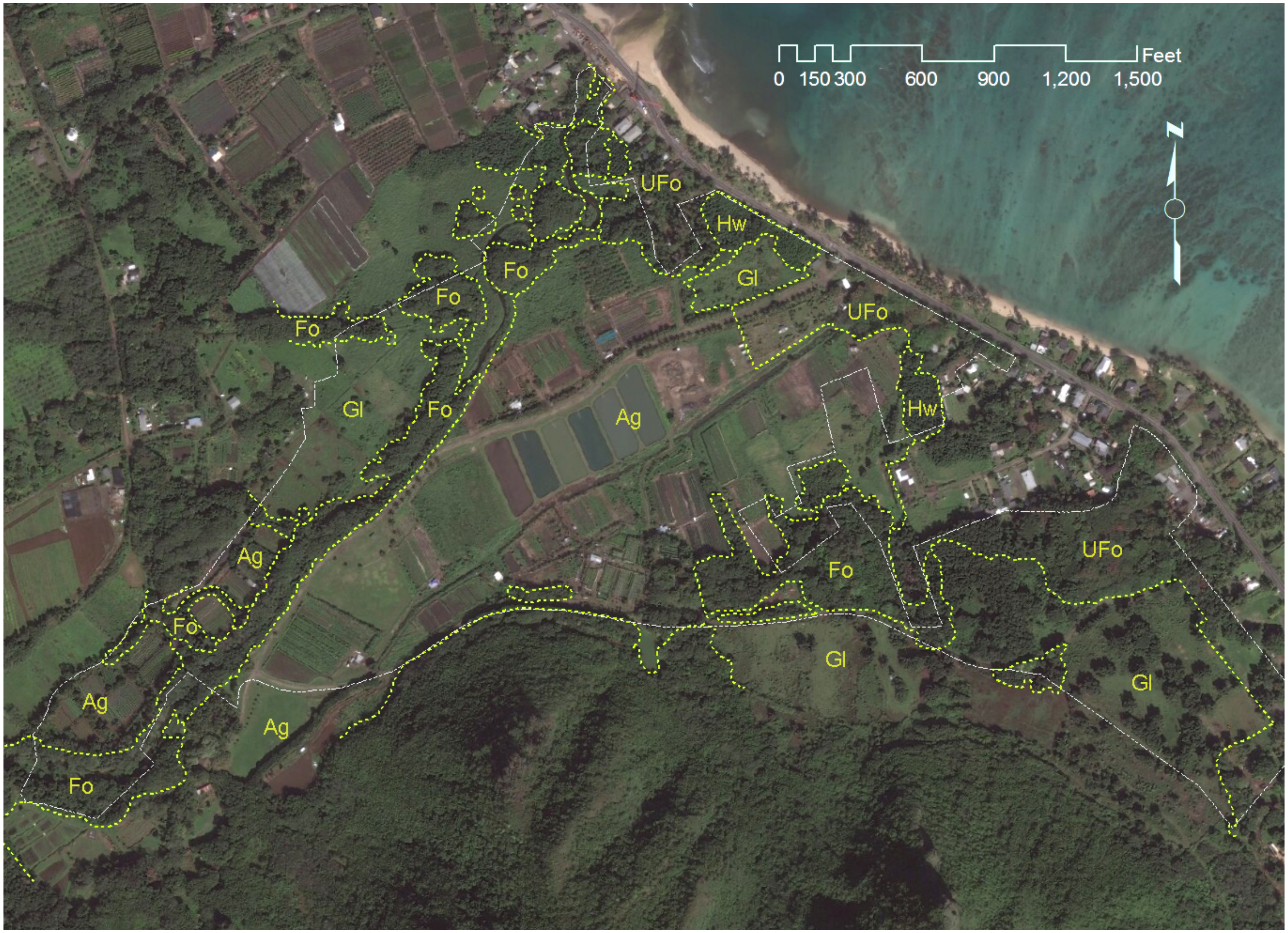


Figure 5. Vegetation map for Plan Area (see text Table 2 for definitions).

Table 3. Wetland status indicators and their definitions (from Lichvar and Gillrich, 2011).

Status indicator (abbreviation)	Description
Obligate (OBL)	Almost always is hydrophytic, rarely occurs in uplands.
Facultative wetland (FACW)	Usually is hydrophytic, but occasionally found in uplands.
Facultative (FAC)	Commonly occurs as either hydrophytic or nonhydrophytic.
Facultative upland (FACU)	Occasionally is hydrophytic, but usually occurs in wetlands.
Upland (UPL)	Rarely is hydrophytic, almost always found in uplands

Methods

Our field investigation consisted of 9 days of field work between September 2 and October 2, 2014. *AECOS* scientists followed the methods of wetland delineation described in *Corps of Engineers Wetland Delineation Manual* ("Manual"; USACE, 1987) and *Regional Supplement* (USACE, 2012a). The wetland status of plant species follows the 2012 National Wetland Plant List (USACE, 2012b) and the 2014 update (Lichvar, et al., 2014).

Under ordinary circumstances, establishment of a jurisdictional wetland requires three positive wetland indicators, one each for hydrology, soils, and vegetation. The boundary between wetland and upland is established as a line outside of which at least one of the three indicators is not present. In practical terms, this boundary is a judgment call, based on establishing clear differences for both sides (upland and wetland) and then selecting a boundary that represents the sharpest line that can be drawn through what is typically a gradient in nature. We established 47 wetland determination sampling points (SP) roughly along 5 transects to delineate wetland boundaries for each plant assemblage and/or landscape feature within the Plan Area (Figure 6). Each sampling point was assigned an identification number (e.g., "SP 1-1", "SP 2-1"), with the first digit corresponding to the transect and the second digit corresponding to the sampling point. Numbers are shown on detailed maps in the text. *AECOS* scientists marked locations of the sampling points and other landscape features in the field with a handheld global navigation satellite system (GNSS) instrument (a Trimble 6000 Series, GeoXT or GeoXH), which can

Figure 6. Distribution of the 47 sampling points (yellow circles) and recorded tracks of biologists (white dots) in the Plan Area.

provide submeter accuracy of a recorded location (position). The GNSS units also recorded the biologists' movements around the survey area (also shown in Fig. 6).

Attachment 1 provides the wetland data sheet for each sampling point. Subsequent to each field visit, *AECOS* scientists analyzed data sheets and drew wetland boundaries onto project maps between stations determined to be in wetlands and stations determined to be out of wetlands, building up the final maps provided by subarea in this report.

Results

We found three types of open water features and 6 "types" of wetlands in the Plan area. Open water features include: estuary, stream, and agriculture ditch. Wetlands are all palustrine wetlands (inland marshes and swamps) and include: temporarily flooded with broad-leaved evergreen trees (PFO3A), semi permanently flooded with broad-leaved evergreen scrub-shrub vegetation (PSSF), temporarily flooded with persistent, emergent vegetation (PEM1A), seasonally flooded with persistent, emergent vegetation (PEM1C), actively artificially flooded, diked and/or impounded with persistent, emergent vegetation (active PEM1Kh), and formerly artificially flooded, diked and/or impounded with persistent, emergent vegetation (relict PEM1Kh).

Open Water—Estuary

Tidal waters are jurisdictional at least up to the "High Tide Line or HTL" or "Mean High Water or MHW" depending upon the permitting authority: Clean Water Act Section 404 or Rivers and Harbors Act Section 10, respectively (USACE, 1986). In Hawaiʻi, HTL is approximated by the elevation of mean higher-high water (MHHW; J. Anamizu, USACE, pers. comm.), an elevation provided for all NOAA tide stations (NOAA, 2014b). If wetlands are present adjacent to the MHHW or MHW, jurisdiction extends to the wetland boundary. Jurisdictional estuarine waters are present in Punaluʻu Stream, Punaluʻu Ditch, and Maipuna Stream (see Figures 7 and 12).

Open Water—Stream

For streams determined to be "waters of the U.S." under the CWA, federal jurisdiction extends up to the ordinary high water mark (OHWM). Because it is a perennial stream (HCPSU, 1990), Punaluʻu Stream is clearly jurisdictional. In a segment of the channel proposed for restoration work (upstream of the Plan

Area, we marked the OWHM with pairs of flags and recorded the locations with the Trimble 6000 Series, GeoXT (Figure 8). Within this survey segment, the following physical characteristics—as provided in a regulatory guidance letter (USACE, 2005)—were considered when establishing the OHWM:

- Natural line impressed on the bank
- Shelving
- Changes in the character of the soil
- Destruction of terrestrial vegetation
- Presence of litter and debris
- Wracking
- Vegetation matted down, bent, or absent
- Sediment sorting
- Leaf litter disturbed or washed away
- Scour
- Deposition
- Multiple observed flow events
- Bed and banks
- Water staining
- Change in the plant community

Figure 7. Jurisdictional estuarine waters are present at the mouth of Punaluʻu Stream and in low areas *mauka* of the highway. Map shows both vegetation zones (yellow, with symbols) and wetland boundaries (light blue). Sampling points (yellow dots) are labeled.

Figure 8. OHWM at stream segment proposed for restoration of eroding right bank.

A levee lines both banks along most of Punaluʻu Stream through the middle of the Plan Area. The side of the bank facing the stream provides a good estimate of where the OHWM would be located. We were provided with 1- and 2-ft contours of the Plan Area based on LIDAR (Light Detection and Ranging) data, and these areas of steep contours were used to draw the rough jurisdictional boundary bordering lower Punaluʻu Stream. Although LIDAR data can see through vegetation to a certain extent, presumably providing a contour map of the ground surface, this ability to penetrate dense vegetation varies from place to place. We found the LIDAR contours to be of limited use in defining low areas or basins for wetland boundaries, but the levees showed up clearly in the LIDAR image. Determination by this method is a planning level designation of the jurisdictional boundary, and not an OHWM determination.

A small, intermittent stream tributary to Punaluʻu Stream (mapped as "Waiono Stream" by ICIF) confluences with Punaluʻu Stream on the left bank in the vicinity of SP 3-10 (Figure 9). Because it likely has a significant nexus to Punaluʻu Stream, this tributary is probably jurisdictional. Where this "stream" crosses through the Plan Area, the stream bed, banks, and OHWM are certainly discontinuous (Figure 10) and cannot be traced. However, when flow is present it discharges into a grassland wetland located on the north side of the levee.

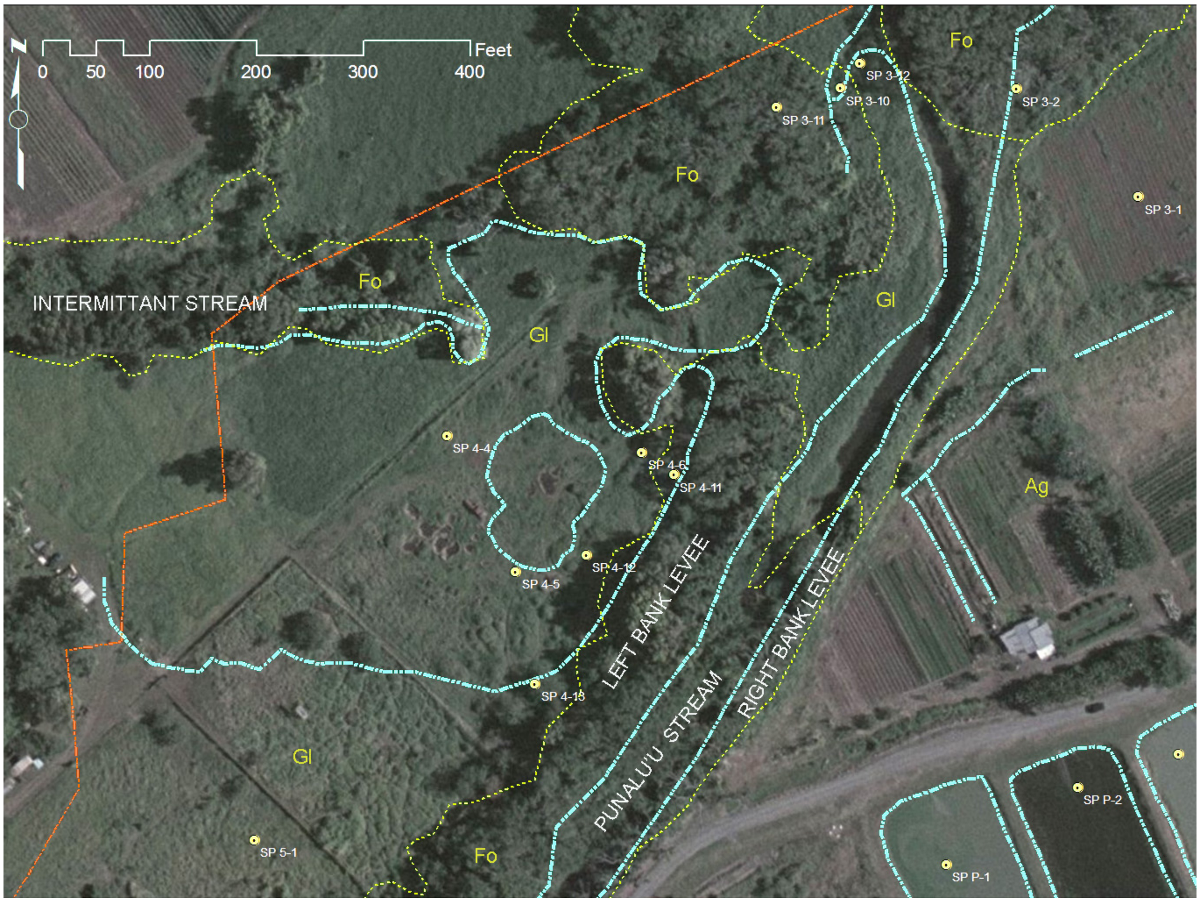


Figure 9. Middle part of Plan Area showing an intermittent stream (where course visible) and associated wetland located outside the left bank levee of Punaluʻu Stream. A small pond is present just north of SP 4-11.

Open Water—Agricultural Ditch

Punaluʻu Ditch appears to be jurisdictional because it certainly has a significant nexus to the Pacific Ocean (Figure 11); however, the flowing water in the ditch is an artifact of how much water is diverted from Punaluʻu Stream and how much water is dispersed to agricultural fields within the watershed prior to discharge into the ocean. Thus, federal jurisdiction of waters in the ditch is uncertain. The OHWM within the ditch (limits of federal jurisdiction) is dependent upon how much water is let into the ditch and where it is distributed. Conservatively, the surveyors' top-of-bank of the nearly vertical banks of this ditch can be used as a jurisdictional boundary.

Figure 10. This unnamed intermittent tributary to Punaluʻu Stream does not have obvious and continuous bed, banks, or OHWM but is associated with a grass-covered wetland.

Wetland—Broad-Leaved Evergreen

PFO3A - Three *hau* (*Hibiscus tiliaceus* or *Talipariti tiliaceum*) forest areas (Hw) are present within the Plan Area. These thickets are difficult to penetrate, but our investigation found hydrophytic vegetation, hydric soils, and wetland hydrology at sampling points near the margins, confirming the entire plant assemblage is wetland (see Figs. 7 and 11). The largest *hau* wetland occurs along Punaluʻu Stream and estuary (SP 2-11, SP 2-8) and extends behind houses on Kamehameha Highway east of the Punaluʻu Stream bridge (outline here based on LIDAR). Another, more extensive *hau* wetland, borders the *mauka* side of Kamehameha Highway west of the main entrance to the Plan Area (SP 2-2, SP 2-3). This wetland is connected to the ocean shore through a culvert under the highway as indicated in Fig. 7. These areas would be classified as temporarily flooded, palustrine wetlands with broad-leaved evergreen trees (PFO3A). Adjacency to Punaluʻu Stream established that the largest *hau* wetland is jurisdictional and the connection via an outflow culvert establishes jurisdiction for the other *hau* forest. A small area of American mangrove (*Rhizophora mangle*), an obligate wetland species, is present just upstream of the culvert, demonstrating tidal (and marine) influence.

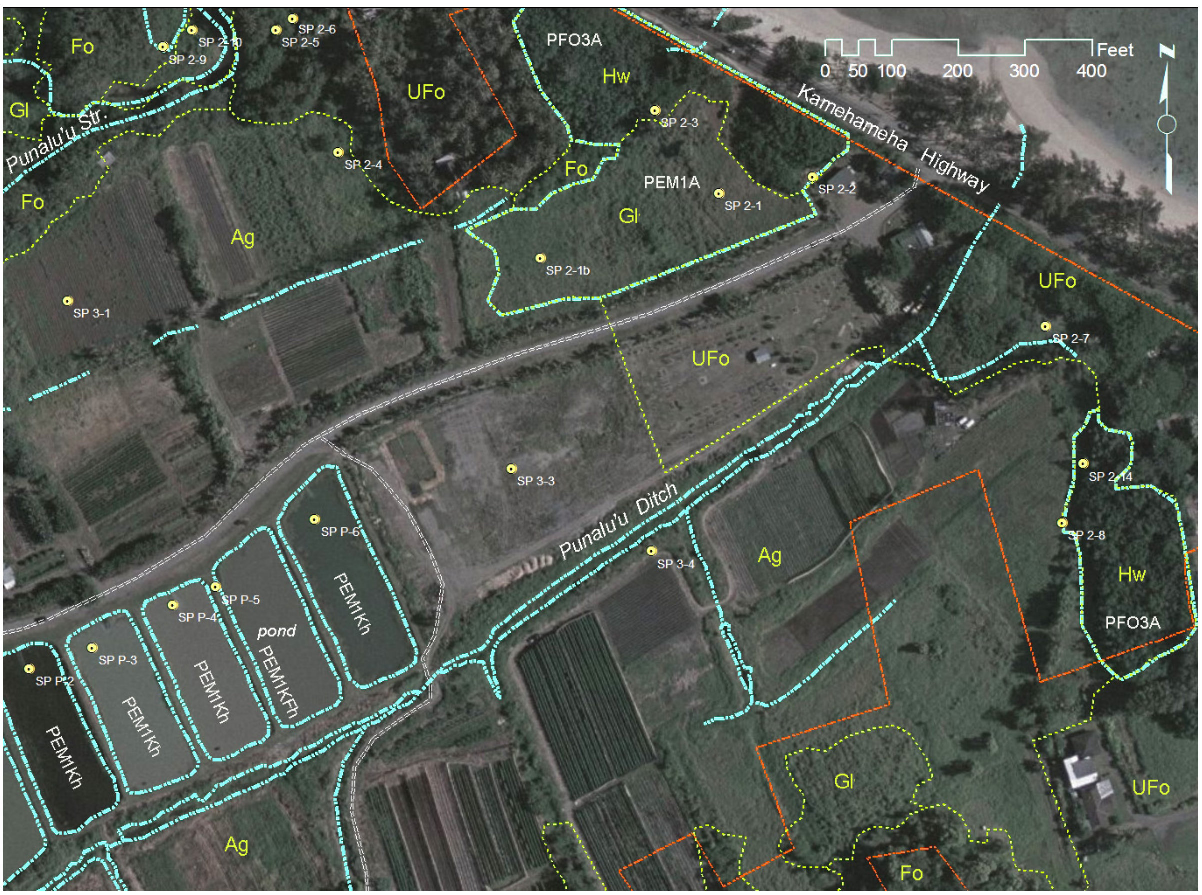


Figure 11. Middle *makai* part of Plan Area around entrance road and Punaluʻu Ditch showing vegetation and wetland boundaries.

The smaller *hau* wetland appears to be isolated, though the closest point of approach is only 90 ft (30 m) from a branch ditch of Punaluʻu Ditch (Fig. 11). Overflow during times of heavy runoff would follow an area of low ground to the branch ditch. Jurisdiction of this wetland should be confirmed by USACE.

PSS3F and PEM1C – A variety of aquatic features occur in the southeast part of the Plan Area (see Figure 12). Two are marshlands dominated by herbs or small shrubs. We attempted to establish a connection between them, but could not find any, although the more northern wetland basin would, at times of high runoff from rainfall, overflow into the southern wetland via a culvert under the farm road.

Figure 12. Southeast Plan Area showing the several aquatic features.

The more northerly wetland is mostly semi-permanently flooded with scrub-shrub vegetation (PSS3F), but includes a circular patch of grass (PEM1C). The scrub-shrub part is a nearly monotypic stand of primrose willow (*Ludwigia* *octovalvis*), an obligate (OBL) wetland species. The PEM1C portion is a monotypic growth of para grass (*Urochloa mutica*). SP 4-10 is located in the primrose willow stand and SP 4-14 is located in the para grass wetland. This wetland appears to be spring-fed and the *mauka* boundary was walked in the field and further defined with the LIDAR map as the base of a slope populated with *hau* trees. The *makai* boundary of the wetland is somewhat defined by a berm. This wetland appears to be in the probable location of an ancient fishpond known as Kaluaʻōlohe (Sterling and Summers, 1978, from McAllister, site 294). The grassy marsh is seen in satellite images from 2000 through 2013 as surrounded by forest, but the forest is gone (and replaced in part by the primrose willow wetland) in a 2014 image. Indeed, most of the trees north and east of the wetland have been removed recently. The wetland grass appears dry in a July 2004 image, suggesting the ground may be intermittently saturated.

Figure 13. The estuarine "ditch" thought to be Maipuna Stream.

There is no apparent direct surface connection between the above described wetland and waters of the U.S. The closest point of the wetland is at least 3000 ft (910 m) from the Pacific Ocean shore and 610 ft (190 m) from a ditch located to the northeast along the Plan Area boundary. This ditch is probably Maipuna Stream (Figs. 12 and 13) and extends some 650 ft (200 m) inland from the ocean shore, but ends abruptly. There is a culvert under Kamehameha Highway. This feature is possibly tidal up to the end: waves were observed translated this far inland. While this stream or ditch may drain the developed lands on the north side, a low berm separates the ditch from Plan Area wetlands in the interior.

A second L-shaped wetland occupies the southwest corner where two farm roads intersect (Fig. 12; SP 3-6). This feature is a seasonally-flooded palustrine wetland with persistent, emergent vegetation (PEM1C). A ditch with water extends to the feature from the culvert under the east-west farm road. Most of the wetland lies along the *mauka* side of the north-south farm road. A depression extends another 400 ft (120 m) southeast beside the road, but ends in a rise that would prevent outflow in this direction. A small culvert passes under the north-south road near the farm road intersection, but wetlands could not be found (SP 3-7, SP 3-8) on the *makai* side of the north-south road (although some standing water was present in this area from recent rains).

All of this area (on both sides of the north-south road) is presently in use as pasture for a herd of cattle. There is no evident surface connection between this wetland and waters of the U.S. The land rises gently but steadily towards Kamehameha Highway and no obvious connection to Maipuna Stream some 440 ft (135 m) away seems to exist. Thus, all of the wetland features in this southeast part of the Plan Area (Fig. 12) appear to be in an isolated basin (except Maipuna Stream and a circular pond next to the stream and Kamehameha Highway) and, therefore, not jurisdictional.

Wetland—Persistent Emergent Marsh

PEM1C and PEM1A - The NWI map does not show any temporarily-flooded persistent emergent palustrine (PEM1A) wetlands present in the Plan Area. Our investigation found the pastureland on the left side of Punaluʻu Stream, *mauka* of the unnamed tributary, is marginally a PEM1A wetland (Fig. 14). A small part of this larger, marginal wetland is a seasonally-flooded persistent emergent palustrine (PEM1C), located just north of SP 4-11. The presence of ditches and *kalo* indicates some part had been managed as a pond field or *loʻi* (Figure 15). The hydrology throughout the larger wetland is not clearly wetland and, may, in fact, be relict wetland hydrology from prior to construction of the levee. The high amount of rainfall and relatively frequent flood events may be just enough to allow this area enough wetland hydrology to just pass this criterion.

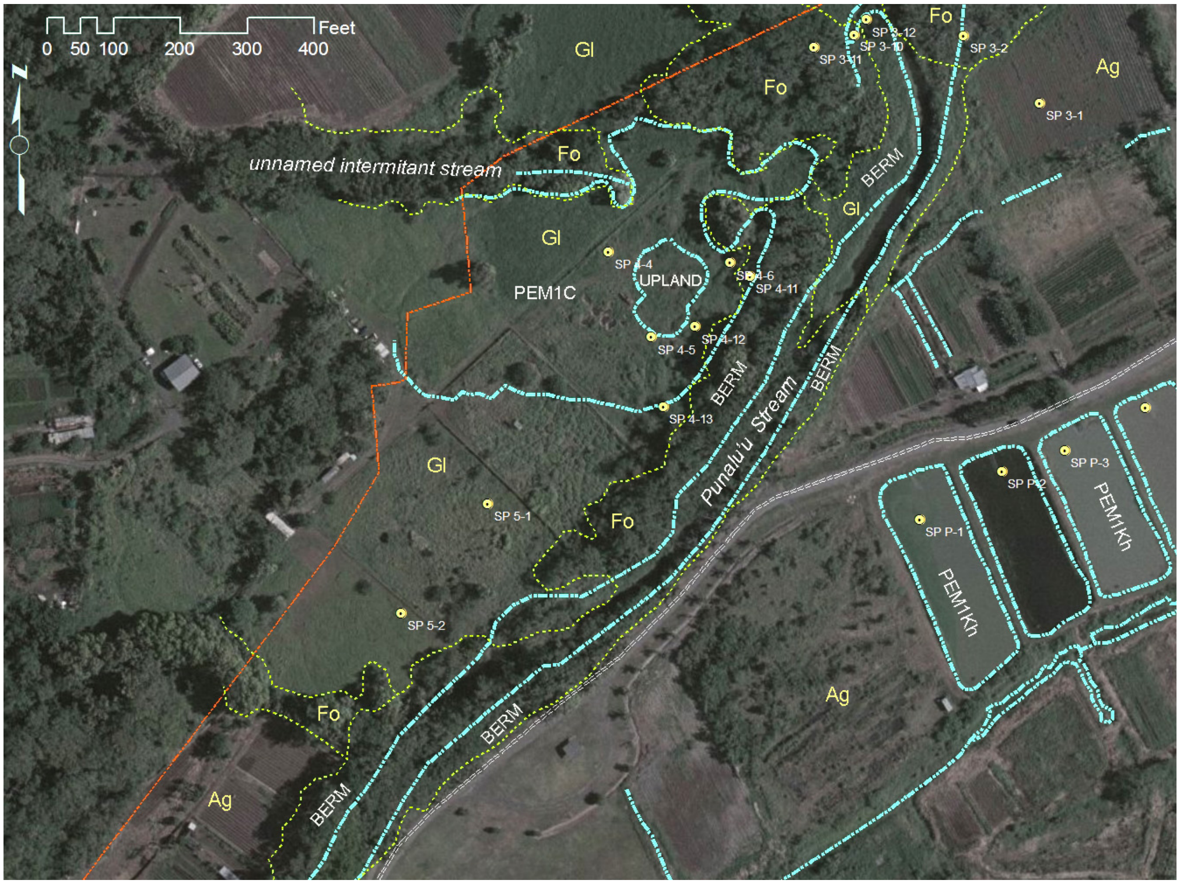


Figure 14. Middle part of Plan Area along Punalu'u Stream.

Part of this seasonally-flooded wetland (e.g., SP 4-6, SP 4-11, SP 4-12, SP 4-13) is in the floodway of Punaluʻu Stream and is in part a former stream course (either prior to construction of the levee or the course of the stream realigned in 1988). This wetland marsh is fed by runoff from the unnamed tributary to Punaluʻu Stream. It is adjacent to Punaluʻu Stream and discharges into the stream at SP 3-10; it is, therefore, clearly jurisdictional.

A para grass field located *mauka* of the *hau* wetland north of the entrance road is also wetland (SP 2-1 , SP 2-1b). This area is a temporarily-flooded persistent emergent palustrine wetland (Fig. 11). The *mauka* boundary is defined by a gradual rise in elevation and the northwestern boundary is defined partly by the ditch that reaches the Pacific Ocean through a culvert under Kamehameha Highway. The southwestern boundary is defined by fill used for the entrance road into the Plan Area. This wetland abuts the *hau* wetland and is, therefore, jurisdictional.

Figure 15. Punaluʻu Stream floodplain PEMI1C wetland appears to have been managed in the past as a *loʻi kalo.*

A para grass field located *mauka* of the *hau* wetland north of the entrance road is also wetland (SP 2-1 , SP 2-1b). This area is a temporarily-flooded persistent emergent palustrine wetland (Fig. 11). The *mauka* boundary is defined by a gradual rise in elevation and the northwestern boundary is defined partly by the ditch that reaches the Pacific Ocean through a culvert under Kamehameha Highway. The southwestern boundary is defined by fill used for the entrance road into the Plan Area. This wetland abuts the *hau* wetland and is, therefore, jurisdictional.

Wetland—Artificially Flooded

Active PEM1KFh - At the time of our sampling, only Pond at P-5 was in active aquaculture (Figs. 11 and 14). This pond is a diked and/or impounded wetland that is semi permanently artificially flooded with persistent, emergent vegetation (PEM1KFh). An edible aquatic plant, water mimosa (*Neptunia oleracea*; Fig. 16), is growing in the pond. This cultivar is not in the 2012 National Wetland Plant List (USACE, 2012b) or the 2014 update (Lichvar, et al., 2014), it is a obligate hydrophyte. At the time of our survey, water was flowing via a pipe into the pond. This pond is isolated and not jurisdictional, but the open water is visited by the endangered Hawaiian stilt (*Himantopus mexicanus knudseni*; see Fig. 16).

Figure 16. Only Pond "P-5" is presently utilized as an aquaculture pond field.

Relict PEM1Kh – Ponds P-1, P-2, P-3, P-4, and P-6 (Fig. 11) each exhibit faint signs of wetland hydrology—possibly relict. Because hydrophytic vegetation and hydric soils are also present in the ponds, they can all be considered wetlands. All of these ponds are isolated, man-made impoundments and not-jurisdictional.

Conclusions

The 200-ac Plan Area has obviously been manipulated for centuries for human use, mostly agriculture. The stream has been diverted, channelized, and diked. The valley floor has been leveled and ditched. Much of the valley floor may have once been wetland and, as the hydrology is altered, areas may revert back to wetland.

Table 4 summarizes the results of our investigation. Area measurements are approximations taken measured on the maps produced by *AECOS*. Acreages are only that portion of wetlands that are within the Plan Area. It is not reasonable to come up with a meaningful value for the stream and open water areas (e.g., agricultural ditch, estuary, and, artificially flooded wetlands), especially where based on an approximation of the OHWM. We determined that roughly 11 ac of the Plan Area is wetland. Of that 11 ac, we would conclude that 8 ac or 73% is jurisdictional.

Table 4. Summary of wetland findings (does not include open water).

Wetland	Wetland type	Area (ac)	Soil pit(s)	Jurisdictional?
Hau at Punalu'u Strm mouth	PFO3A	1.0	2-11, 2-9, 2-12	Yes
Hau by Kam. Hwy.	PFO3A	1.5	2-2, 2-3	Yes
Hau wetland	PFO3A	1.0	2-8, 2-14	No
Primrose willow & para grass wetland (SE)	PSS34/PEM1C	1.3	4-10, 4-14	No
SE cattle pasture	PEM1C	0.5	3-6	No
Grassland NW of Punalu'u Stream	PEM1A/ PEM1C	3.5	4-4, 4-6, 4-11, 4-12	Yes
Entrance road grassland	PEM1C	1.8	2-1, 2-1b	Yes

References

AECOS, Inc. 2002.Reconnaissance survey of aquatic biota and riparian vegetation for Kamehameha Highway Bridge replacement at Punaluʻu, windward Oʻahu. Prep. for: SEI. *AECOS* No. 1011A. 11 pp.

Cowardin, L. M., V. Carter, F. C. Golet, and E. T. LaRoe. 1974. Classification of wetlands and deepwater habitats of the United States. FWS/OBS-79/31. 131 pp.

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. *Bull. Amer. Meteor. Soc.* 94: 313-316. doi. 10.1175/BAMS-D-11-00228.1. Available online at URL: http://rainfall.geography.hawaii.edu/interactivemap.html; last accessed October 17, 2014.

Hawaii Cooperative Park Service Unit. 1990. Hawaii stream assessment. A preliminary appraisal of Hawaii's stream resources. Prep. for State of Hawaii, Commission on Water Resource Management. National Park Service, Hawaii Cooperative Park Service Unit, Rept. No. R84: 294 pp.

Hawaiʻi Department of Land and Natural Resources. 2014. Hawaiʻi – National Flood Insurance Program, flood hazard assessment tool. Available online at: http://gis.hawaiinfip.org/FHAT/#; last accessed on October 21, 2014.

Hawaiʻi Department of Land and Natural Resources, Commission on Water Resource Management (HDLNR – COWRM). 2008. Application for a Stream Diversion Works Permit (SDWP.2008.3), Reconstruction of stream diversion and intake, Punaluʻu Stream, Punaluʻu, Oʻahu, TMK: (1) 5-3-011:001. 13 pp.

Hawaiʻi Department of Land and Natural Resources, Division of Water and Land Development (HDLNR – DWLD). 1988. Punaluʻu Stream channel clearing project, investigation of complaint, Punaluʻu, Koʻolauloa, Oʻahu. 27 pp, incl. attachment.

Lichvar, R. W. and J. J. Gillrich. 2011. Final protocol for assigning wetland indicator status ratings during National Wetland Plant List Update. Prep. for: US Army Corps of Engineers. ERDC/CRREL TN-11-1. 19 pp.

Lichvar, R. W., M. Butterwick, N. C. Melivin, and W. N. Kirchner. 2014. The National Wetland Plant List: 2014 Update of Wetland Ratings. *Phytoneuron* 2014-41: 1-42.

McElroy, W. K. and S. Eminger. Draft—Archaeological inventory survey of Punaluʻu, Koʻolauloa District, Island of Oʻahu, TMKs: (1)5-3-001:041, -003:001 (por.), -004:007, -004:013, -004:018, -004:019, -007:023 (por.), and -011:001 (por.). Prep. for Kamehameha Schools by Keala Pono Archaeological Consulting. 270 pp., incl. appendices.

Natural Resource Conservation Service US Department of Agriculture (NRCS). 2006. *Land Resource Regions and Major Land Resource Areas of the United States, the Caribbean, and the Pacific Basin*. U.S. Department of Agriculture Handbook No. 296. 682 pp. Available online at URL: http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_050898.pdf; last accessed on November 7, 2014.

_______. 2014a. Web Soil Survey 3.1. Available online at URL: http://websoilsurvey.nrcs.usda.gov/; last accessed on October 20, 2014.

_______. 2014b. National Hydric Soils List by State. Available online at URL: http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/use/?cid=nrcs142p2_053957; last accessed on June 20, 2014.

National Oceanic and Atmospheric Administration – National Weather Service Forecast Office, Honolulu, HI (NOAA-NWS). 2014. Hydrology in Hawaii. Available online at URL: http://www.prh.noaa.gov/hnl/hydro/pages/oahu_ytd_08.gif; last accessed on October 21, 2014.

Nichols, W. D., P. J. Shade, and C. D. Hunt. 1996. Summary of the Oʻahu, Hawaiʻi, regional aquifer-system analysis. USGS prof. paper no. 1412-A. 57 pp. Available online at URL: http://pubs.usgs.gov/pp/1412a/report.pdf; last accessed on October 20, 2014.

Sterling, E. P. and C. C. Summers. 1978. *Sites of Oahu*. Bishop Museum Press. 352 pp.

Townscape, Inc. 2010. Punaluʻu Ahupuaʻa Plan (Review Version). Prep. for: Kamehameha Schools Land Assets Division. 124 pp.

U.S. Army Corps of Engineers (USACE). 1986. Corps of Engineers, Department of the Army, Department of Defense, 33 CFR II, Parts 328 and 329.

Navigation and Navigable Waters. *Federal Register*, 51 (41250 and 41251, November 13, 1986).

U.S. Army Corps of Engineers (USACE). 1987. *Corps of Engineers Wetlands Delineation Manual*. Tech. Rept. Y-87-1. Environmental Laboratory, Dept. of the Army, Waterways Experiment Station, Vicksberg.

_______. 1988. Investigative report of Punaluʻu Stream. 4/18/88. 51 pp.

_______. 1991. July 1, 1991 letter from Stanley T. Arakaki, Chief, Operations Division to Creighton U. Mattoon, Chair Koʻolauloa Neighborhood Board. 2 pp.

_______. 2005. Regulatory Guidance Letter 05-05 Ordinary High Water Mark (OHWM) Identification. 4 pp.

_______. 2012a. *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Hawaiʻi and Pacific Islands Region Version 2.0,* ed. J. F. Berkowitz, J. S. Wakeley, R. W. Lichvar, and C. V. Noble. ERDC/EL TR-12-5. U.S. Army Engineer Research and Development Center. Vicksberg, MS. 130 pp incl. appendices.

_______. 2012b. Part II. Department of Defense. Department of the Army, Corps of Engineers. 77 CFR 90. Publication of the Final National Wetland Plant List. *Federal Register*, 77 (90; May 9, 2012): 27210-27214.

U.S. Army Corps of Engineers (USACE) and U.S. Environmental Protection Agency (USACE and USEPA). 2014. Part II. 33 CFR Part 328 and 40 CFR Parts 110, 112, 116, 117, 122, 230, 232, 300, 302, and 401. Definition of "Waters of the United States" Under the Clean Water Act. *Federal Register*, 79 (76; April 21, 2014): 22118-22274.

U.S. Environmental Protection Agency (USEPA). 2004. Part II. 40 CFR §230.3. Definitions. *Federal Register*, 23 (xx; April 21, 2004): 250-251.

_______. 2010. Part II. 40 CFR §230.3. Definitions. *Federal Register*, 79 (76; April 21, 2014): 22118-22274.

_______. 2004. Part II. 40 CFR §230.3. Definitions. *Federal Register*, 23 (xx; April 21, 2004): 250-251.

U.S. Fish and Wildlife Service (USFWS). 2006. National Wetlands Inventory maps, Hawaii: U.S. Fish and Wildlife Service. Available online at URL:

http://www.fws.gov/wetlands/Data/ Mapper.html; last accessed on October 17, 2014.

U.S. Geological Survey (USGS). 2014a. USGS Surface-water annual statistics for Hawai'i.; USGS 16301050 Punaluu Str abv Punaluu Ditch Intake, Oahu, HI. Available online at URL: http://waterdata.usgs.gov/hi/nwis/annual/?referred_module=sw&site_no=16301050&por_16301050_1=2643628,00060,1,1954,2014&year_type=W&format=html_table&date_format=YYYY-MM-DD&rdb_compression=file&submitted_form=parameter_selection_list; last accessed on October 20, 2014.

_______. 2014b. National gap analysis program (GAP), land cover data viewer. Available online at: http://gis1.usgs.gov/csas/gap/ viewer/land_cover/Map.aspx; last accessed on October 21, 2014

Wagner, W. L., D. R Herbst, and S. H. Sohmer. 1990. *Manual of the Flowering Plants of Hawai'i*. University of Hawaii Press, Honolulu, Hawaii. 2 vols. 1854 pp.

_______ and _______. 1999. *Supplement to the Manual of the flowering plants of Hawai'i*, pp. 1855-1918. *In:* Wagner, W. L., D.R. Herbst, and S.H. Sohmer, *Manual of the flowering plants of Hawai'i. Revised edition*. 2 vols. University of Hawaii Press and Bishop Museum Press, Honolulu.

Attachment 1

Wetland determination data forms

WETLAND DETERMINATION DATA FORM—Hawai'i and Pacific Islands

Project/Site: Punalu'u City: Punalu'u Sampling Date: Sep 19, 2014 Time: 1000

Applicant/Owner: Kamehameha Schools State/Terr./Comm.: Hawai'i Island: O'ahu Sampling Point: **SP 1-1**

Investigator(s): Susan Burr and Chad Linebaugh TMK/Parcel: 5-3-003:001

Landform (hillslope, coastal plain, etc.): coastal plain Local relief (concave, convex, none): none

Lat: 21° 34'38.57402"N Long: 157° 53'05.23858"W Datum: WGS 84 Slope (%): none

Soil Map Unit Name: Pearl Harbor clay (PH) NWI classification: non-wetland (PEM1C† on NWI map)

Are climactic/hydrologic conditions on the site typical for this time of year: Yes___ No X‡ (If no, explain in Remarks)

Are Vegetation No , Soil No , or Hydrology No significantly disturbed? Are "Normal Circumstances" present? Yes X No___

Are Vegetation No , Soil No , or Hydrology No naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS—Attach a site map showing sampling point locations transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No ___	
Hydric Soil Present?	Yes ___	No X	**Is the Sampled Area**
Wetland Hydrology Present?	Yes ___	No X	**within a Wetland? Yes___ No X**

Remarks: † PEM1C = persistent, emergent, seasonally flooded palustrine wetland

‡ See Hydrology Remarks

VEGETATION—Use scientific names of plants.

Tree Stratum (Plot size: 30-ft radius)	Absolute % Cover	Dominant Species?	Indicator Status
1. None			
2.			
3.			
4.			
5.			
	0 =Total Cover		
Sapling/Shrub Stratum (Plot size: 20-ft radius)			
1. None			
2.			
3.			
4.			
5.			
	0 =Total Cover		
Herb Stratum (Plot size: 5-ft radius)			
1. *Megathyrsus maximus*	98	Yes	FAC
2. *Macroptilium atropurpureum*	1	No	FAC
3. *Paederia foetida*	1	No	UPL
4.			
5.			
6.			
7.			
8.			
	100 =Total Cover		
Woody Vine Stratum (Plot size: 5-ft radius)			
1. None			
2.			
	0 =Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 1 (A)

Total Number of Dominant Species Across All Strata: 1 **(B)**

Percent of Dominant Species That Are OBL, FACW, or FAC: 100 (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species ___	x1= ___
FACW species ___	x2= ___
FAC species ___	x3= ___
FACU species ___	x4= ___
UPL species ___	x5= ___
Column Totals: ___ (A)	___ (B)

Prevalence Index = B/A= ___

Hydrophytic Vegetation Indicators:

___ 1 - Rapid Test for Hydrophytic Vegetation

X 2 - Dominance Test is >50%

___ 3 - Prevalence Index is ≤3.0[1]

___ Problematic Hydrophytic Vegetation [1] (Explain in Remarks or in the delineation report)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes X No___

Remarks

SOIL

Sampling Point: 1-1

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0 – 15	7.5YR 3/1	100	none				loam	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains

[2]Location: PL=Pore Lining, M=Matrix

Hydric Soil Indicators:

___ Histisols (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Muck Presence (A8)
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Dark-Surface (S7)
___ Loamy Gleyed Matrix (F2)
___ Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

___ Stratified Layers (A5)
___ Sandy Mucky Mineral (S1)
___ Red Parent Material (TF2)
___ Very Shallow Dark Surface (TF12)
___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type:

Depth (inches):

Hydric Soil Present: Yes___ No X

Remarks:

Pearl Harbor clay is on the 2012 list of hydric soils. Soil profile does not confirm mapped soil type.

HYDROLOGY

Wetland Hydrology Indicators: (Explain observations in Remarks, if needed.)

Primary Indicators (minimum of one required: check all that apply)

___ Surface Water (A1)
___ High Water Table (A2)
___ Saturation (A3)
___ Water Marks (B1)
___ Sediment Deposits (B2)
___ Drift Deposits (B3)
___ Algal Mat or Crust (B4)
___ Iron Deposits (B5)
___ Inundation Visible on Aerial Imagery (B7)
___ Water Stained Leaves (B9)
___ Aquatic Fauna (B13)
___ Tilapia Nests (B17)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres on Living Roots (C3)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Tiled Soils (C6)
___ Thin Muck Surface (C7)
___ Fiddler Crab Burrows (C10) (Guam, CNMI, and American Samoa)
___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

___ Surface Soil Cracks (B6)
___ Sparsely Vegetated Concave Surface (B8)
___ Drainage Patterns (B10)
___ Dry-Season Water Table (C2)
___ Salt Deposits (C5)
___ Stunted or Stressed Plants (D1)
___ Geomorphic Position (D2)
___ Shallow Aquitard (D3)
___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes___ No X Depth (inches): none

Water Table Present? Yes___ No X Depth (inches): >15

Saturation Present? (includes capillary fringe) Yes___ No X Depth (inches): >15

Wetland Hydrology Present? Yes___ No X

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

As of Aug 2014, Punaluu Pump and Punaluu Stream rain gages were at 141% and 114% of year to date average (http://www.prh.noaa.gov/hnl/hydro/pages/oahu_ytd_08.gif)

WETLAND DETERMINATION DATA FORM—Hawai‘i and Pacific Islands

Project/Site: Punalu‘u City: Punalu‘u Sampling Date: Sep 19, 2014 Time: 1030

Applicant/Owner: Kamehameha Schools State/Terr./Comm.: Hawai‘i Island: O‘ahu Sampling Point: **SP 1-2**

Investigator(s): Susan Burr and Chad Linebaugh TMK/Parcel: 5-3-003:001

Landform (hillslope, coastal plain, etc.): coastal plain Local relief (concave, convex, none): concave

Lat: 21° 34’40.82708”N Long: 157° 53’06.25859 ”W Datum: WGS 84 Slope (%): <1

Soil Map Unit Name: Pearl Harbor clay (PH) NWI classification: non-wetland (E2FO3N† on NWI map)

Are climactic/hydrologic conditions on the site typical for this time of year: Yes ____ No X‡ (If no, explain in Remarks)

Are Vegetation No , Soil No , or Hydrology No significantly disturbed? Are “Normal Circumstances” present? Yes X No ____

Are Vegetation No , Soil No , or Hydrology No naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS—Attach a site map showing sampling point locations transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X No ____	
Hydric Soil Present?	Yes ____ No X	**Is the Sampled Area**
Wetland Hydrology Present?	Yes ____ No X	**within a Wetland? Yes ____ No X**

Remarks: † E2FO3N regularly flooded, broad-leaved evergreen forested, intertidal estuarine wetland

‡ See Hydrology Remarks.SP 1-2 is located *makai* of a berm along the right bank of Punalu‘u Stream.

VEGETATION—Use scientific names of plants.

Tree Stratum (Plot size: 30-ft radius)	Absolute % Cover	Dominant Species?	Indicator Status
1. *Talipariti tiliaceum*	98	Yes	FAC
2.			
3.			
4.			
5.			
	98 =Total Cover		
Sapling/Shrub Stratum (Plot size: 20-ft radius)			
1. None			
2.			
3.			
4.			
5.			
	0 =Total Cover		
Herb Stratum (Plot size: 5-ft radius)			
1. None			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
	0 =Total Cover		
Woody Vine Stratum (Plot size: 5-ft radius)			
1. None			
2.			
	0 =Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 1 (A)

Total Number of Dominant Species Across All Strata: 1 **(B)**

Percent of Dominant Species That Are OBL, FACW, or FAC: 100 (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species ____	x1= ____
FACW species ____	x2= ____
FAC species ____	x3= ____
FACU species ____	x4= ____
UPL species ____	x5= ____
Column Totals: ____ (A)	____ (B)

Prevalence Index = B/A= ____

Hydrophytic Vegetation Indicators:

___ 1 - Rapid Test for Hydrophytic Vegetation

X 2 - Dominance Test is >50%

___ 3 - Prevalence Index is ≤3.0[1]

___ Problematic Hydrophytic Vegetation [1] (Explain in Remarks or in the delineation report)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes X No ____

Remarks

SOIL **Sampling Point: 1-2**

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type [1]	Loc [2]	Texture	Remarks
0 – 13	10YR 3/3	100	none				clay loam	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains [2]Location: PL=Pore Lining, M=Matrix

Hydric Soil Indicators:

___ Histisols (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Muck Presence (A8)
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Dark-Surface (S7)
___ Loamy Gleyed Matrix (F2)
___ Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

___ Stratified Layers (A5)
___ Sandy Mucky Mineral (S1)
___ Red Parent Material (TF2)
___ Very Shallow Dark Surface (TF12)
___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type:___

Depth (inches):___

Hydric Soil Present: Yes___ No X

Remarks:

Pearl Harbor clay is on the 2012 list of hydric soils. Soil profile does not confirm mapped soil type.

HYDROLOGY

Wetland Hydrology Indicators: (Explain observations in Remarks, if needed.)

Primary Indicators (minimum of one required: check all that apply)

___ Surface Water (A1)
___ High Water Table (A2)
___ Saturation (A3)
___ Water Marks (B1)
___ Sediment Deposits (B2)
___ Drift Deposits (B3)
___ Algal Mat or Crust (B4)
___ Iron Deposits (B5)
___ Innundation Visible on Aerial Imagery (B7)
___ Water Stained Leaves (B9)
___ Aquatic Fauna (B13)
___ Tilapia Nests (B17)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres on Living Roots (C3)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Tiled Soils (C6)
___ Thin Muck Surface (C7)
___ Fiddler Crab Burrows (C10) (Guam, CNMI, and American Samoa)
___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

___ Surface Soil Cracks (B6)
___ Sparsely Vegetated Concave Surface (B8)
___ Drainage Patterns (B10)
___ Dry-Season Water Table (C2)
___ Salt Deposits (C5)
___ Stunted or Stressed Plants (D1)
___ Geomorphic Position (D2)
___ Shallow Aquitard (D3)
___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes___ No X Depth (inches): none

Water Table Present? Yes___ No X Depth (inches): >13

Saturation Present? (includes capillary fringe) Yes___ No X Depth (inches): >13

Wetland Hydrology Present? Yes___ No X

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

As of Aug 2014, Punaluu Pump and Punaluu Stream rain gages were at 141% and 114% of year to date average (http://www.prh.noaa.gov/hnl/hydro/pages/oahu_ytd_08.gif)

WETLAND DETERMINATION DATA FORM—Hawai‘i and Pacific Islands

Project/Site: Punalu‘u City: Punalu‘u Sampling Date: Sep 19, 2014 Time: 1050

Applicant/Owner: Kamehameha Schools State/Terr./Comm.: Hawai‘i Island: O‘ahu Sampling Point: **SP 1-3**

Investigator(s): Susan Burr and Chad Linebaugh TMK/Parcel: 5-3-003:001

Landform (hillslope, coastal plain, etc.): coastal plain Local relief (concave, convex, none): concave

Lat: 21° 34’40.88115”N Long: 157° 53’05.55273 ”W Datum: WGS 84 Slope (%): <1

Soil Map Unit Name: Pearl Harbor clay (PH) NWI classification: non-wetland (E2FO3N† on NWI map)

Are climactic/hydrologic conditions on the site typical for this time of year: Yes____ No X‡ (If no, explain in Remarks)

Are Vegetation No , Soil No , or Hydrology No significantly disturbed? Are “Normal Circumstances” present? Yes X No____

Are Vegetation No , Soil No , or Hydrology No naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS—Attach a site map showing sampling point locations transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X No ____	
Hydric Soil Present?	Yes ____ No X	**Is the Sampled Area**
Wetland Hydrology Present?	Yes X No ____	**within a Wetland? Yes____ No X**

Remarks: † E2FO3N regularly flooded, broad-leaved evergreen forested, intertidal estuarine wetland.

‡ See Hydrology Remarks. SP 1-3 is located at the lowest point on a peninsula.

VEGETATION—Use scientific names of plants.

Tree Stratum (Plot size: 30-ft radius)	Absolute % Cover	Dominant Species?	Indicator Status
1. *Terminalia catappa*	75	Yes	FAC
2.			
3.			
4.			
5.			
	75 =Total Cover		
Sapling/Shrub Stratum (Plot size: 20-ft radius)			
1. *Terminalia catappa*	20	Yes	FAC
2. *Talipariti tiliaceum*	3	Yes	FAC
3.			
4.			
5.			
	23 =Total Cover		
Herb Stratum (Plot size: 5-ft radius)			
1. *Terminalia catappa* (seedlings)	6	Yes	FAC
2.			
3.			
4.			
5.			
6.			
7.			
8.			
	6 =Total Cover		
Woody Vine Stratum (Plot size: 5-ft radius)			
1. None			
2.			
	0 =Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 4 (A)

Total Number of Dominant Species Across All Strata: 4 **(B)**

Percent of Dominant Species That Are OBL, FACW, or FAC: 100 (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species ____	x1= ____
FACW species ____	x2= ____
FAC species ____	x3= ____
FACU species ____	x4= ____
UPL species ____	x5= ____
Column Totals: ____ (A)	____ (B)

Prevalence Index = B/A= ____

Hydrophytic Vegetation Indicators:

___ 1 - Rapid Test for Hydrophytic Vegetation

X 2 - Dominance Test is >50%

___ 3 - Prevalence Index is ≤3.0[1]

___ Problematic Hydrophytic Vegetation [1] (Explain in Remarks or in the delineation report)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes X No____

Remarks

SOIL

Sampling Point: 1-3

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0 – 12	7.5YR 3/3	100	none				clay loam	
12 - 15	7.5YR 4/2	100	none				sandy loam	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains
[2]Location: PL=Pore Lining, M=Matrix

Hydric Soil Indicators:

___ Histisols (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Muck Presence (A8)
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Dark-Surface (S7)
___ Loamy Gleyed Matrix (F2)
___ Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

___ Stratified Layers (A5)
___ Sandy Mucky Mineral (S1)
___ Red Parent Material (TF2)
___ Very Shallow Dark Surface (TF12)
___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: ____

Depth (inches): ____

Hydric Soil Present: Yes ____ No X

Remarks:

Pearl Harbor clay is on the 2012 list of hydric soils. Soil profile does not confirm mapped soil type.

HYDROLOGY

Wetland Hydrology Indicators: (Explain observations in Remarks, if needed.)

Primary Indicators (minimum of one required: check all that apply)

___ Surface Water (A1)
___ High Water Table (A2)
___ Saturation (A3)
___ Water Marks (B1)
___ Sediment Deposits (B2)
X Drift Deposits (B3)
___ Algal Mat or Crust (B4)
___ Iron Deposits (B5)
___ Innundation Visible on Aerial Imagery (B7)
___ Water Stained Leaves (B9)
___ Aquatic Fauna (B13)
___ Tilapia Nests (B17)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres on Living Roots (C3)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Tiled Soils (C6)
___ Thin Muck Surface (C7)
___ Fiddler Crab Burrows (C10) (Guam, CNMI, and American Samoa)
___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

___ Surface Soil Cracks (B6)
___ Sparsely Vegetated Concave Surface (B8)
___ Drainage Patterns (B10)
___ Dry-Season Water Table (C2)
___ Salt Deposits (C5)
___ Stunted or Stressed Plants (D1)
X Geomorphic Position (D2)
___ Shallow Aquitard (D3)
___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes ____ No X Depth (inches): none

Water Table Present? Yes ____ No X Depth (inches): >15

Saturation Present? (includes capillary fringe) Yes X No ‘ Depth (inches): 15

Wetland Hydrology Present? Yes X No ____

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:
As of Aug 2014, Punaluu Pump and Punaluu Stream rain gages were at 141% and 114% of year to date average (http://www.prh.noaa.gov/hnl/hydro/pages/oahu_ytd_08.gif)
It appears that water flowed from west to east over this peninsula when Punaluʻu Stream topped its banks in July 2014 storm.
Negative α, α′ diprydil test throughout soil profile.

WETLAND DETERMINATION DATA FORM—Hawai'i and Pacific Islands

Project/Site: Punalu'u City: Punalu'u Sampling Date: Sep 2, 2014 Time: 1000

Applicant/Owner: Kamehameha Schools State/Terr./Comm.: Hawai'i Island: O'ahu Sampling Point: **SP 2-1**

Investigator(s): Susan Burr and Chad Linebaugh TMK/Parcel: 5-3-003:001

Landform (hillslope, coastal plain, etc.): coastal plain Local relief (concave, convex, none): none

Lat: 21° 34'35.24029"N Long: 157° 52'57.42546 "W Datum: WGS 84 Slope (%): 0

Soil Map Unit Name: Pearl Harbor clay (PH)* NWI classification: PEM1A† (not on NWI map)

Are climactic/hydrologic conditions on the site typical for this time of year: Yes ____ No X‡ (If no, explain in Remarks)

Are Vegetation No , Soil No , or Hydrology No significantly disturbed? Are "Normal Circumstances" present? Yes X No ____

Are Vegetation No , Soil No , or Hydrology No naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS—Attach a site map showing sampling point locations transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X No ____	
Hydric Soil Present?	Yes X No ____	**Is the Sampled Area**
Wetland Hydrology Present?	Yes X No ____	**within a Wetland? Yes X No ____**

Remarks: * Near boundary with Kaloko clay non-calcareous variant (KfB)

† PEM1A = temporary flooded, persistent, emergent palustrine wetland.‡ See Hydrology Remarks.

VEGETATION—Use scientific names of plants.

Tree Stratum (Plot size: 30-ft radius)	Absolute % Cover	Dominant Species?	Indicator Status
1. None			
2.			
3.			
4.			
5.			
	0 =Total Cover		
Sapling/Shrub Stratum (Plot size: 20-ft radius)			
1. None			
2.			
3.			
4.			
5.			
	0 =Total Cover		
Herb Stratum (Plot size: 5-ft radius)			
1. *Urochloa mutica*	95	Yes	FACW
2. *Paederia foetida*	5	No	UPL
3. *Pluchea indica*	3	No	FAC
4.			
5.			
6.			
7.			
8.			
	103 =Total Cover		
Woody Vine Stratum (Plot size: 5-ft radius)			
1. None			
2.			
	0 =Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: ____ (A)

Total Number of Dominant Species Across All Strata: ____ **(B)**

Percent of Dominant Species That Are OBL, FACW, or FAC: ____ (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species ____	x1= ____
FACW species ____	x2= ____
FAC species ____	x3= ____
FACU species ____	x4= ____
UPL species ____	x5= ____
Column Totals: ____ (A)	____ (B)

Prevalence Index = B/A= ____

Hydrophytic Vegetation Indicators:

X 1 - Rapid Test for Hydrophytic Vegetation

___ 2 - Dominance Test is >50%

___ 3 - Prevalence Index is ≤3.0[1]

___ Problematic Hydrophytic Vegetation [1] (Explain in Remarks or in the delineation report)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes X No ____

Remarks

SOIL **Sampling Point: 2-1**

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0 – 8	10YR 3/3	70	10YR 2/1	30	D	M	silty clay	(mucky mineral)
8 – 10	10YR 4/2	80	10YR 5/8	20	C	M & PL	silt loam	
10 - 11	10YR 2/1	100	none				muck	
11-13	10YR 5/2	80	10YR 4/6	20	C	M	sand	
13 - 14	10YR 2/1	100	none				muck	
14 -15	10YR 5/2	80	10YR 4/6	20	C	M	sand	
15 - 20	7.5YR 2.5/1	100	none				muck	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains [2]Location: PL=Pore Lining, M=Matrix

Hydric Soil Indicators:

- ___ Histisols (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Muck Presence (A8)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Dark-Surface (S7)
- ___ Loamy Gleyed Matrix (F2)
- X Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ___ Stratified Layers (A5)
- ___ Sandy Mucky Mineral (S1)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type:__________

Depth (inches):__________

Hydric Soil Present: Yes X No ____

Remarks:

Both Pearl Harbor clay and Kaloko clay non-calcareous variant are on the 2012 list of hydric soils. Soil profile confirms mapped soil type.

HYDROLOGY

Wetland Hydrology Indicators: (Explain observations in Remarks, if needed.)

Primary Indicators (minimum of one required: check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- X Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Innundation Visible on Aerial Imagery (B7)
- ___ Water Stained Leaves (B9)
- ___ Aquatic Fauna (B13)
- ___ Tilapia Nests (B17)
- ___ Hydrogen Sulfide Odor (C1)
- X Oxidized Rhizospheres on Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tiled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Fiddler Crab Burrows (C10) (Guam, CNMI, and American Samoa)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Salt Deposits (C5)
- ___ Stunted or Stressed Plants (D1)
- ___ Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- X FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes____ No X Depth (inches): none

Water Table Present? Yes X No____ Depth (inches): 14

Saturation Present? (includes capillary fringe) Yes X No ‘ Depth (inches): btw. 6 & 14

Wetland Hydrology Present? Yes X No ____

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

As of Aug 2014, Punaluu Pump and Punaluu Stream rain gages were at 141% and 114% of year to date average (http://www.prh.noaa.gov/hnl/hydro/pages/oahu_ytd_08.gif)

Positive α, α′ diprydil test at 15 in—too deep to meet C4 indicator.

WETLAND DETERMINATION DATA FORM—Hawaiʻi and Pacific Islands

Project/Site: Punaluʻu City: Punaluʻu Sampling Date: Sep 4, 2014 Time: 1445

Applicant/Owner: Kamehameha Schools State/Terr./Comm.: Hawaiʻi Island: Oʻahu Sampling Point: **SP 2-1b**

Investigator(s): Susan Burr and Chad Linebaugh TMK/Parcel: 5-3-003:001

Landform (hillslope, coastal plain, etc.): coastal plain Local relief (concave, convex, none): none

Lat: 21° 34'35.24029"N Long: 157° 52'57.42546 "W Datum: WGS 84 Slope (%): 0

Soil Map Unit Name: Kaloko clay, non-calcareous variant* NWI classification: PEM1A† (not on NWI map)

Are climactic/hydrologic conditions on the site typical for this time of year: Yes____ No X‡ (If no, explain in Remarks)

Are Vegetation No, Soil No, or Hydrology No significantly disturbed? Are "Normal Circumstances" present? Yes X No____

Are Vegetation No, Soil No, or Hydrology No naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS—Attach a site map showing sampling point locations transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No ____	
Hydric Soil Present?	Yes X	No ____	**Is the Sampled Area**
Wetland Hydrology Present?	Yes X	No ____	**within a Wetland? Yes X No____**

Remarks: * Near boundary with Kaloko clay non-calcareous variant (KfB)

† PEM1A = temporary flooded, persistent, emergent palustrine wetland.‡ See Hydrology Remarks.

VEGETATION—Use scientific names of plants.

Tree Stratum (Plot size: 30-ft radius)	Absolute % Cover	Dominant Species?	Indicator Status
1. None			
2.			
3.			
4.			
5.			
	0 =Total Cover		
Sapling/Shrub Stratum (Plot size: 20-ft radius)			
1. None			
2.			
3.			
4.			
5.			
	0 =Total Cover		
Herb Stratum (Plot size: 5-ft radius)			
1. *Urochloa mutica*	100	Yes	FACW
2.			
3.			
4.			
5.			
6.			
7.			
8.			
	100 =Total Cover		
Woody Vine Stratum (Plot size: 5-ft radius)			
1. None			
2.			
	0 =Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: ________ (A)

Total Number of Dominant Species Across All Strata: ________ **(B)**

Percent of Dominant Species That Are OBL, FACW, or FAC: ________ (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species	____	x1= ____
FACW species	____	x2= ____
FAC species	____	x3= ____
FACU species	____	x4= ____
UPL species	____	x5= ____
Column Totals:	____ (A)	____ (B)

Prevalence Index = B/A= ________

Hydrophytic Vegetation Indicators:

X 1 - Rapid Test for Hydrophytic Vegetation

___ 2 - Dominance Test is >50%

___ 3 - Prevalence Index is ≤3.0[1]

___ Problematic Hydrophytic Vegetation [1] (Explain in Remarks or in the delineation report)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes X No____

Remarks

SOIL

Sampling Point: 2-1b

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth	Matrix		Redox Features					
(inches)	Color (moist)	%	Color (moist)	%	Type[1]	Loc[2]	Texture	Remarks
0 – 3	10YR 3/3	100	none				silty clay	
3 – 14	Gley 1 4/N	80	5YR 4/6	10	C	PL	silty clay	
	10YR 3/3	10						

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains [2]Location: PL=Pore Lining, M=Matrix

Hydric Soil Indicators:

___ Histisols (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Muck Presence (A8)
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Dark-Surface (S7)
___ Loamy Gleyed Matrix (F2)
_X_ Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

___ Stratified Layers (A5)
___ Sandy Mucky Mineral (S1)
___ Red Parent Material (TF2)
___ Very Shallow Dark Surface (TF12)
___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type:____________________

Depth (inches):____________________

Hydric Soil Present: Yes X No ____

Remarks:

Kaloko clay non-calcareous variant is on the 2012 list of hydric soils. Soil profile does not confirm mapped soil type.

HYDROLOGY

Wetland Hydrology Indicators: (Explain observations in Remarks, if needed.)

Primary Indicators (minimum of one required: check all that apply)

___ Surface Water (A1)
___ High Water Table (A2)
___ Saturation (A3)
___ Water Marks (B1)
___ Sediment Deposits (B2)
___ Drift Deposits (B3)
___ Algal Mat or Crust (B4)
___ Iron Deposits (B5)
___ Innundation Visible on Aerial Imagery (B7)
___ Water Stained Leaves (B9)
___ Aquatic Fauna (B13)
___ Tilapia Nests (B17)
___ Hydrogen Sulfide Odor (C1)
_X_ Oxidized Rhizospheres on Living Roots (C3)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Tiled Soils (C6)
___ Thin Muck Surface (C7)
___ Fiddler Crab Burrows (C10) (Guam, CNMI, and American Samoa)
___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

___ Surface Soil Cracks (B6)
___ Sparsely Vegetated Concave Surface (B8)
___ Drainage Patterns (B10)
___ Dry-Season Water Table (C2)
___ Salt Deposits (C5)
___ Stunted or Stressed Plants (D1)
___ Geomorphic Position (D2)
___ Shallow Aquitard (D3)
_X_ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes____ No X Depth (inches): none

Water Table Present? Yes____ No X Depth (inches): >14

Saturation Present? (includes capillary fringe) Yes____ No ‘X Depth (inches): >14

Wetland Hydrology Present? Yes X No ____

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

As of Aug 2014, Punaluu Pump and Punaluu Stream rain gages were at 141% and 114% of year to date average (http://www.prh.noaa.gov/hnl/hydro/pages/oahu_ytd_08.gif)

WETLAND DETERMINATION DATA FORM—Hawaiʻi and Pacific Islands

Project/Site: Punaluʻu City: Punaluʻu Sampling Date: Sep 2, 2014 Time: 1050

Applicant/Owner: Kamehameha Schools State/Terr./Comm.: Hawaiʻi Island: Oʻahu Sampling Point: **SP 2-2**

Investigator(s): Susan Burr and Chad Linebaugh TMK/Parcel: 5-3-003:001

Landform (hillslope, coastal plain, etc.): coastal plain Local relief (concave, convex, none): none

Lat: 21° 34'35.65"N Long: 157° 52'55.83"W Datum: WGS 84 Slope (%): 0

Soil Map Unit Name: Pearl Harbor clay (PH)* NWI classification: PF03C† (not on NWI map)

Are climactic/hydrologic conditions on the site typical for this time of year: Yes____ No X‡ (If no, explain in Remarks)

Are Vegetation No , Soil No , or Hydrology No significantly disturbed? Are "Normal Circumstances" present? Yes X No____

Are Vegetation No , Soil No , or Hydrology No naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS—Attach a site map showing sampling point locations transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No	
Hydric Soil Present?	Yes X	No	**Is the Sampled Area**
Wetland Hydrology Present?	Yes X	No	**within a Wetland? Yes X No**

Remarks: * Near boundary with Kaloko clay non-calcareous variant (KfB)

† PF03C = seasonally flooded, broad-leaved evergreen forested palustrine wetland.‡ See Hydrology Remarks.

VEGETATION—Use scientific names of plants.

Tree Stratum (Plot size: 30-ft radius)	Absolute % Cover	Dominant Species?	Indicator Status
1. *Talipariti tiliaceum*	95	Yes	FAC
2.			
3.			
4.			
5.			
	95 =Total Cover		
Sapling/Shrub Stratum (Plot size: 20-ft radius)			
1. None			
2.			
3.			
4.			
5.			
	0 =Total Cover		
Herb Stratum (Plot size: 5-ft radius)			
1. None			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
	0 =Total Cover		
Woody Vine Stratum (Plot size: 5-ft radius)			
1. None			
2.			
	0 =Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 1 (A)

Total Number of Dominant Species Across All Strata: 1 **(B)**

Percent of Dominant Species That Are OBL, FACW, or FAC: 100 (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species	x1=
FACW species	x2=
FAC species	x3=
FACU species	x4=
UPL species	x5=
Column Totals: (A)	(B)

Prevalence Index = B/A=

Hydrophytic Vegetation Indicators:

___ 1 - Rapid Test for Hydrophytic Vegetation

X 2 - Dominance Test is >50%

___ 3 - Prevalence Index is ≤3.0[1]

___ Problematic Hydrophytic Vegetation [1] (Explain in Remarks or in the delineation report)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes X No____

Remarks

SOIL

Sampling Point: 2-2

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0 – 7	10YR 3/2	100	none				silty clay loam	
7 – 19	10YR 2/1	100	none				mucky mineral	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains   [2]Location: PL=Pore Lining, M=Matrix

Hydric Soil Indicators:

- ___ Histisols (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Muck Presence (A8)
- X Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Dark-Surface (S7)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ___ Stratified Layers (A5)
- ___ Sandy Mucky Mineral (S1)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: ____________________

Depth (inches): ____________________

Hydric Soil Present: Yes X No ____

Remarks:

Pearl Harbor clay is on the 2012 list of hydric soils. Soil profile confirms mapped soil type.

HYDROLOGY

Wetland Hydrology Indicators: (Explain observations in Remarks, if needed.)

Primary Indicators (minimum of one required: check all that apply)

- ___ Surface Water (A1)
- X High Water Table (A2)
- X Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Innundation Visible on Aerial Imagery (B7)
- ___ Water Stained Leaves (B9)
- ___ Aquatic Fauna (B13)
- ___ Tilapia Nests (B17)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres on Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tiled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Fiddler Crab Burrows (C10) (Guam, CNMI, and American Samoa)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Drainage Patterns (B10)
- X Dry-Season Water Table (C2)
- ___ Salt Deposits (C5)
- ___ Stunted or Stressed Plants (D1)
- ___ Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- ___ FAC-Neutral Test (D5)

Field Observations:

	Yes	No	Depth (inches)
Surface Water Present?		X	none
Water Table Present?	X		10
Saturation Present? (includes capillary fringe)	X	‘	8

Wetland Hydrology Present? Yes X No ____

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

As of Aug 2014, Punaluu Pump and Punaluu Stream rain gages were at 141% and 114% of year to date average (http://www.prh.noaa.gov/hnl/hydro/pages/oahu_ytd_08.gif)

Hummocky

WETLAND DETERMINATION DATA FORM—Hawai'i and Pacific Islands

Project/Site: Punalu'u City: Punalu'u Sampling Date: Sep 2, 2014 Time: 1115

Applicant/Owner: Kamehameha Schools State/Terr./Comm.: Hawai'i Island: O'ahu Sampling Point: **SP 2-3**

Investigator(s): Susan Burr and Chad Linebaugh TMK/Parcel: 5-3-003:001

Landform (hillslope, coastal plain, etc.): coastal plain Local relief (concave, convex, none): none

Lat: 21° 34'36.50935"N Long: 157° 52'58.44569 "W Datum: WGS 84 Slope (%): 0

Soil Map Unit Name: Pearl Harbor clay (PH)* NWI classification: PF03C† (not on NWI map)

Are climactic/hydrologic conditions on the site typical for this time of year: Yes____ No X‡ (If no, explain in Remarks)

Are Vegetation No , Soil No , or Hydrology No significantly disturbed? Are "Normal Circumstances" present? Yes X No____

Are Vegetation No , Soil No , or Hydrology No naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS—Attach a site map showing sampling point locations transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X No ____	
Hydric Soil Present?	Yes X No ____	**Is the Sampled Area**
Wetland Hydrology Present?	Yes X No ____	**within a Wetland? Yes X No____**

Remarks: * Near boundary with Kaloko clay non-calcareous variant (KfB)

† PF03C = seasonally flooded, broad-leaved evergreen forested palustrine wetland.‡ See Hydrology Remarks.

VEGETATION—Use scientific names of plants.

Tree Stratum (Plot size: 30-ft radius)	Absolute % Cover	Dominant Species?	Indicator Status
1. *Talipariti tiliaceum*	98	Yes	FAC
2.			
3.			
4.			
5.			
	98 =Total Cover		
Sapling/Shrub Stratum (Plot size: 20-ft radius)			
1. None			
2.			
3.			
4.			
5.			
	0 =Total Cover		
Herb Stratum (Plot size: 5-ft radius)			
1. None			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
	0 =Total Cover		
Woody Vine Stratum (Plot size: 5-ft radius)			
1. None			
2.			
	0 =Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 1 (A)

Total Number of Dominant Species Across All Strata: 1 **(B)**

Percent of Dominant Species That Are OBL, FACW, or FAC: 100 (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species	____	x1= ____
FACW species	____	x2= ____
FAC species	____	x3= ____
FACU species	____	x4= ____
UPL species	____	x5= ____
Column Totals:	____ (A)	____ (B)

Prevalence Index = B/A= ____

Hydrophytic Vegetation Indicators:

___ 1 - Rapid Test for Hydrophytic Vegetation

X 2 - Dominance Test is >50%

___ 3 - Prevalence Index is ≤3.0[1]

___ Problematic Hydrophytic Vegetation [1] (Explain in Remarks or in the delineation report)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes X No____

Remarks: Remaining ground is bare

SOIL

Sampling Point: 2-3

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0 – 3	10YR 3/2	100	none				silty loam	
3 – 9	10YR 4/2	85	10YR 5/8	15	C	PL	silty loam	prominent redox features
9 - 11	10YR 5/2	85	10YR 5/8	15	C	M	sand	prominent redox features
11 – 17	10YR 3/1	80	10YR 5/8	20	C	M	muck	prominent redox features

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains [2]Location: PL=Pore Lining, M=Matrix

Hydric Soil Indicators:

___ Histisols (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Muck Presence (A8)
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Dark-Surface (S7)
___ Loamy Gleyed Matrix (F2)
_X_ Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

___ Stratified Layers (A5)
___ Sandy Mucky Mineral (S1)
___ Red Parent Material (TF2)
___ Very Shallow Dark Surface (TF12)
___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type:___

Depth (inches):___

Hydric Soil Present: Yes X No___

Remarks:

Both Pearl Harbor clay and Kaloko clay non-calcareous variant are on the 2012 list of hydric soils. Soil profile generally confirms mapped soil type (except layer of sand).

HYDROLOGY

Wetland Hydrology Indicators: (Explain observations in Remarks, if needed.)

Primary Indicators (minimum of one required: check all that apply)

___ Surface Water (A1)
___ High Water Table (A2)
_X_ Saturation (A3)
___ Water Marks (B1)
___ Sediment Deposits (B2)
___ Drift Deposits (B3)
___ Algal Mat or Crust (B4)
___ Iron Deposits (B5)
___ Innundation Visible on Aerial Imagery (B7)
_X_ Water Stained Leaves (B9)
___ Aquatic Fauna (B13)
___ Tilapia Nests (B17)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres on Living Roots (C3)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Tiled Soils (C6)
___ Thin Muck Surface (C7)
___ Fiddler Crab Burrows (C10) (Guam, CNMI, and American Samoa)
___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

_X_ Surface Soil Cracks (B6)
___ Sparsely Vegetated Concave Surface (B8)
___ Drainage Patterns (B10)
___ Dry-Season Water Table (C2)
___ Salt Deposits (C5)
___ Stunted or Stressed Plants (D1)
___ Geomorphic Position (D2)
___ Shallow Aquitard (D3)
___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes___ No X Depth (inches): none

Water Table Present? Yes___ No X Depth (inches): >17

Saturation Present? (includes capillary fringe) Yes X No ‘ Depth (inches): 9

Wetland Hydrology Present? Yes X No___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

As of Aug 2014, Punaluu Pump and Punaluu Stream rain gages were at 141% and 114% of year to date average (http://www.prh.noaa.gov/hnl/hydro/pages/oahu_ytd_08.gif)

WETLAND DETERMINATION DATA FORM—Hawaiʻi and Pacific Islands

Project/Site: Punaluʻu City: Punaluʻu Sampling Date: Sep 2, 2014 Time: 1205

Applicant/Owner: Kamehameha Schools State/Terr./Comm.: Hawaiʻi Island: Oʻahu Sampling Point: **SP 2-4**

Investigator(s): Susan Burr and Chad Linebaugh TMK/Parcel: 5-3-003:001

Landform (hillslope, coastal plain, etc.): coastal plain Local relief (concave, convex, none): none

Lat: 21° 34'35.90271"N Long: 157° 53'03.45682 "W Datum: WGS 84 Slope (%): 0

Soil Map Unit Name: Hanalei silty stony clay (HoB) NWI classification: Non-wetland (indicated as PEM1KFh† on NWI map)

Are climactic/hydrologic conditions on the site typical for this time of year: Yes ___ No X‡ (If no, explain in Remarks)

Are Vegetation No , Soil No , or Hydrology No significantly disturbed? Are "Normal Circumstances" present? Yes X No ___

Are Vegetation No , Soil No , or Hydrology No naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS—Attach a site map showing sampling point locations transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X No ___	
Hydric Soil Present?	Yes ___ No X	**Is the Sampled Area**
Wetland Hydrology Present?	Yes ___ No X	**within a Wetland? Yes ___ No X**

Remarks: SP 2-4 is located at lowest point in the field. The part of the field located farther away from Punaluʻu Stream is 100% *Megathyrsus maximus*.

† PEM1KFh = artificially, semi-permanently flooded, persistent, emergent palustrine wetland. ‡ See Hydrology Remarks.

VEGETATION—Use scientific names of plants.

	Absolute % Cover	Dominant Species?	Indicator Status
Tree Stratum (Plot size: 30-ft radius)			
1. None			
2.			
3.			
4.			
5.			
	0 =Total Cover		
Sapling/Shrub Stratum (Plot size: 20-ft radius)			
1. None			
2.			
3.			
4.			
5.			
	0 =Total Cover		
Herb Stratum (Plot size: 5-ft radius)			
1. *Commelina diffusa*	85	Yes	FACW
2. *Ipomoea alba*	8	No	FAC
3. *Paederia foetida*	5	No	UPL
4. *Megathyrsus maximus*	2	No	FAC
5.			
6.			
7.			
8.			
	100 =Total Cover		
Woody Vine Stratum (Plot size: 5-ft radius)			
1. None			
2.			
	0 =Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: ___ (A)

Total Number of Dominant Species Across All Strata: ___ **(B)**

Percent of Dominant Species That Are OBL, FACW, or FAC: ___ (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species ___	x1= ___
FACW species ___	x2= ___
FAC species ___	x3= ___
FACU species ___	x4= ___
UPL species ___	x5= ___
Column Totals: ___ (A)	___ (B)

Prevalence Index = B/A= ___

Hydrophytic Vegetation Indicators:

X 1 - Rapid Test for Hydrophytic Vegetation

___ 2 - Dominance Test is >50%

___ 3 - Prevalence Index is ≤3.0[1]

___ Problematic Hydrophytic Vegetation [1] (Explain in Remarks or in the delineation report)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes X No ___

Remarks:
Trema orientalis (FACU) trees are on fringe of field and provide shade.

SOIL **Sampling Point: 2-4**

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0 – 14	10YR 3/3	100	none				clay loam	
14 – 17	10YR 4/1	93	5YR 4/3	7	C	PL	clay	prominent redox features

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains [2]Location: PL=Pore Lining, M=Matrix

Hydric Soil Indicators:

___ Histisols (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Muck Presence (A8)
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Dark-Surface (S7)
___ Loamy Gleyed Matrix (F2)
___ Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

___ Stratified Layers (A5)
___ Sandy Mucky Mineral (S1)
___ Red Parent Material (TF2)
___ Very Shallow Dark Surface (TF12)
___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type:______

Depth (inches):______

Hydric Soil Present: Yes______ No X

Remarks:

Hanalei silty stony clay is on the 2012 list of hydric soils. Top layer of soil profile does not confirm mapped soil type.

Redox features are too deep for soil to meet F3 criteria.

HYDROLOGY

Wetland Hydrology Indicators: (Explain observations in Remarks, if needed.)

Primary Indicators (minimum of one required: check all that apply)

___ Surface Water (A1)
___ High Water Table (A2)
___ Saturation (A3)
___ Water Marks (B1)
___ Sediment Deposits (B2)
___ Drift Deposits (B3)
___ Algal Mat or Crust (B4)
___ Iron Deposits (B5)
___ Innundation Visible on Aerial Imagery (B7)
___ Water Stained Leaves (B9)
___ Aquatic Fauna (B13)
___ Tilapia Nests (B17)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres on Living Roots (C3)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Tiled Soils (C6)
___ Thin Muck Surface (C7)
___ Fiddler Crab Burrows (C10) (Guam, CNMI, and American Samoa)
___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

___ Surface Soil Cracks (B6)
___ Sparsely Vegetated Concave Surface (B8)
___ Drainage Patterns (B10)
___ Dry-Season Water Table (C2)
___ Salt Deposits (C5)
___ Stunted or Stressed Plants (D1)
___ Geomorphic Position (D2)
___ Shallow Aquitard (D3)
_X_ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes______ No X Depth (inches): none

Water Table Present? Yes______ No X Depth (inches): >17

Saturation Present? (includes capillary fringe) Yes______ No ‘X Depth (inches): >17

Wetland Hydrology Present? Yes______ No X

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

As of Aug 2014, Punaluu Pump and Punaluu Stream rain gages were at 141% and 114% of year to date average (http://www.prh.noaa.gov/hnl/hydro/pages/oahu_ytd_08.gif)

Negative α, α′ diprydil test throughout soil profile.

WETLAND DETERMINATION DATA FORM—Hawaiʻi and Pacific Islands

Project/Site: Punaluʻu City: Punaluʻu Sampling Date: Sep 2, 2014 Time: 1240

Applicant/Owner: Kamehameha Schools State/Terr./Comm.: Hawaiʻi Island: Oʻahu Sampling Point: **SP 2-5**

Investigator(s): Susan Burr and Chad Linebaugh TMK/Parcel: 5-3-003:001

Landform (hillslope, coastal plain, etc.): coastal plain Local relief (concave, convex, none): none

Lat: 21° 34'37.71565"N Long: 157° 53'04.46204 "W Datum: WGS 84 Slope (%): 0

Soil Map Unit Name: Hanalei silty stony clay (HoB), 0 to 6% slopes NWI classification: Non-wetland (indicated as PFO3C† on NWI map)

Are climactic/hydrologic conditions on the site typical for this time of year: Yes ____ No X‡ (If no, explain in Remarks)

Are Vegetation No , Soil No , or Hydrology No significantly disturbed? Are "Normal Circumstances" present? Yes X No ____

Are Vegetation No , Soil No , or Hydrology No naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS—Attach a site map showing sampling point locations transects, important features, etc.

Hydrophytic Vegetation Present?	Yes ____	No X
Hydric Soil Present?	Yes ____	No X
Wetland Hydrology Present?	Yes ____	No X

Is the Sampled Area within a Wetland? Yes ____ No X

Remarks: SP 2-5 is located approximately 3 m away from a berm on right bank of Punaluʻu Stream.

† PF03C = seasonally flooded, broad-leaved evergreen forested palustrine wetland. See Hydrology Remarks.

VEGETATION—Use scientific names of plants.

	Absolute % Cover	Dominant Species?	Indicator Status
Tree Stratum (Plot size: 30-ft radius)			
1. *Talipariti tiliaceum*	10	Yes	FAC
2. *Trema orientalis*	5	Yes	FACU
3. *Cocos nucifera*	5	Yes	FACU
4.			
5.			
	20 =Total Cover		
Sapling/Shrub Stratum (Plot size: 20-ft radius)			
1. *Talipariti tiliaceum*	70	Yes	FAC
2.			
3.			
4.			
5.			
	70 =Total Cover		
Herb Stratum (Plot size: 5-ft radius)			
1. None			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
	0 =Total Cover		
Woody Vine Stratum (Plot size: 5-ft radius)			
1. None			
2.			
	0 =Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 2 (A)

Total Number of Dominant Species Across All Strata: 4 **(B)**

Percent of Dominant Species That Are OBL, FACW, or FAC: 50 (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species		x1=
FACW species		x2=
FAC species	80	x3= 240
FACU species	10	x4= 40
UPL species		x5=
Column Totals:	90 (A)	280 (B)

Prevalence Index = B/A= 3.1

Hydrophytic Vegetation Indicators:

___ 1 - Rapid Test for Hydrophytic Vegetation

___ 2 - Dominance Test is >50%

___ 3 - Prevalence Index is ≤3.0[1]

___ Problematic Hydrophytic Vegetation [1] (Explain in Remarks or in the delineation report)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes ____ No X

Remarks:

SOIL

Sampling Point: 2-5

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0 – 14	10YR 3/3	100	none				silty clay loam	
14 – 17	10YR 3/3	90	none				silty clay loam	
	limestone gravel	10						

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains [2]Location: PL=Pore Lining, M=Matrix

Hydric Soil Indicators:

___ Histisols (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Muck Presence (A8)
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Dark-Surface (S7)
___ Loamy Gleyed Matrix (F2)
___ Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

___ Stratified Layers (A5)
___ Sandy Mucky Mineral (S1)
___ Red Parent Material (TF2)
___ Very Shallow Dark Surface (TF12)
___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type:___

Depth (inches):___

Hydric Soil Present: Yes___ No X

Remarks:

Hanalei silty stony clay is on the 2012 list of hydric soils. Soil profile does not confirm mapped soil type.

HYDROLOGY

Wetland Hydrology Indicators: (Explain observations in Remarks, if needed.)

Primary Indicators (minimum of one required: check all that apply)

___ Surface Water (A1)
___ High Water Table (A2)
___ Saturation (A3)
___ Water Marks (B1)
___ Sediment Deposits (B2)
___ Drift Deposits (B3)
___ Algal Mat or Crust (B4)
___ Iron Deposits (B5)
___ Innundation Visible on Aerial Imagery (B7)
___ Water Stained Leaves (B9)
___ Aquatic Fauna (B13)
___ Tilapia Nests (B17)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres on Living Roots (C3)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Tiled Soils (C6)
___ Thin Muck Surface (C7)
___ Fiddler Crab Burrows (C10) (Guam, CNMI, and American Samoa)
___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

___ Surface Soil Cracks (B6)
___ Sparsely Vegetated Concave Surface (B8)
___ Drainage Patterns (B10)
___ Dry-Season Water Table (C2)
___ Salt Deposits (C5)
___ Stunted or Stressed Plants (D1)
___ Geomorphic Position (D2)
___ Shallow Aquitard (D3)
___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes___ No X Depth (inches): none

Water Table Present? Yes___ No X Depth (inches): >17

Saturation Present? (includes capillary fringe) Yes___ No ‘X Depth (inches): >17

Wetland Hydrology Present? Yes___ No X

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

As of Aug 2014, Punaluu Pump and Punaluu Stream rain gages were at 141% and 114% of year to date average (http://www.prh.noaa.gov/hnl/hydro/pages/oahu_ytd_08.gif)

WETLAND DETERMINATION DATA FORM—Hawai‘i and Pacific Islands

Project/Site: Punalu‘u City: Punalu‘u Sampling Date: Sep 2, 2014 Time: 1255

Applicant/Owner: Kamehameha Schools State/Terr./Comm.: Hawai‘i Island: O‘ahu Sampling Point: **SP 2-6**

Investigator(s): Susan Burr and Chad Linebaugh TMK/Parcel: 5-3-003:001

Landform (hillslope, coastal plain, etc.): coastal plain, floodplain of Punalu‘u Stream Local relief (concave, convex, none): none

Lat: 21° 34’37.89695”N Long: 157° 53’04.16948 ”W Datum: WGS 84 Slope (%): 0

Soil Map Unit Name: Hanalei silty stony clay (HoB), 0 to 6% slopes NWI classification: Non-wetland (indicated as PFO3C† on NWI map)

Are climactic/hydrologic conditions on the site typical for this time of year: Yes ____ No X‡ (If no, explain in Remarks)

Are Vegetation No , Soil No , or Hydrology No significantly disturbed? Are “Normal Circumstances” present? Yes X No ____

Are Vegetation No , Soil No , or Hydrology No naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS—Attach a site map showing sampling point locations transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No ____	
Hydric Soil Present?	Yes ____	No X	**Is the Sampled Area**
Wetland Hydrology Present?	Yes X	No ____	**within a Wetland? Yes ____ No X**

Remarks: † PF03C = seasonally flooded, broad-leaved evergreen forested palustrine wetland

‡ See Hydrology Remarks.

VEGETATION—Use scientific names of plants.

Tree Stratum (Plot size: 30-ft radius)	Absolute % Cover	Dominant Species?	Indicator Status
1. None			
2.			
3.			
4.			
5.			
	0 =Total Cover		
Sapling/Shrub Stratum (Plot size: 20-ft radius)			
1. None			
2.			
3.			
4.			
5.			
	0 =Total Cover		
Herb Stratum (Plot size: 5-ft radius)			
1. *Sphagneticola trilobata*	40	Yes	FAC
2. *Epipremnum pinnatum*	10	No	FAC
3. *Megathyrsus maximus*	5	No	FAC
4. *Commelina diffusa*	50	Yes	FACW
5.			
6.			
7.			
8.			
	105 =Total Cover		
Woody Vine Stratum (Plot size: 5-ft radius)			
1. None			
2.			
	0 =Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 2 (A)

Total Number of Dominant Species Across All Strata: 2 **(B)**

Percent of Dominant Species That Are OBL, FACW, or FAC: 100 (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species ____	x1= ____
FACW species ____	x2= ____
FAC species ____	x3= ____
FACU species ____	x4= ____
UPL species ____	x5= ____
Column Totals: ____ (A)	____ (B)

Prevalence Index = B/A= ____

Hydrophytic Vegetation Indicators:

___ 1 - Rapid Test for Hydrophytic Vegetation

X 2 - Dominance Test is >50%

___ 3 - Prevalence Index is ≤3.0[1]

___ Problematic Hydrophytic Vegetation [1] (Explain in Remarks or in the delineation report)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes X No ____

Remarks:
Plot is shaded by *Trema* orientalis (FACU) trees, but they are outside plot.

SOIL **Sampling Point: 2-6**

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	%	Redox Features Color (moist)	%	Type[1]	Loc[2]	Texture	Remarks
0 – 3	10YR 3/3	100	none				sandy clay loam	
3 – 9	10YR 3/3	100	none				clay loam	
9 – 17	10YR 3/1	30					sandy loam	
	gravel	30						
	limestone sand	40						

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains [2]Location: PL=Pore Lining, M=Matrix

Hydric Soil Indicators:

___ Histisols (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Muck Presence (A8)
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Dark-Surface (S7)
___ Loamy Gleyed Matrix (F2)
___ Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

___ Stratified Layers (A5)
___ Sandy Mucky Mineral (S1)
___ Red Parent Material (TF2)
___ Very Shallow Dark Surface (TF12)
___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: ____

Depth (inches): ____

Hydric Soil Present: Yes____ No X

Remarks:

Hanalei silty stony clay is on the 2012 list of hydric soils. Soil profile does not confirm mapped soil type.

HYDROLOGY

Wetland Hydrology Indicators: (Explain observations in Remarks, if needed.)

Primary Indicators (minimum of one required: check all that apply)

___ Surface Water (A1)
___ High Water Table (A2)
X Saturation (A3)
___ Water Marks (B1)
___ Sediment Deposits (B2)
___ Drift Deposits (B3)
___ Algal Mat or Crust (B4)
___ Iron Deposits (B5)
___ Inundation Visible on Aerial Imagery (B7)
___ Water Stained Leaves (B9)
___ Aquatic Fauna (B13)
___ Tilapia Nests (B17)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres on Living Roots (C3)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Tiled Soils (C6)
___ Thin Muck Surface (C7)
___ Fiddler Crab Burrows (C10) (Guam, CNMI, and American Samoa)
___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

___ Surface Soil Cracks (B6)
___ Sparsely Vegetated Concave Surface (B8)
___ Drainage Patterns (B10)
___ Dry-Season Water Table (C2)
___ Salt Deposits (C5)
___ Stunted or Stressed Plants (D1)
___ Geomorphic Position (D2)
___ Shallow Aquitard (D3)
___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes____ No X Depth (inches): none

Water Table Present? Yes____ No X Depth (inches): >17

Saturation Present? (includes capillary fringe) Yes X No____ Depth (inches): 0 to 3

Wetland Hydrology Present? Yes X No____

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

As of Aug 2014, Punaluu Pump and Punaluu Stream rain gages were at 141% and 114% of year to date average (http://www.prh.noaa.gov/hnl/hydro/pages/oahu_ytd_08.gif)

Evidence of recent flooding by overtopping of Punaluʻu Stream during July 2014 storm.

Corbicula fluminea shells in upper layers.

WETLAND DETERMINATION DATA FORM—Hawai‘i and Pacific Islands

Project/Site: Punalu‘u City: Punalu‘u Sampling Date: Sep 4, 2014 Time: 1035

Applicant/Owner: Kamehameha Schools State/Terr./Comm.: Hawai‘i Island: O‘ahu Sampling Point: **SP 2-7**

Investigator(s): Susan Burr and Chad Linebaugh TMK/Parcel: 5-3-003:001

Landform (hillslope, coastal plain, etc.): coastal plain Local relief (concave, convex, none): none

Lat: 21° 34’33.23834”N Long: 157° 52’52.22958 ”W Datum: WGS 84 Slope (%): 0

Soil Map Unit Name: Jaucas sand, 0 to 15% slops/Pearl Harbor clay NWI classification: Non-wetland (not on NWI map)

Are climactic/hydrologic conditions on the site typical for this time of year: Yes___ No X‡ (If no, explain in Remarks)

Are Vegetation No , Soil No , or Hydrology No significantly disturbed? Are “Normal Circumstances” present? Yes X No___

Are Vegetation No , Soil No , or Hydrology No naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS—Attach a site map showing sampling point locations transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X No ___	
Hydric Soil Present?	Yes ___ No X	**Is the Sampled Area**
Wetland Hydrology Present?	Yes ___ No X	**within a Wetland? Yes___ No X**

Remarks: SP 2-7 is at lowest point in plant assemblage area. An agricultural ditch is located *mauka* of area, Kam Hwy and shoulder fill are located *makai* of area. ‡ See Hydrology Remarks.

VEGETATION—Use scientific names of plants.

Tree Stratum (Plot size: 30-ft radius)	Absolute % Cover	Dominant Species?	Indicator Status
1. None			
2.			
3.			
4.			
5.			
	0 =Total Cover		
Sapling/Shrub Stratum (Plot size: 20-ft radius)			
1. *Leucaena leucocephala*	<5	Yes	UPL
2. *Pluchea carolinensis*	<1	No	FAC
3.			
4.			
5.			
	<6 =Total Cover		
Herb Stratum (Plot size: 5-ft radius)			
1. *Urochloa mutica*	95	Yes	FACW
2. *Bidens alba*	3	No	UPL
3. *Megathyrsus maximus*	2	No	FAC
4. *Paederia foetida*	3	No	UPL
5. *Sphagneticola trilobata*	2	No	FAC
6.			
7.			
8.			
	105 =Total Cover		
Woody Vine Stratum (Plot size: 5-ft radius)			
1. None			
2.			
	0 =Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 1 (A)

Total Number of Dominant Species Across All Strata: 2 **(B)**

Percent of Dominant Species That Are OBL, FACW, or FAC: 50 (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species	0	x1= 0
FACW species	95	x2= 190
FAC species	4.5	x3= 13.5
FACU species	0	x4= 0
UPL species	8.5	x5= 42.5
Column Totals:	108 (A)	246 (B)

Prevalence Index = B/A= 2.3

Hydrophytic Vegetation Indicators:

___ 1 - Rapid Test for Hydrophytic Vegetation

___ 2 - Dominance Test is >50%

X 3 - Prevalence Index is ≤3.0[1]

___ Problematic Hydrophytic Vegetation [1] (Explain in Remarks or in the delineation report)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes X No___

Remarks:
Plot is shaded by *Trema* orientalis (FACU) trees, but they are outside plot. Plant assemblage is urban mixed forest

SOIL

Sampling Point: 2-7

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0 – 12	10YR 3/3	95	none				sandy loam	
	limestone	5					gravel & coarse sand	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains [2]Location: PL=Pore Lining, M=Matrix

Hydric Soil Indicators:

___ Histisols (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Muck Presence (A8)
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Dark-Surface (S7)
___ Loamy Gleyed Matrix (F2)
___ Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

___ Stratified Layers (A5)
___ Sandy Mucky Mineral (S1)
___ Red Parent Material (TF2)
___ Very Shallow Dark Surface (TF12)
___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: ______

Depth (inches): ______

Hydric Soil Present: Yes ____ No X

Remarks:

Pearl Harbor clay is on the 2012 list of hydric soils. Soil profile does not confirm mapped soil type.

HYDROLOGY

Wetland Hydrology Indicators: (Explain observations in Remarks, if needed.)

Primary Indicators (minimum of one required: check all that apply)

___ Surface Water (A1)
___ High Water Table (A2)
___ Saturation (A3)
___ Water Marks (B1)
___ Sediment Deposits (B2)
___ Drift Deposits (B3)
___ Algal Mat or Crust (B4)
___ Iron Deposits (B5)
___ Inundation Visible on Aerial Imagery (B7)
___ Water Stained Leaves (B9)
___ Aquatic Fauna (B13)
___ Tilapia Nests (B17)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres on Living Roots (C3)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Tiled Soils (C6)
___ Thin Muck Surface (C7)
___ Fiddler Crab Burrows (C10) (Guam, CNMI, and American Samoa)
___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

___ Surface Soil Cracks (B6)
___ Sparsely Vegetated Concave Surface (B8)
___ Drainage Patterns (B10)
___ Dry-Season Water Table (C2)
___ Salt Deposits (C5)
___ Stunted or Stressed Plants (D1)
___ Geomorphic Position (D2)
___ Shallow Aquitard (D3)
___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes ____ No X Depth (inches): none

Water Table Present? Yes ____ No X Depth (inches): >12

Saturation Present? (includes capillary fringe) Yes ____ No X Depth (inches): >12

Wetland Hydrology Present? Yes ____ No X

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

As of Aug 2014, Punaluu Pump and Punaluu Stream rain gages were at 141% and 114% of year to date average (http://www.prh.noaa.gov/hnl/hydro/pages/oahu_ytd_08.gif)

WETLAND DETERMINATION DATA FORM—Hawaiʻi and Pacific Islands

Project/Site: Punaluʻu City: Punaluʻu Sampling Date: Sep 4, 2014 Time: 1100

Applicant/Owner: Kamehameha Schools State/Terr./Comm.: Hawaiʻi Island: Oʻahu Sampling Point: **SP 2-8**

Investigator(s): Susan Burr and Chad Linebaugh TMK/Parcel: 5-3-003:001

Landform (hillslope, coastal plain, etc.): coastal plain Local relief (concave, convex, none): none

Lat: 21° 34'30.36637"N Long: 157° 52'52.03796 "W Datum: WGS 84 Slope (%): 0

Soil Map Unit Name: Kaena stony clay, 2 to 6% slopes NWI classification: PF03C† (not on NWI map)

Are climactic/hydrologic conditions on the site typical for this time of year: Yes ____ No X‡ (If no, explain in Remarks)

Are Vegetation No , Soil No , or Hydrology No significantly disturbed? Are "Normal Circumstances" present? Yes X No ____

Are Vegetation No , Soil No , or Hydrology No naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS—Attach a site map showing sampling point locations transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X No ____	
Hydric Soil Present?	Yes X No ____	**Is the Sampled Area**
Wetland Hydrology Present?	Yes X No ____	**within a Wetland? Yes X No ____** near boundary

Remarks: SP 2-8 is located near the edge of the *hau* forest. † PF03C = seasonally flooded, broad-leaved evergreen forested palustrine wetland.
‡ See Hydrology Remarks.

VEGETATION—Use scientific names of plants.

Tree Stratum (Plot size: 30-ft radius)	Absolute % Cover	Dominant Species?	Indicator Status
1. *Talipariti tiliaceum*	100	Yes	FAC
2.			
3.			
4.			
5.			
	100 =Total Cover		
Sapling/Shrub Stratum (Plot size: 20-ft radius)			
1. *Ardisia elliptica*	<5	Yes	FACU
2. *Leucaena leucocephala*	<1	No	UPL
3.			
4.			
5.			
	<6 =Total Cover		
Herb Stratum (Plot size: 5-ft radius)			
1. None			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
	0 =Total Cover		
Woody Vine Stratum (Plot size: 5-ft radius)			
1. None			
2.			
	0 =Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 1 (A)

Total Number of Dominant Species Across All Strata: 2 **(B)**

Percent of Dominant Species That Are OBL, FACW, or FAC: 50 (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species	0	x1= 0
FACW species	0	x2= 0
FAC species	100	x3= 300
FACU species	2.5	x4= 10
UPL species	.5	x5= 2.5
Column Totals:	103 (A)	312.5 (B)

Prevalence Index = B/A= 3.0

Hydrophytic Vegetation Indicators:

___ 1 - Rapid Test for Hydrophytic Vegetation

___ 2 - Dominance Test is >50%

X 3 - Prevalence Index is ≤3.0[1]

___ Problematic Hydrophytic Vegetation [1] (Explain in Remarks or in the delineation report)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes X No ____

Remarks: Deeper in the *hau* forest, only mature *hau* trees area present.

SOIL **Sampling Point: 2-8**

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0 – 12	10YR 3/1	100	none				muck	
12 – 14	10YR 5/6	60	10YR 6/1	40	D	M	sand	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains [2]Location: PL=Pore Lining, M=Matrix

Hydric Soil Indicators:

- ___ Histisols (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- X Muck Presence (A8)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Dark-Surface (S7)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ___ Stratified Layers (A5)
- ___ Sandy Mucky Mineral (S1)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: ______

Depth (inches): ______

Hydric Soil Present: **Yes** X **No** ___

Remarks:

Kaena stony clay, 2 to 6% slopes is not on the 2012 list of hydric soils. Soil profile does not confirm mapped soil type. Lower layer (sand) may be Jaucas series.

HYDROLOGY

Wetland Hydrology Indicators: (Explain observations in Remarks, if needed.)

Primary Indicators (minimum of one required: check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- X Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Innundation Visible on Aerial Imagery (B7)
- ___ Water Stained Leaves (B9)
- ___ Aquatic Fauna (B13)
- ___ Tilapia Nests (B17)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres on Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tiled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Fiddler Crab Burrows (C10) (Guam, CNMI, and American Samoa)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Salt Deposits (C5)
- ___ Stunted or Stressed Plants (D1)
- ___ Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- ___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes ___ No X Depth (inches): none

Water Table Present? Yes X No ___ Depth (inches): >14

Saturation Present? (includes capillary fringe) Yes X No ___ Depth (inches): 11

Wetland Hydrology Present? **Yes** X **No** ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:
As of Aug 2014, Punaluu Pump and Punaluu Stream rain gages were at 141% and 114% of year to date average (http://www.prh.noaa.gov/hnl/hydro/pages/oahu_ytd_08.gif)

Hummocky
Negative α, α′ diprydil test throughout soil profile.
Pit dug on a hump, near edge of hau forest.

WETLAND DETERMINATION DATA FORM—Hawai‘i and Pacific Islands

Project/Site: Punalu‘u City: Punalu‘u Sampling Date: Sep 17, 2014 Time: 1100

Applicant/Owner: Kamehameha Schools State/Terr./Comm.: Hawai‘i Island: O‘ahu Sampling Point: **SP 2-9**

Investigator(s): Susan Burr and Chad Linebaugh TMK/Parcel: 5-3-003:001

Landform (hillslope, coastal plain, etc.): coastal plain, floodplain of Punalu‘u Stream Local relief (concave, convex, none): concave

Lat: 21° 34’37.49996”N Long: 157° 53’06.26942 ”W Datum: WGS 84 Slope (%): 0

Soil Map Unit Name: Hanalei stony silty clay, 2 to 6% slopes NWI classification: PEM1A†

Are climactic/hydrologic conditions on the site typical for this time of year: Yes ____ No X‡ (If no, explain in Remarks)

Are Vegetation No , Soil No , or Hydrology No significantly disturbed? Are “Normal Circumstances” present? Yes X No ____

Are Vegetation No , Soil No , or Hydrology No naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS—Attach a site map showing sampling point locations transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X No ____	
Hydric Soil Present?	Yes X No ____	**Is the Sampled Area**
Wetland Hydrology Present?	Yes X No ____	**within a Wetland? Yes X No ____**

Remarks: SP 2-9 is located near a bend in the river.

† PEM1a = temporary, emergent, seasonally flooded palustrine wetland. ‡ See Hydrology Remarks.

VEGETATION—Use scientific names of plants.

Tree Stratum (Plot size: 30-ft radius)	Absolute % Cover	Dominant Species?	Indicator Status
1. None			
2.			
3.			
4.			
5.			
	0 =Total Cover		
Sapling/Shrub Stratum (Plot size: 20-ft radius)			
1. None			
2.			
	0 =Total Cover		
Herb Stratum (Plot size: 5-ft radius)			
1. *Coix lacryma-jobi*	15	Yes	FACW
2. *Sphagneticola trilobata*	20	Yes	FAC
3. *Megathyrsus maximums*	15	Yes	FAC
4. *Commelina diffusa*	5	No	FACW
5. unidentified ginger	3	No	- - -
6. *Eleusine indica*	2	No	FACU
7. *Cyperus polystachyos*	2	No	FACW
8. *Ricinus communis*	2	No	FACU
9. *Amaranthus spinosus*	1	No	FACU
10. *Paederia foetida*	1	No	UPL
11. *Coccinia grandis*	3	No	UPL
12. *Urochloa mutica*	2	No	FACW
	71 =Total Cover		
Woody Vine Stratum (Plot size: 5-ft radius)			
1. None			
	0 =Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 3 (A)

Total Number of Dominant Species Across All Strata: 3 **(B)**

Percent of Dominant Species That Are OBL, FACW, or FAC: 100 (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species ____	x1= ____
FACW species ____	x2= ____
FAC species ____	x3= ____
FACU species ____	x4= ____
UPL species .	x5= ____
Column Totals: ____ (A)	____ (B)

Prevalence Index = B/A= ____

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- X 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ Problematic Hydrophytic Vegetation [1] (Explain in Remarks or in the delineation report)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes X No ____

Remarks:
Trema orientalis located upslope (at higher elevation) and shading plot. Remaining ground is bare.

SOIL

Sampling Point: 2-9

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0 – 6	7.5YR 3/3	100	none				sandy loam	unconsolidated, recently deposited
6 – 18	10YR 4/1	85	5YR 5/8	15	C	M	sandy loam	with river rock
								prominent redox concentrations

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains
[2]Location: PL=Pore Lining, M=Matrix

Hydric Soil Indicators:
- ___ Histisols (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Muck Presence (A8)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Dark-Surface (S7)
- ___ Loamy Gleyed Matrix (F2)
- X Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:
- ___ Stratified Layers (A5)
- ___ Sandy Mucky Mineral (S1)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: ______

Depth (inches): ______

Hydric Soil Present: Yes X No ___

Remarks:

Hanalei stony silty clay, 2 to 6% slopes is on the 2012 list of hydric soils. Soil profile confirms mapped soil type.

HYDROLOGY

Wetland Hydrology Indicators: (Explain observations in Remarks, if needed.)

Primary Indicators (minimum of one required: check all that apply)
- ___ Surface Water (A1)
- X High Water Table (A2)
- X Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Innundation Visible on Aerial Imagery (B7)
- ___ Water Stained Leaves (B9)
- ___ Aquatic Fauna (B13)
- ___ Tilapia Nests (B17)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres on Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tiled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Fiddler Crab Burrows (C10) (Guam, CNMI, and American Samoa)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)
- ___ Surface Soil Cracks (B6)
- X Sparsely Vegetated Concave Surface (B8)
- X Drainage Patterns (B10)
- X Dry-Season Water Table (C2)
- ___ Salt Deposits (C5)
- ___ Stunted or Stressed Plants (D1)
- X Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- X FAC-Neutral Test (D5)

Field Observations:

Surface Water Present?	Yes ___	No X	Depth (inches): none
Water Table Present?	Yes X	No ___	Depth (inches): 12
Saturation Present? (includes capillary fringe)	Yes X	No ___	Depth (inches): 11

Wetland Hydrology Present? Yes X No ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

As of Aug 2014, Punaluu Pump and Punaluu Stream rain gages were at 141% and 114% of year to date average (http://www.prh.noaa.gov/hnl/hydro/pages/oahu_ytd_08.gif)

Two puddles (with fish) located 2 m away.

WETLAND DETERMINATION DATA FORM—Hawai'i and Pacific Islands

Project/Site: Punalu'u City: Punalu'u Sampling Date: Sep 17, 2014 Time: 1345

Applicant/Owner: Kamehameha Schools State/Terr./Comm.: Hawai'i Island: O'ahu Sampling Point: **SP 2-10**

Investigator(s): Susan Burr and Chad Linebaugh TMK/Parcel: 5-3-003:001

Landform (hillslope, coastal plain, etc.): coastal plain, berm of Punalu'u Stream Local relief (concave, convex, none): convex

Lat: 21° 34'37.75782"N Long: 157° 53'05.79385 "W Datum: WGS 84 Slope (%): 1

Soil Map Unit Name: Hanalei stony silty clay, 2 to 6% slopes NWI classification: Non-wetland (PEM1C† on NWI map)

Are climactic/hydrologic conditions on the site typical for this time of year: Yes ____ No X‡ (If no, explain in Remarks)

Are Vegetation No, Soil No, or Hydrology No significantly disturbed? Are "Normal Circumstances" present? Yes X No ____

Are Vegetation No, Soil No, or Hydrology No naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS—Attach a site map showing sampling point locations transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No	**Is the Sampled Area within a Wetland? Yes ____ No X**
Hydric Soil Present?	Yes	No X	
Wetland Hydrology Present?	Yes X	No	

Remarks: SP 2-10 is located approximately 15 m away from SP 2-9. † PEM1C = persistent, emergent, seasonally flooded palustrine wetland

‡ See Hydrology Remarks.

VEGETATION—Use scientific names of plants.

Tree Stratum (Plot size: 30-ft radius)	Absolute % Cover	Dominant Species?	Indicator Status
1. *Macaranga tanarius*	3	Yes	FAC
2.			
3.			
4.			
5.			
	3 =Total Cover		
Sapling/Shrub Stratum (Plot size: 20-ft radius)			
1. None			
2.			
3.			
5.			
	0 =Total Cover		
Herb Stratum (Plot size: 5-ft radius)			
1. *Megathyrsus maximums*	90	Yes	FAC
2. *Diplazium esculentum*	20	Yes	FACW
3. *Paederia foetida*	2	No	UPL
4. *Commelina diffusa*	5	No	FACW
5.			
6.			
7.			
8.			
9.			
	117 =Total Cover		
Woody Vine Stratum (Plot size: 5-ft radius)			
1. None			
2.			
	0 =Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 3 (A)

Total Number of Dominant Species Across All Strata: 3 **(B)**

Percent of Dominant Species That Are OBL, FACW, or FAC: 100 (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species ____	x1= ____
FACW species ____	x2= ____
FAC species ____	x3= ____
FACU species ____	x4= ____
UPL species .	x5= ____
Column Totals: ____ (A)	____ (B)

Prevalence Index = B/A= ____

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- X 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ Problematic Hydrophytic Vegetation [1] (Explain in Remarks or in the delineation report)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes X No ____

Remarks: *Trema orientalis* located upslope (at higher elevation) and shading plot. Remaining ground is bare.

SOIL **Sampling Point: 2-10**

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0 – 8	10YR 3/3	100	none				silt loam	
8 – 16	10YR 3/3	99	10YR 5/8	1	C	PL	sandy loam	prominent redox concentrations

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains [2]Location: PL=Pore Lining, M=Matrix

Hydric Soil Indicators:
- ___ Histisols (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Muck Presence (A8)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Dark-Surface (S7)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:
- ___ Stratified Layers (A5)
- ___ Sandy Mucky Mineral (S1)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type:________

Depth (inches):________

Hydric Soil Present: Yes ____ **No** X

Remarks:

Hanalei stony silty clay, 2 to 6% slopes is on the 2012 list of hydric soils. Soil profile does not confirm mapped soil type.

HYDROLOGY

Wetland Hydrology Indicators: (Explain observations in Remarks, if needed.)

Primary Indicators (minimum of one required: check all that apply)
- ___ Surface Water (A1)
- X High Water Table (A2)
- X Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Water Stained Leaves (B9)
- ___ Aquatic Fauna (B13)
- ___ Tilapia Nests (B17)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres on Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tiled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Fiddler Crab Burrows (C10) (Guam, CNMI, and American Samoa)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)
- ___ Surface Soil Cracks (B6)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Drainage Patterns (B10)
- X Dry-Season Water Table (C2)
- ___ Salt Deposits (C5)
- ___ Stunted or Stressed Plants (D1)
- ___ Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- X FAC-Neutral Test (D5)

Field Observations:

Surface Water Present?	Yes ___	No X	Depth (inches): none
Water Table Present?	Yes X	No ___	Depth (inches): 12
Saturation Present? (includes capillary fringe)	Yes X	No ___	Depth (inches): 12

Wetland Hydrology Present? Yes X **No** ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

As of Aug 2014, Punaluu Pump and Punaluu Stream rain gages were at 141% and 114% of year to date average (http://www.prh.noaa.gov/hnl/hydro/pages/oahu_ytd_08.gif)

Negative α, α′ diprydil test throughout soil profile.

WETLAND DETERMINATION DATA FORM—Hawaiʻi and Pacific Islands

Project/Site: Punaluʻu City: Punaluʻu Sampling Date: Sep 18, 2014 Time: 1215

Applicant/Owner: Kamehameha Schools State/Terr./Comm.: Hawaiʻi Island: Oʻahu Sampling Point: **SP 2-11**

Investigator(s): Susan Burr and Chad Linebaugh TMK/Parcel: 5-3-004:002

Landform (hillslope, coastal plain, etc.): coastal plain Local relief (concave, convex, none): none

Lat: 21° 34'39.164"N (approx.) Long: 157° 53'09.329 "W (approx.) Datum: WGS 84 Slope (%): 0

Soil Map Unit Name: Kaena stony clay, 2 to 6% slopes NWI classification: PF03C (also on NWI map)

Are climactic/hydrologic conditions on the site typical for this time of year: Yes___ No X‡ (If no, explain in Remarks)

Are Vegetation No , Soil No , or Hydrology No significantly disturbed? Are "Normal Circumstances" present? Yes X No___

Are Vegetation No , Soil No , or Hydrology No naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS—Attach a site map showing sampling point locations transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X No ___	
Hydric Soil Present?	Yes X No ___	**Is the Sampled Area**
Wetland Hydrology Present?	Yes X No ___	**within a Wetland? Yes X No___**

Remarks: † PF03C = seasonally flooded, broad-leaved evergreen forested palustrine wetland.

‡ See Hydrology Remarks.

VEGETATION—Use scientific names of plants.

Tree Stratum (Plot size: 30-ft radius)	Absolute % Cover	Dominant Species?	Indicator Status
1. *Talipariti tiliaceum*	98	Yes	FAC
2.			
3.			
4.			
5.			
	98 =Total Cover		
Sapling/Shrub Stratum (Plot size: 20-ft radius)			
1. None			
2.			
3.			
4.			
5.			
	0 =Total Cover		
Herb Stratum (Plot size: 5-ft radius)			
1. None			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
	0 =Total Cover		
Woody Vine Stratum (Plot size: 5-ft radius)			
1. None			
2.			
	0 =Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 1 (A)

Total Number of Dominant Species Across All Strata: 1 **(B)**

Percent of Dominant Species That Are OBL, FACW, or FAC: 100 (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species ___	x1= ___
FACW species ___	x2= ___
FAC species ___	x3= ___
FACU species ___	x4= ___
UPL species ___	x5= ___
Column Totals: ___ (A)	___ (B)

Prevalence Index = B/A= ___

Hydrophytic Vegetation Indicators:

___ 1 - Rapid Test for Hydrophytic Vegetation

X 2 - Dominance Test is >50%

___ 3 - Prevalence Index is ≤3.0[1]

___ Problematic Hydrophytic Vegetation [1] (Explain in Remarks or in the delineation report)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes X No___

Remarks:
Plot is located about 2.5 m in from the edge of the *Megathyrsus maximus* and *hau* interface.

SOIL **Sampling Point: 2-11**

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0 – 6	7.5YR 2.5/2	100	none				silty clay loam	
6 –12	7.5YR 4/2	90	7.5YR 6/8	10	C	M	silty clay loam	prominent redox concentrations

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains [2]Location: PL=Pore Lining, M=Matrix

Hydric Soil Indicators:

___ Histisols (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Muck Presence (A8)
_X_ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Dark-Surface (S7)
___ Loamy Gleyed Matrix (F2)
___ Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

___ Stratified Layers (A5)
___ Sandy Mucky Mineral (S1)
___ Red Parent Material (TF2)
___ Very Shallow Dark Surface (TF12)
___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type:___

Depth (inches):___

Hydric Soil Present: **Yes** _X_ **No** ___

Remarks:

Kaena stony clay, 2 to 6% slopes is not on the 2012 list of hydric soils. Soil profile confirms mapped soil type.

HYDROLOGY

Wetland Hydrology Indicators: (Explain observations in Remarks, if needed.)

Primary Indicators (minimum of one required: check all that apply)

___ Surface Water (A1)
_X_ High Water Table (A2)
_X_ Saturation (A3)
___ Water Marks (B1)
___ Sediment Deposits (B2)
___ Drift Deposits (B3)
___ Algal Mat or Crust (B4)
___ Iron Deposits (B5)
___ Innundation Visible on Aerial Imagery (B7)
_X_ Water Stained Leaves (B9)
___ Aquatic Fauna (B13)
___ Tilapia Nests (B17)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres on Living Roots (C3)
_X_ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Tiled Soils (C6)
___ Thin Muck Surface (C7)
___ Fiddler Crab Burrows (C10) (Guam, CNMI, and American Samoa)
___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

___ Surface Soil Cracks (B6)
___ Sparsely Vegetated Concave Surface (B8)
___ Drainage Patterns (B10)
_X_ Dry-Season Water Table (C2)
___ Salt Deposits (C5)
___ Stunted or Stressed Plants (D1)
___ Geomorphic Position (D2)
___ Shallow Aquitard (D3)
___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes___ No _X_ Depth (inches): none

Water Table Present? Yes _X_ No___ Depth (inches): 6

Saturation Present? (includes capillary fringe) Yes _X_ No___ Depth (inches): 6

Wetland Hydrology Present? **Yes** _X_ **No** ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

As of Aug 2014, Punaluu Pump and Punaluu Stream rain gages were at 141% and 114% of year to date average (http://www.prh.noaa.gov/hnl/hydro/pages/oahu_ytd_08.gif)

Positive α, α′ diprydil test at 6 in.

WETLAND DETERMINATION DATA FORM—Hawaiʻi and Pacific Islands

Project/Site: Punaluʻu City: Punaluʻu Sampling Date: Sep 18, 2014 Time: 1245

Applicant/Owner: Kamehameha Schools State/Terr./Comm.: Hawaiʻi Island: Oʻahu Sampling Point: **SP 2-12**

Investigator(s): Susan Burr and Chad Linebaugh TMK/Parcel: 5-3-004:002

Landform (hillslope, coastal plain, etc.): coastal plain Local relief (concave, convex, none): none

Lat: 21° 34'38.92523"N Long: 157° 53'09.31647 "W Datum: WGS 84 Slope (%): 0

Soil Map Unit Name: Kaena stony clay, 2 to 6% slopes NWI classification: PEM1A (PEM1C† on NWI map)

Are climactic/hydrologic conditions on the site typical for this time of year: Yes ____ No X‡ (If no, explain in Remarks)

Are Vegetation No , Soil No , or Hydrology No significantly disturbed? Are "Normal Circumstances" present? Yes X No ____

Are Vegetation No , Soil No , or Hydrology No naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS—Attach a site map showing sampling point locations transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No ____	
Hydric Soil Present?	Yes X	No ____	**Is the Sampled Area**
Wetland Hydrology Present?	Yes X	No ____	**within a Wetland? Yes X No ____**

Remarks: † PEM1C = persistent, emergent, seasonally flooded palustrine wetland PEM1A = persistent, emergent, temporary flooded palustrine wetland

‡ See Hydrology Remarks.

VEGETATION—Use scientific names of plants.

	Absolute % Cover	Dominant Species?	Indicator Status
Tree Stratum (Plot size: 30-ft radius)			
1. None			
2.			
3.			
4.			
5.			
	0	=Total Cover	
Sapling/Shrub Stratum (Plot size: 20-ft radius)			
1. *Talipariti tiliaceum*	5	Yes	FAC
2.			
3.			
4.			
5.			
	5	=Total Cover	
Herb Stratum (Plot size: 5-ft radius)			
1. *Megathyrsus maximums*	95	Yes	FAC
2. *Commelina diffusa*	2	No	FACW
3. *Paederia foetida*	3	No	UPL
4.			
5.			
6.			
7.			
8.			
	100	=Total Cover	
Woody Vine Stratum (Plot size: 5-ft radius)			
1. None			
2.			
	0	=Total Cover	

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 2 (A)

Total Number of Dominant Species Across All Strata: 2 **(B)**

Percent of Dominant Species That Are OBL, FACW, or FAC: 100 (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species ____	x1= ____
FACW species ____	x2= ____
FAC species ____	x3= ____
FACU species ____	x4= ____
UPL species ____	x5= ____
Column Totals: ____ (A)	____ (B)

Prevalence Index = B/A= ____

Hydrophytic Vegetation Indicators:

____ 1 - Rapid Test for Hydrophytic Vegetation

X 2 - Dominance Test is >50%

____ 3 - Prevalence Index is ≤3.0[1]

____ Problematic Hydrophytic Vegetation [1] (Explain in Remarks or in the delineation report)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes X No ____

Remarks: Plot is located about 2.5 m in from the edge of the *Megathyrsus maximus* and *hau* interface.

SOIL **Sampling Point: 2-12**

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
+6 - 0								duff and stems
0 – 9	7.5YR 2.5/2	100	none				silty clay loam	
9 –16	7.5YR 4/21	90	5YR 7/6	10	C	M	silty clay loam	prominent redox concentrations

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains [2]Location: PL=Pore Lining, M=Matrix

Hydric Soil Indicators:

___ Histisols (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Muck Presence (A8)
X Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Dark-Surface (S7)
___ Loamy Gleyed Matrix (F2)
___ Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

___ Stratified Layers (A5)
___ Sandy Mucky Mineral (S1)
___ Red Parent Material (TF2)
___ Very Shallow Dark Surface (TF12)
___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type:

Depth (inches):

Hydric Soil Present: Yes X No

Remarks:

Kaena stony clay, 2 to 6% slopes is not on the 2012 list of hydric soils. Soil profile confirms mapped soil type.

HYDROLOGY

Wetland Hydrology Indicators: (Explain observations in Remarks, if needed.)

Primary Indicators (minimum of one required: check all that apply)

___ Surface Water (A1)
___ High Water Table (A2)
X Saturation (A3)
___ Water Marks (B1)
___ Sediment Deposits (B2)
___ Drift Deposits (B3)
___ Algal Mat or Crust (B4)
___ Iron Deposits (B5)
___ Innundation Visible on Aerial Imagery (B7)
___ Water Stained Leaves (B9)
___ Aquatic Fauna (B13)
___ Tilapia Nests (B17)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres on Living Roots (C3)
X Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Tiled Soils (C6)
___ Thin Muck Surface (C7)
___ Fiddler Crab Burrows (C10) (Guam, CNMI, and American Samoa)
___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

___ Surface Soil Cracks (B6)
___ Sparsely Vegetated Concave Surface (B8)
___ Drainage Patterns (B10)
X Dry-Season Water Table (C2)
___ Salt Deposits (C5)
___ Stunted or Stressed Plants (D1)
___ Geomorphic Position (D2)
___ Shallow Aquitard (D3)
___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes___ No X Depth (inches): none

Water Table Present? Yes X No___ Depth (inches): 14

Saturation Present? (includes capillary fringe) Yes X No___ Depth (inches): 12

Wetland Hydrology Present? Yes X No

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

As of Aug 2014, Punaluu Pump and Punaluu Stream rain gages were at 141% and 114% of year to date average (http://www.prh.noaa.gov/hnl/hydro/pages/oahu_ytd_08.gif)

Positive α, α′ diprydil test.

WETLAND DETERMINATION DATA FORM—Hawaiʻi and Pacific Islands

Project/Site: Punaluʻu City: Punaluʻu Sampling Date: Sep 18, 2014 Time: 1313

Applicant/Owner: Kamehameha Schools State/Terr./Comm.: Hawaiʻi Island: Oʻahu Sampling Point: **SP 2-13**

Investigator(s): Susan Burr and Chad Linebaugh TMK/Parcel: 5-3-004:002

Landform (hillslope, coastal plain, etc.): coastal plain Local relief (concave, convex, none): concave

Lat: 21° 34'81.81747"N Long: 157° 53'09.29456 "W Datum: WGS 84 Slope (%): <1

Soil Map Unit Name: Kaena stony clay, 2 to 6% slopes NWI classification: PEM1A (PEM1C on NWI map)

Are climactic/hydrologic conditions on the site typical for this time of year: Yes ____ No X‡ (If no, explain in Remarks)

Are Vegetation No , Soil No , or Hydrology No significantly disturbed? Are "Normal Circumstances" present? Yes X No ____

Are Vegetation No , Soil No , or Hydrology No naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS—Attach a site map showing sampling point locations transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X No ____	
Hydric Soil Present?	Yes ____ No X	**Is the Sampled Area**
Wetland Hydrology Present?	Yes ____ No X	**within a Wetland? Yes ____ No X**

Remarks: † PEM1C = persistent, emergent, seasonally flooded palustrine wetland PEM1A = persistent, emergent, temporary flooded palustrine wetland ‡ See Hydrology Remarks.

VEGETATION—Use scientific names of plants.

Tree Stratum (Plot size: 30-ft radius)	Absolute % Cover	Dominant Species?	Indicator Status
1. None			
2.			
3.			
4.			
5.			
	0 =Total Cover		
Sapling/Shrub Stratum (Plot size: 20-ft radius)			
1. None			
2.			
3.			
4.			
5.			
	0 =Total Cover		
Herb Stratum (Plot size: 5-ft radius)			
1. *Megathyrsus maximums*	96	Yes	FAC
2. *Macroptilium atropurpureum*	1	No	FACU
3. *Paederia foetida*	2	No	UPL
4. *Ipomoea alba*	1	No	FAC
5.			
6.			
7.			
8.			
	100 =Total Cover		
Woody Vine Stratum (Plot size: 5-ft radius)			
1. None			
2.			
	0 =Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 1 (A)

Total Number of Dominant Species Across All Strata: 1 **(B)**

Percent of Dominant Species That Are OBL, FACW, or FAC: 100 (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species ____	x1= ____
FACW species ____	x2= ____
FAC species ____	x3= ____
FACU species ____	x4= ____
UPL species ____	x5= ____
Column Totals: ____ (A)	____ (B)

Prevalence Index = B/A= ____

Hydrophytic Vegetation Indicators:

____ 1 - Rapid Test for Hydrophytic Vegetation
X 2 - Dominance Test is >50%
____ 3 - Prevalence Index is ≤3.0[1]
____ Problematic Hydrophytic Vegetation [1] (Explain in Remarks or in the delineation report)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes X No ____

Remarks: Plot is located about 2.5 m in from the edge of the *Megathyrsus maximus* and *hau* interface.

SOIL **Sampling Point: 2-13**

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0 – 12	10YR 3/2	100	none				silty clay loam	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains [2]Location: PL=Pore Lining, M=Matrix

Hydric Soil Indicators:

- ___ Histisols (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Muck Presence (A8)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Dark-Surface (S7)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ___ Stratified Layers (A5)
- ___ Sandy Mucky Mineral (S1)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: ______

Depth (inches): ______

Hydric Soil Present: Yes ______ No X

Remarks:

Kaena stony clay, 2 to 6% slopes is not on the 2012 list of hydric soils. Soil profile does not confirm mapped soil type.

HYDROLOGY

Wetland Hydrology Indicators: (Explain observations in Remarks, if needed.)

Primary Indicators (minimum of one required: check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Water Stained Leaves (B9)
- ___ Aquatic Fauna (B13)
- ___ Tilapia Nests (B17)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres on Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tiled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Fiddler Crab Burrows (C10) (Guam, CNMI, and American Samoa)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Salt Deposits (C5)
- ___ Stunted or Stressed Plants (D1)
- ___ Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- ___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present?	Yes ______	No X	Depth (inches): none
Water Table Present?	Yes ______	No X	Depth (inches): >12
Saturation Present? (includes capillary fringe)	Yes ______	No X	Depth (inches): >12

Wetland Hydrology Present? Yes ______ No X

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

As of Aug 2014, Punaluu Pump and Punaluu Stream rain gages were at 141% and 114% of year to date average (http://www.prh.noaa.gov/hnl/hydro/pages/oahu_ytd_08.gif)

WETLAND DETERMINATION DATA FORM—Hawai'i and Pacific Islands

Project/Site: Punalu'u City: Punalu'u Sampling Date: Oct 2, 2014 Time: 1040

Applicant/Owner: Kamehameha Schools State/Terr./Comm.: Hawai'i Island: O'ahu Sampling Point: **SP 2-14**

Investigator(s): Susan Burr and Chad Linebaugh TMK/Parcel: 5-3-003:001

Landform (hillslope, coastal plain, etc.): coastal plain Local relief (concave, convex, none): concave

Lat: 21° 34'38.54515"N Long: 157° 53'05.21531 "W Datum: WGS 84 Slope (%): <1

Soil Map Unit Name: Pearl Harbor clay NWI classification: PF03C† (not on NWI map)

Are climactic/hydrologic conditions on the site typical for this time of year: Yes ___ No X‡ (If no, explain in Remarks)

Are Vegetation No , Soil No , or Hydrology No significantly disturbed? Are "Normal Circumstances" present? Yes X No ___

Are Vegetation No , Soil No , or Hydrology No naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS—Attach a site map showing sampling point locations transects, important features, etc.

Hydrophytic Vegetation Present? Yes X No ___		
Hydric Soil Present? Yes X No ___	Is the Sampled Area	
Wetland Hydrology Present? Yes X No ___	**within a Wetland? Yes X No ___**	

Remarks: SP 2-14 is located farther in the *hau* forest than SP-08. † PF03C = seasonally flooded, broad-leaved evergreen forested palustrine wetland.
‡ See Hydrology Remarks.

VEGETATION—Use scientific names of plants.

Tree Stratum (Plot size: 30-ft radius)	Absolute % Cover	Dominant Species?	Indicator Status
1. *Talipariti tiliaceum*	99	Yes	FAC
2.			
3.			
4.			
5.			
	99 =Total Cover		
Sapling/Shrub Stratum (Plot size: 20-ft radius)			
1. None			
2.			
3.			
4.			
5.			
	=Total Cover		
Herb Stratum (Plot size: 5-ft radius)			
1. None			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
	0 =Total Cover		
Woody Vine Stratum (Plot size: 5-ft radius)			
1. None			
2.			
	0 =Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 1 (A)

Total Number of Dominant Species Across All Strata: 1 **(B)**

Percent of Dominant Species That Are OBL, FACW, or FAC: 100 (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species ___	x1= ___
FACW species ___	x2= ___
FAC species ___	x3= ___
FACU species ___	x4= ___
UPL species ___	x5= ___
Column Totals: ___ (A)	___ (B)

Prevalence Index = B/A= ___

Hydrophytic Vegetation Indicators:

___ 1 - Rapid Test for Hydrophytic Vegetation

X 2 - Dominance Test is >50%

___ 3 - Prevalence Index is ≤3.0[1]

___ Problematic Hydrophytic Vegetation [1] (Explain in Remarks or in the delineation report)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes X No ___

Remarks:

SOIL

Sampling Point: 2-14

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0 – 8	10YR 3/1	100	none				sandy clay loam	very high in organics
8 – 16	Gley 1 4/N	98	7.5YR 4/8	2	C	M	silty clay loam	higher in organics than above layer

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains [2]Location: PL=Pore Lining, M=Matrix

Hydric Soil Indicators:

- ___ Histisols (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Muck Presence (A8)
- X Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Dark-Surface (S7)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ___ Stratified Layers (A5)
- ___ Sandy Mucky Mineral (S1)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: ______

Depth (inches): ______

Hydric Soil Present: Yes X No ___

Remarks:

Pearl Harbor clay is not on the 2012 list of hydric soils. Soil confirms mapped soil type.

HYDROLOGY

Wetland Hydrology Indicators: (Explain observations in Remarks, if needed.)

Primary Indicators (minimum of one required: check all that apply)

- X Surface Water (A1)
- X High Water Table (A2)
- X Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Inundation Visible on Aerial Imagery (B7)
- X Water Stained Leaves (B9)
- ___ Aquatic Fauna (B13)
- ___ Tilapia Nests (B17)
- ___ Hydrogen Sulfide Odor (C1)
- X Oxidized Rhizospheres on Living Roots (C3)
- X Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tiled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Fiddler Crab Burrows (C10) (Guam, CNMI, and American Samoa)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Salt Deposits (C5)
- ___ Stunted or Stressed Plants (D1)
- ___ Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- ___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes X No ___ Depth (inches): 3

Water Table Present? Yes X No ___ Depth (inches): at surface

Saturation Present? (includes capillary fringe) Yes X No ___ Depth (inches): at surface

Wetland Hydrology Present? Yes X No ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

As of Aug 2014, Punaluu Pump and Punaluu Stream rain gages were at 141% and 114% of year to date average (http://www.prh.noaa.gov/hnl/hydro/pages/oahu_ytd_08.gif)

Hummocky
Positive α, α′ diprydil test at 8 inches.

WETLAND DETERMINATION DATA FORM—Hawai‘i and Pacific Islands

Project/Site: Punalu‘u City: Punalu‘u Sampling Date: Sep 2, 2014 Time: 1440

Applicant/Owner: Kamehameha Schools State/Terr./Comm.: Hawai‘i Island: O‘ahu Sampling Point: **SP 3-1**

Investigator(s): Susan Burr and Chad Linebaugh TMK/Parcel: 5-3-003:001

Landform (hillslope, coastal plain, etc.): coastal plain Local relief (concave, convex, none): concave

Lat: 21° 34’32.83”N Long: 157° 53’08.74 ”W Datum: WGS 84 Slope (%): <1

Soil Map Unit Name: Hanalei stony clay, 2 to 6% slopes NWI classification: Non-wetland (not on NWI map)

Are climactic/hydrologic conditions on the site typical for this time of year: Yes____ No X‡ (If no, explain in Remarks)

Are Vegetation No , Soil No , or Hydrology No significantly disturbed? Are “Normal Circumstances” present? Yes X No____

Are Vegetation No , Soil No , or Hydrology No naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS—Attach a site map showing sampling point locations transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X No ____	
Hydric Soil Present?	Yes ____ No X	**Is the Sampled Area**
Wetland Hydrology Present?	Yes ____ No X	**within a Wetland? Yes____ No X**

Remarks: ‡ See Hydrology Remarks.

VEGETATION—Use scientific names of plants.

Tree Stratum (Plot size: 50-m radius)	Absolute % Cover	Dominant Species?	Indicator Status
1. None			
2.			
3.			
4.			
5.			
	0 =Total Cover		
Sapling/Shrub Stratum (Plot size: 50-m radius)			
1. None			
2.			
3.			
4.			
5.			
	0 =Total Cover		
Herb Stratum (Plot size: 50-m radius)			
1. *Megathyrsus maximums*	100	Yes	FAC
2.			
3.			
4.			
5.			
6.			
7.			
8.			
	100 =Total Cover		
Woody Vine Stratum (Plot size: 50-m radius)			
1. None			
2.			
	0 =Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 1 (A)

Total Number of Dominant Species Across All Strata: 1 **(B)**

Percent of Dominant Species That Are OBL, FACW, or FAC: 100 (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species		x1=
FACW species		x2=
FAC species		x3=
FACU species		x4=
UPL species		x5=
Column Totals:	(A)	(B)

Prevalence Index = B/A=____

Hydrophytic Vegetation Indicators:

___ 1 - Rapid Test for Hydrophytic Vegetation

X 2 - Dominance Test is >50%

___ 3 - Prevalence Index is ≤3.0[1]

___ Problematic Hydrophytic Vegetation [1] (Explain in Remarks or in the delineation report)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes X No____

Remarks:

SOIL

Sampling Point: 3-1

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0 – 21	10YR 3/3	100	none				sandy loam	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains

[2]Location: PL=Pore Lining, M=Matrix

Hydric Soil Indicators:

___ Histisols (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Muck Presence (A8)
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Dark-Surface (S7)
___ Loamy Gleyed Matrix (F2)
___ Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

___ Stratified Layers (A5)
___ Sandy Mucky Mineral (S1)
___ Red Parent Material (TF2)
___ Very Shallow Dark Surface (TF12)
___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: ______

Depth (inches): ______

Hydric Soil Present: Yes ______ No X

Remarks:

Hanalei stony clay, 2 to 6% slopes is on the 2012 list of hydric soils. Soil profile does not confirm mapped soil type.

HYDROLOGY

Wetland Hydrology Indicators: (Explain observations in Remarks, if needed.)

Primary Indicators (minimum of one required: check all that apply)

___ Surface Water (A1)
___ High Water Table (A2)
___ Saturation (A3)
___ Water Marks (B1)
___ Sediment Deposits (B2)
___ Drift Deposits (B3)
___ Algal Mat or Crust (B4)
___ Iron Deposits (B5)
___ Inundation Visible on Aerial Imagery (B7)
___ Water Stained Leaves (B9)
___ Aquatic Fauna (B13)
___ Tilapia Nests (B17)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres on Living Roots (C3)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Tiled Soils (C6)
___ Thin Muck Surface (C7)
___ Fiddler Crab Burrows (C10) (Guam, CNMI, and American Samoa)
___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

___ Surface Soil Cracks (B6)
___ Sparsely Vegetated Concave Surface (B8)
___ Drainage Patterns (B10)
___ Dry-Season Water Table (C2)
___ Salt Deposits (C5)
___ Stunted or Stressed Plants (D1)
___ Geomorphic Position (D2)
___ Shallow Aquitard (D3)
___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes ______ No X Depth (inches): none

Water Table Present? Yes ______ No X Depth (inches): >21

Saturation Present? (includes capillary fringe) Yes ______ No X Depth (inches): >21

Wetland Hydrology Present? Yes ______ No X

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

As of Aug 2014, Punaluu Pump and Punaluu Stream rain gages were at 141% and 114% of year to date average (http://www.prh.noaa.gov/hnl/hydro/pages/oahu_ytd_08.gif)

Negative α, α′ diprydil test throughout soil profile.

WETLAND DETERMINATION DATA FORM—Hawai‘i and Pacific Islands

Project/Site: Punalu‘u City: Punalu‘u Sampling Date: Sep 2, 2014 Time: 1505

Applicant/Owner: Kamehameha Schools State/Terr./Comm.: Hawai‘i Island: O‘ahu Sampling Point: **SP 3-2**

Investigator(s): Susan Burr and Chad Linebaugh TMK/Parcel: 5-3-003:001

Landform (hillslope, coastal plain, etc.): coastal plain Local relief (concave, convex, none): concave

Lat: 21° 34'34.58"N Long: 157° 53'08.72"W Datum: WGS 84 Slope (%): <1

Soil Map Unit Name: Hanalei stony clay, 2 to 6% slopes NWI classification: Non-wetland (PFO3† on NWI map)

Are climactic/hydrologic conditions on the site typical for this time of year: Yes ____ No X‡ (If no, explain in Remarks)

Are Vegetation No, Soil No, or Hydrology No significantly disturbed? Are "Normal Circumstances" present? Yes X No ____

Are Vegetation No, Soil No, or Hydrology No naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS—Attach a site map showing sampling point locations transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X No ____		
Hydric Soil Present?	Yes ____ No X	Is the Sampled Area	
Wetland Hydrology Present?	Yes ____ No X	**within a Wetland? Yes ____ No X**	

Remarks: † PF03C = seasonally flooded, broad-leaved evergreen forested palustrine wetland.

‡ See Hydrology Remarks.

VEGETATION—Use scientific names of plants.

Tree Stratum (Plot size: 30-ft radius)	Absolute % Cover	Dominant Species?	Indicator Status
1. *Trema orientalis*	80	Yes	FACU
2. *Pandanus tectorius*	1	No	FAC
3. *Schefflera actinophylla*	1	No	UPL
4.			
5.			
	82 =Total Cover		
Sapling/Shrub Stratum (Plot size: 20-ft radius)			
1. None			
2.			
3.			
4.			
5.			
	0 =Total Cover		
Herb Stratum (Plot size: 5-ft radius)			
1. *Megathyrsus maximums*	25	Yes	FAC
2. *Sphagneticola trilobata*	20	Yes	FAC
3. *Macroptilium atropurpureum*	10	No	FACU
4. *Cyperus involucratus*	<1	No	FACW
5. *Commelina diffusa*	5	No	FACW
6. *Paederia foetida*	5	No	UPL
7. *Aleurites moluccana*	2	No	FACU
8. *Colocasia esculenta*	<2	No	OBL
	<70 =Total Cover		
Woody Vine Stratum (Plot size: 5-ft radius)			
1. None			
2.			
	0 =Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 2 (A)

Total Number of Dominant Species Across All Strata: 3 **(B)**

Percent of Dominant Species That Are OBL, FACW, or FAC: 67 (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species ____	x1= ____
FACW species ____	x2= ____
FAC species ____	x3= ____
FACU species ____	x4= ____
UPL species ____	x5= ____
Column Totals: ____ (A)	____ (B)

Prevalence Index = B/A= ____

Hydrophytic Vegetation Indicators:

____ 1 - Rapid Test for Hydrophytic Vegetation

X 2 - Dominance Test is >50%

____ 3 - Prevalence Index is ≤3.0[1]

____ Problematic Hydrophytic Vegetation [1] (Explain in Remarks or in the delineation report)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes X No ____

Remarks:

SOIL **Sampling Point: 3-2**

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth	Matrix		Redox Features					
(inches)	Color (moist)	%	Color (moist)	%	Type [1]	Loc[2]	Texture	Remarks
0 – 17	10YR 3/2	100	none				silty clay	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains [2]Location: PL=Pore Lining, M=Matrix

Hydric Soil Indicators:

___ Histisols (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Muck Presence (A8)
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Dark-Surface (S7)
___ Loamy Gleyed Matrix (F2)
___ Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

___ Stratified Layers (A5)
___ Sandy Mucky Mineral (S1)
___ Red Parent Material (TF2)
___ Very Shallow Dark Surface (TF12)
___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type:______

Depth (inches):______

Hydric Soil Present: Yes______ No__X__

Remarks:

Hanalei stony clay, 2 to 6% slopes is on the 2012 list of hydric soils. Soil profile does not confirm mapped soil type.

HYDROLOGY

Wetland Hydrology Indicators: (Explain observations in Remarks, if needed.)

Primary Indicators (minimum of one required: check all that apply)

___ Surface Water (A1)
___ High Water Table (A2)
___ Saturation (A3)
___ Water Marks (B1)
___ Sediment Deposits (B2)
___ Drift Deposits (B3)
___ Algal Mat or Crust (B4)
___ Iron Deposits (B5)
___ Inundation Visible on Aerial Imagery (B7)
___ Water Stained Leaves (B9)
___ Aquatic Fauna (B13)
___ Tilapia Nests (B17)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres on Living Roots (C3)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Tiled Soils (C6)
___ Thin Muck Surface (C7)
___ Fiddler Crab Burrows (C10) (Guam, CNMI, and American Samoa)
___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

___ Surface Soil Cracks (B6)
___ Sparsely Vegetated Concave Surface (B8)
___ Drainage Patterns (B10)
___ Dry-Season Water Table (C2)
___ Salt Deposits (C5)
___ Stunted or Stressed Plants (D1)
___ Geomorphic Position (D2)
___ Shallow Aquitard (D3)
___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes______ No__X__ Depth (inches): none

Water Table Present? Yes______ No__X__ Depth (inches): >17

Saturation Present? (includes capillary fringe) Yes______ No__X__ Depth (inches): >17

Wetland Hydrology Present? Yes______ No__X__

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

As of Aug 2014, Punaluu Pump and Punaluu Stream rain gages were at 141% and 114% of year to date average (http://www.prh.noaa.gov/hnl/hydro/pages/oahu_ytd_08.gif)

Wrack on trees provides evidence that Punaluʻu Stream flooded this area during the July 2014 storm. Also, river rocks on surface and uprooted are present.

WETLAND DETERMINATION DATA FORM—Hawai‘i and Pacific Islands

Project/Site: Punalu‘u City: Punalu‘u Sampling Date: Sep 2, 2014 Time: 1550

Applicant/Owner: Kamehameha Schools State/Terr./Comm.: Hawai‘i Island: O‘ahu Sampling Point: **SP 3-3**

Investigator(s): Susan Burr and Chad Linebaugh TMK/Parcel: 5-3-003:001

Landform (hillslope, coastal plain, etc.): coastal plain Local relief (concave, convex, none): concave

Lat: 21° 34’31.48”N Long: 157° 53’00.91”W Datum: WGS 84 Slope (%): <1

Soil Map Unit Name: Kaloko clay, noncalcarous variant NWI classification: Non-wetland (not on NWI map)

Are climactic/hydrologic conditions on the site typical for this time of year: Yes ____ No X‡ (If no, explain in Remarks)

Are Vegetation No , Soil No , or Hydrology No significantly disturbed? Are “Normal Circumstances” present? Yes X No ____

Are Vegetation No , Soil No , or Hydrology No naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS—Attach a site map showing sampling point locations transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X No ____	
Hydric Soil Present?	Yes ____ No X	**Is the Sampled Area**
Wetland Hydrology Present?	Yes ____ No X	**within a Wetland? Yes ____ No X**

Remarks: ‡ See Hydrology Remarks.

VEGETATION—Use scientific names of plants.

Tree Stratum (Plot size: 30-ft radius)	Absolute % Cover	Dominant Species?	Indicator Status
1. None			
2.			
3.			
4.			
5.			
	0 =Total Cover		
Sapling/Shrub Stratum (Plot size: 20-ft radius)			
1. None			
2.			
3.			
4.			
5.			
	0 =Total Cover		
Herb Stratum (Plot size: 5-ft radius)			
1. *Urochloa mutica*	80	Yes	FACW
2. *Bidens alba*	15	No	UPL
3. *Macroptilium atropurpureum*	5	No	FAC
4.			
5.			
6.			
7.			
8.			
	100 =Total Cover		
Woody Vine Stratum (Plot size: 5-ft radius)			
1. None			
2.			
	0 =Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: ____ (A)

Total Number of Dominant Species Across All Strata: ____ **(B)**

Percent of Dominant Species That Are OBL, FACW, or FAC: ____ (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species ____	x1= ____
FACW species ____	x2= ____
FAC species ____	x3= ____
FACU species ____	x4= ____
UPL species ____	x5= ____
Column Totals: ____ (A)	____ (B)

Prevalence Index = B/A= ____

Hydrophytic Vegetation Indicators:

X 1 - Rapid Test for Hydrophytic Vegetation

___ 2 - Dominance Test is >50%

___ 3 - Prevalence Index is ≤3.0[1]

___ Problematic Hydrophytic Vegetation [1] (Explain in Remarks or in the delineation report)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes X No ____

Remarks:

SOIL **Sampling Point:** 3-3

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type [1]	Loc [2]	Texture	Remarks
0 – 4	10YR 3/1	100	none				sandy loam	
4 – 5	gravel	100						

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains [2]Location: PL=Pore Lining, M=Matrix

Hydric Soil Indicators:

___ Histisols (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Muck Presence (A8)
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Dark-Surface (S7)
___ Loamy Gleyed Matrix (F2)
___ Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

___ Stratified Layers (A5)
___ Sandy Mucky Mineral (S1)
___ Red Parent Material (TF2)
___ Very Shallow Dark Surface (TF12)
___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type:______

Depth (inches):______

Hydric Soil Present: Yes______ **No** X

Remarks:

Kaloko clay, noncalcareous variant is on the 2012 list of hydric soils. Soil profile does not confirm mapped soil type; it appears to be fill.

HYDROLOGY

Wetland Hydrology Indicators: (Explain observations in Remarks, if needed.)

Primary Indicators (minimum of one required: check all that apply)

___ Surface Water (A1)
___ High Water Table (A2)
___ Saturation (A3)
___ Water Marks (B1)
___ Sediment Deposits (B2)
___ Drift Deposits (B3)
___ Algal Mat or Crust (B4)
___ Iron Deposits (B5)
___ Inundation Visible on Aerial Imagery (B7)
___ Water Stained Leaves (B9)
___ Aquatic Fauna (B13)
___ Tilapia Nests (B17)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres on Living Roots (C3)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Tiled Soils (C6)
___ Thin Muck Surface (C7)
___ Fiddler Crab Burrows (C10) (Guam, CNMI, and American Samoa)
___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

___ Surface Soil Cracks (B6)
___ Sparsely Vegetated Concave Surface (B8)
___ Drainage Patterns (B10)
___ Dry-Season Water Table (C2)
___ Salt Deposits (C5)
___ Stunted or Stressed Plants (D1)
___ Geomorphic Position (D2)
___ Shallow Aquitard (D3)
___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes______ No X Depth (inches): none

Water Table Present? Yes______ No X Depth (inches): >17

Saturation Present? (includes capillary fringe) Yes______ No X Depth (inches): >17

Wetland Hydrology Present? Yes______ **No** X

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

As of Aug 2014, Punaluu Pump and Punaluu Stream rain gages were at 141% and 114% of year to date average (http://www.prh.noaa.gov/hnl/hydro/pages/oahu_ytd_08.gif)

Field was recently used as a construction staging area for Punaluʻu Bridge replacement project.

WETLAND DETERMINATION DATA FORM—Hawai‘i and Pacific Islands

Project/Site: Punalu‘u City: Punalu‘u Sampling Date: Sep 4, 2014 Time: 1137

Applicant/Owner: Kamehameha Schools State/Terr./Comm.: Hawai‘i Island: O‘ahu Sampling Point: **SP 3-4**

Investigator(s): Susan Burr and Chad Linebaugh TMK/Parcel: 5-3-003:001

Landform (hillslope, coastal plain, etc.): coastal plain Local relief (concave, convex, none): concave

Lat: 21° 34’29.94337”N Long: 157° 52’58.55286 ”W Datum: WGS 84 Slope (%): <1

Soil Map Unit Name: Pearl Harbor clay NWI classification: Non-wetland (not on NWI map)

Are climactic/hydrologic conditions on the site typical for this time of year: Yes ____ No X‡ (If no, explain in Remarks)

Are Vegetation No , Soil No , or Hydrology No significantly disturbed? Are “Normal Circumstances” present? Yes X No ____

Are Vegetation No , Soil No , or Hydrology No naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS—Attach a site map showing sampling point locations transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X No ____	
Hydric Soil Present?	Yes X No ____	**Is the Sampled Area**
Wetland Hydrology Present?	Yes ____ No X	**within a Wetland? Yes ____ No X**

Remarks: SP 3-4 is located at an open trench excavated for archaeological survey. ‡ See Hydrology Remarks.

VEGETATION—Use scientific names of plants.

Tree Stratum (Plot size: 30-ft radius)	Absolute % Cover	Dominant Species?	Indicator Status
1. None			
2.			
3.			
4.			
5.			
	0 =Total Cover		
Sapling/Shrub Stratum (Plot size: 20-ft radius)			
1. *Ricinus communis*	4	Yes	FACU
2. *Indigo suffruticosa*	<1	No	UPL
3.			
4.			
5.			
	<5 =Total Cover		
Herb Stratum (Plot size: 5-ft radius)			
1. *Urochloa mutica*	98	Yes	FACW
2. *Megathyrsus maximus*	2	No	FAC
3.			
4.			
5.			
6.			
7.			
8.			
	100 =Total Cover		
Woody Vine Stratum (Plot size: 5-ft radius)			
1. None			
2.			
	0 =Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 1 (A)

Total Number of Dominant Species Across All Strata: 1 **(B)**

Percent of Dominant Species That Are OBL, FACW, or FAC: 50 (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species	0	x1= 0
FACW species	98	x2= 196
FAC species	2	x3= 6
FACU species	4	x4= 16
UPL species	.5	x5= 2.5
Column Totals:	104.5 (A)	222.5 (B)

Prevalence Index = B/A= 2.2

Hydrophytic Vegetation Indicators:

___ 1 - Rapid Test for Hydrophytic Vegetation

___ 2 - Dominance Test is >50%

X 3 - Prevalence Index is ≤3.0[1]

___ Problematic Hydrophytic Vegetation [1] (Explain in Remarks or in the delineation report)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes X No ____

Remarks:

SOIL

Sampling Point: 3-4

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0 – 3	10YR 3/2	100	none				sandy clay loam	
3 –12	10YR 3/2	50					clay	
	10YR 3/1	50						
12 – 20	10YR 3/1	98	10YR 5/8	2	PL		clay	
>20							sand	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains [2]Location: PL=Pore Lining, M=Matrix

Hydric Soil Indicators:

___ Histisols (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Muck Presence (A8)
_X_ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Dark-Surface (S7)
___ Loamy Gleyed Matrix (F2)
___ Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

___ Stratified Layers (A5)
___ Sandy Mucky Mineral (S1)
___ Red Parent Material (TF2)
___ Very Shallow Dark Surface (TF12)
___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: ____________

Depth (inches): ____________

Hydric Soil Present: Yes X No ___

Remarks:

Pearl Harbor clay is on the 2012 list of hydric soils. Soil profile does not confirm mapped soil type (more closely resembles Mokuleia clay loam, which is not on the 2012 list of hydric soils).

HYDROLOGY

Wetland Hydrology Indicators: (Explain observations in Remarks, if needed.)

Primary Indicators (minimum of one required: check all that apply)

___ Surface Water (A1)
___ High Water Table (A2)
___ Saturation (A3)
___ Water Marks (B1)
___ Sediment Deposits (B2)
___ Drift Deposits (B3)
___ Algal Mat or Crust (B4)
___ Iron Deposits (B5)
___ Innundation Visible on Aerial Imagery (B7)
___ Water Stained Leaves (B9)
___ Aquatic Fauna (B13)
___ Tilapia Nests (B17)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres on Living Roots (C3)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Tiled Soils (C6)
___ Thin Muck Surface (C7)
___ Fiddler Crab Burrows (C10) (Guam, CNMI, and American Samoa)
___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

___ Surface Soil Cracks (B6)
___ Sparsely Vegetated Concave Surface (B8)
___ Drainage Patterns (B10)
___ Dry-Season Water Table (C2)
___ Salt Deposits (C5)
___ Stunted or Stressed Plants (D1)
___ Geomorphic Position (D2)
___ Shallow Aquitard (D3)
___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes ___ No X Depth (inches): none

Water Table Present? Yes X No ___ Depth (inches): 25

Saturation Present? (includes capillary fringe) Yes X No ___ Depth (inches): 18

Wetland Hydrology Present? Yes ___ No X

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

As of Aug 2014, Punaluu Pump and Punaluu Stream rain gages were at 141% and 114% of year to date average (http://www.prh.noaa.gov/hnl/hydro/pages/oahu_ytd_08.gif)

Nearby Punaluʻu Ditch may have the effect of draining the soil here.

WETLAND DETERMINATION DATA FORM—Hawaiʻi and Pacific Islands

Project/Site: Punaluʻu City: Punaluʻu Sampling Date: Sep 15, 2014 Time: 1000

Applicant/Owner: Kamehameha Schools State/Terr./Comm.: Hawaiʻi Island: Oʻahu Sampling Point: **SP 3-5**

Investigator(s): Susan Burr and Eric Guinther TMK/Parcel: 5-3-001:041

Landform (hillslope, coastal plain, etc.): coastal plain, depression Local relief (concave, convex, none): concave

Lat: 21° 34'20.15541"N Long: 157° 52'42.84571 "W Datum: WGS 84 Slope (%): <1

Soil Map Unit Name: Keaau clay, 0 to 2% slopes NWI classification: Non-wetland (not on NWI map)

Are climactic/hydrologic conditions on the site typical for this time of year: Yes ____ No X‡ (If no, explain in Remarks)

Are Vegetation No , Soil No , or Hydrology No significantly disturbed? Are "Normal Circumstances" present? Yes X No ____

Are Vegetation No , Soil No , or Hydrology No naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS—Attach a site map showing sampling point locations transects, important features, etc.

Hydrophytic Vegetation Present?	Yes ____ No X	
Hydric Soil Present?	Yes ____ No X	**Is the Sampled Area**
Wetland Hydrology Present?	Yes ____ No X	**within a Wetland? Yes ____ No X**

Remarks: SP 3-5 at an open trench recently opened for archaeological investigation.

‡ See Hydrology Remarks.

VEGETATION—Use scientific names of plants.

Tree Stratum (Plot size: 30-ft radius)	Absolute % Cover	Dominant Species?	Indicator Status
1. None			
2.			
3.			
4.			
5.			
	0 =Total Cover		
Sapling/Shrub Stratum (Plot size: 20-ft radius)			
1. None			
2.			
3.			
4.			
5.			
	0 =Total Cover		
Herb Stratum (Plot size: 5-ft radius)			
1. *Mimosa pudica*	60	Yes	FACU
2. *Paspalum conjugatum*	10	No	FAC
3. *Axonophus compressus*	20	Yes	FAC
4. *Cynodon dactylon*	10	No	FAC
5.			
6.			
7.			
8.			
	100 =Total Cover		
Woody Vine Stratum (Plot size: 5-ft radius)			
1. None			
2.			
	0 =Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 1 (A)

Total Number of Dominant Species Across All Strata: 2 **(B)**

Percent of Dominant Species That Are OBL, FACW, or FAC: 50 (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species	0	x1= 0
FACW species	0	x2= 0
FAC species	40	x3= 120
FACU species	60	x4= 240
UPL species	0	x5= 0
Column Totals:	100 (A)	360 (B)

Prevalence Index = B/A= 3.6

Hydrophytic Vegetation Indicators:

___ 1 - Rapid Test for Hydrophytic Vegetation

___ 2 - Dominance Test is >50%

___ 3 - Prevalence Index is ≤3.0[1]

___ Problematic Hydrophytic Vegetation [1] (Explain in Remarks or in the delineation report)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes ____ No X

Remarks: Pasture land, grazed by cattle.

SOIL **Sampling Point: 3-5**

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0 – 14	10YR 3/1	100	none				sandy clay loam	
14 –34	10YR 7/3	100	none				loamy sand	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains [2]Location: PL=Pore Lining, M=Matrix

Hydric Soil Indicators:

- ___ Histisols (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Muck Presence (A8)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Dark-Surface (S7)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ___ Stratified Layers (A5)
- ___ Sandy Mucky Mineral (S1)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type:____________

Depth (inches):____________

Hydric Soil Present: Yes____ **No** X

Remarks:

Keaau clay, 0 to 2% slopes is on the 2012 list of hydric soils. Soil profile does not confirm mapped soil type (more closely resembles Mokuleia clay loam, which is not on the 2012 list of hydric soils).

HYDROLOGY

Wetland Hydrology Indicators: (Explain observations in Remarks, if needed.)

Primary Indicators (minimum of one required: check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Innundation Visible on Aerial Imagery (B7)
- ___ Water Stained Leaves (B9)
- ___ Aquatic Fauna (B13)
- ___ Tilapia Nests (B17)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres on Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tiled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Fiddler Crab Burrows (C10) (Guam, CNMI, and American Samoa)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Salt Deposits (C5)
- ___ Stunted or Stressed Plants (D1)
- ___ Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- ___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes____ No X Depth (inches): none

Water Table Present? Yes X No____ Depth (inches): 38

Saturation Present? (includes capillary fringe) Yes X No____ Depth (inches): 38

Wetland Hydrology Present? Yes____ **No** X

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

As of Aug 2014, Punaluu Pump and Punaluu Stream rain gages were at 141% and 114% of year to date average (http://www.prh.noaa.gov/hnl/hydro/pages/oahu_ytd_08.gif)

Punaluu Rain Gage at 240 ft (USGS 213335157540601 884.4) received over 1 in of rain between 2100 Sep 14 and 0300 Sep 15 (waterdata.usgs.gov) Flooding in area was evident.

WETLAND DETERMINATION DATA FORM—Hawaiʻi and Pacific Islands

Project/Site: Punaluʻu City: Punaluʻu Sampling Date: Sep 15, 2014 Time: 1015

Applicant/Owner: Kamehameha Schools State/Terr./Comm.: Hawaiʻi Island: Oʻahu Sampling Point: **SP 3-6**

Investigator(s): Susan Burr and Eric Guinther TMK/Parcel: 5-3-001:041

Landform (hillslope, coastal plain, etc.): coastal plain, depression at toe of slope Local relief (concave, convex, none): concave

Lat: 21° 34'19.49821"N Long: 157° 52'41.54893"W Datum: WGS 84 Slope (%): <1

Soil Map Unit Name: Keaau clay, 0 to 2% slopes NWI classification: PEM1A† (not on NWI map)

Are climactic/hydrologic conditions on the site typical for this time of year: Yes ___ No X‡ (If no, explain in Remarks)

Are Vegetation No , Soil No , or Hydrology No significantly disturbed? Are "Normal Circumstances" present? Yes X No ___

Are Vegetation No , Soil No , or Hydrology No naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS—Attach a site map showing sampling point locations transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X No ___	
Hydric Soil Present?	Yes X No ___	**Is the Sampled Area**
Wetland Hydrology Present?	Yes X No ___	**within a Wetland? Yes X No ___**

Remarks: † PEM1A = persistent, emergent, temporary flooded palustrine wetland

‡ See Hydrology Remarks.

VEGETATION—Use scientific names of plants.

	Absolute % Cover	Dominant Species?	Indicator Status
Tree Stratum (Plot size: 30-ft radius)			
1. None			
2.			
3.			
4.			
5.			
	0 =Total Cover		
Sapling/Shrub Stratum (Plot size: 20-ft radius)			
1. *Pluchea carolinensis*	40	Yes	FAC
2.			
3.			
4.			
5.			
	40 =Total Cover		
Herb Stratum (Plot size: 5-ft radius)			
1. *Commelina diffusa*	40	Yes	FACW
2. *Paspalum conjugatum*	25	Yes	FAC
3. *Echinochloa colona*	20	Yes	FACW
4.			
5.			
6.			
7.			
8.			
	85 =Total Cover		
Woody Vine Stratum (Plot size: 5-ft radius)			
1. None			
2.			
	0 =Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 4 (A)

Total Number of Dominant Species Across All Strata: 4 **(B)**

Percent of Dominant Species That Are OBL, FACW, or FAC: 100 (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species	x1=
FACW species	x2=
FAC species	x3=
FACU species	x4=
UPL species	x5=
Column Totals: (A)	(B)

Prevalence Index = B/A=

Hydrophytic Vegetation Indicators:

___ 1 - Rapid Test for Hydrophytic Vegetation

X 2 - Dominance Test is >50%

___ 3 - Prevalence Index is ≤3.0[1]

___ Problematic Hydrophytic Vegetation [1] (Explain in Remarks or in the delineation report)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes X No ___

Remarks: Pasture land, grazed by cattle. Remaining ground is open water

SOIL

Sampling Point: 3-6

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0 – 6	10YR 2/1	100	none				mucky mineral	mostly clay
6 – 12	10YR 7/2	90	10YR 5/4	10	C	PL	loamy sand	distinct redox features

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains [2]Location: PL=Pore Lining, M=Matrix

Hydric Soil Indicators:

- ___ Histisols (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Muck Presence (A8)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Gleyed Matrix (S4)
- _X_ Sandy Redox (S5)
- ___ Dark-Surface (S7)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ___ Stratified Layers (A5)
- ___ Sandy Mucky Mineral (S1)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: ______

Depth (inches): ______

Hydric Soil Present: Yes __X__ No ____

Remarks:

Keaau clay, 0 to 2% slopes is on the 2012 list of hydric soils. Soil profile generally confirms mapped soil type, with C layer shallower than described for series.

HYDROLOGY

Wetland Hydrology Indicators: (Explain observations in Remarks, if needed.)

Primary Indicators (minimum of one required: check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Innundation Visible on Aerial Imagery (B7)
- ___ Water Stained Leaves (B9)
- ___ Aquatic Fauna (B13)
- ___ Tilapia Nests (B17)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres on Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tiled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Fiddler Crab Burrows (C10) (Guam, CNMI, and American Samoa)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Salt Deposits (C5)
- ___ Stunted or Stressed Plants (D1)
- ___ Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- ___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes __X__ No ____ Depth (inches): 1 to 3

Water Table Present? Yes __X__ No ____ Depth (inches): at surface

Saturation Present? (includes capillary fringe) Yes __X__ No ____ Depth (inches): at surface

Wetland Hydrology Present? Yes __X__ No ____

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

As of Aug 2014, Punaluu Pump and Punaluu Stream rain gages were at 141% and 114% of year to date average (http://www.prh.noaa.gov/hnl/hydro/pages/oahu_ytd_08.gif)

Punaluu Rain Gage at 240 ft (USGS 213335157540601 884.4) received over 1 in of rain between 2100 Sep 14 and 0300 Sep 15 (waterdata.usgs.gov) Flooding in area was evident.

WETLAND DETERMINATION DATA FORM—Hawaiʻi and Pacific Islands

Project/Site: Punaluʻu City: Punaluʻu Sampling Date: Sep 15, 2014 Time: 1100

Applicant/Owner: Kamehameha Schools State/Terr./Comm.: Hawaiʻi Island: Oʻahu Sampling Point: **SP 3-7**

Investigator(s): Susan Burr and Eric Guinther TMK/Parcel: 5-3-001:041

Landform (hillslope, coastal plain, etc.): coastal plain Local relief (concave, convex, none): concave

Lat: 21° 34ʼ20.02628”N Long: 157° 52ʼ39.99778 ”W Datum: WGS 84 Slope (%): <1

Soil Map Unit Name: Mokuleia loam NWI classification: non-wetland (not on NWI map)

Are climactic/hydrologic conditions on the site typical for this time of year: Yes____ No X‡ (If no, explain in Remarks)

Are Vegetation No , Soil No , or Hydrology No significantly disturbed? Are “Normal Circumstances” present? Yes X No____

Are Vegetation No , Soil No , or Hydrology No naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS—Attach a site map showing sampling point locations transects, important features, etc.

Hydrophytic Vegetation Present? Yes____ No X	
Hydric Soil Present? Yes____ No X	**Is the Sampled Area**
Wetland Hydrology Present? Yes____ No X	**within a Wetland? Yes____ No X**

Remarks: ‡ See Hydrology Remarks.

VEGETATION—Use scientific names of plants.

Tree Stratum (Plot size: 30-ft radius)	Absolute % Cover	Dominant Species?	Indicator Status
1. None			
2.			
3.			
4.			
5.			
	0 =Total Cover		
Sapling/Shrub Stratum (Plot size: 20-ft radius)			
1. None			
2.			
3.			
4.			
5.			
	0 =Total Cover		
Herb Stratum (Plot size: 5-ft radius)			
1. *Cyperus rotundus*	80	Yes	FACU
2. *Paspalum conjugatum*	2	No	FAC
3. *Echinochloa colona*	2	No	FACW
4. *Axonopus compressus*	7	No	FAC
5. *Amaranthus spinosus*	5	No	FACU
6. Kyllinga brevifolia	3	No	FAC
7.			
8.			
	99 =Total Cover		
Woody Vine Stratum (Plot size: 5-ft radius)			
1. None			
2.			
	0 =Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 0 (A)

Total Number of Dominant Species Across All Strata: 1 **(B)**

Percent of Dominant Species That Are OBL, FACW, or FAC: 0 (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species	0	x1= 0
FACW species	2	x2= 4
FAC species	12	x3= 36
FACU species	85	x4= 340
UPL species	0	x5= 0
Column Totals:	99 (A)	378 (B)

Prevalence Index = B/A= 3.8

Hydrophytic Vegetation Indicators:

___ 1 - Rapid Test for Hydrophytic Vegetation

___ 2 - Dominance Test is >50%

___ 3 - Prevalence Index is ≤3.0[1]

___ Problematic Hydrophytic Vegetation [1] (Explain in Remarks or in the delineation report)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes____ No X

Remarks: Pasture land, grazed by cattle. Remaining ground is bare.

SOIL

Sampling Point: 3-7

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0 – 9	10YR 2/1	93	7.5YR 4/4	7	C	PL & M	sandy loam	prominent redox features
9 – 17	7.5YR 7/2	99	7.5YR 4/6	1	C	M	loamy sand	prominent redox features

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains   [2]Location: PL=Pore Lining, M=Matrix

Hydric Soil Indicators:

___ Histisols (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Muck Presence (A8)
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Dark-Surface (S7)
___ Loamy Gleyed Matrix (F2)
___ Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

___ Stratified Layers (A5)
___ Sandy Mucky Mineral (S1)
___ Red Parent Material (TF2)
___ Very Shallow Dark Surface (TF12)
___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: ____________

Depth (inches): ____________

Hydric Soil Present: **Yes** ______ **No** X

Remarks:

Mokuleia loam is not on the 2012 list of hydric soils. Soil profile generally confirms mapped soil type.

Mottles appear to be more associated with iron masses in soil than as redox features.

HYDROLOGY

Wetland Hydrology Indicators: (Explain observations in Remarks, if needed.)

Primary Indicators (minimum of one required: check all that apply)

___ Surface Water (A1)
___ High Water Table (A2)
___ Saturation (A3)
___ Water Marks (B1)
___ Sediment Deposits (B2)
___ Drift Deposits (B3)
___ Algal Mat or Crust (B4)
___ Iron Deposits (B5)
___ Innundation Visible on Aerial Imagery (B7)
___ Water Stained Leaves (B9)
___ Aquatic Fauna (B13)
___ Tilapia Nests (B17)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres on Living Roots (C3)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Tiled Soils (C6)
___ Thin Muck Surface (C7)
___ Fiddler Crab Burrows (C10) (Guam, CNMI, and American Samoa)
___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

___ Surface Soil Cracks (B6)
___ Sparsely Vegetated Concave Surface (B8)
___ Drainage Patterns (B10)
___ Dry-Season Water Table (C2)
___ Salt Deposits (C5)
___ Stunted or Stressed Plants (D1)
___ Geomorphic Position (D2)
___ Shallow Aquitard (D3)
___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes ______ No X Depth (inches): none

Water Table Present? Yes ______ No X Depth (inches): >17

Saturation Present? (includes capillary fringe) Yes ______ No X Depth (inches): >17

Wetland Hydrology Present? **Yes** ______ **No** X

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:
As of Aug 2014, Punaluu Pump and Punaluu Stream rain gages were at 141% and 114% of year to date average (http://www.prh.noaa.gov/hnl/hydro/pages/oahu_ytd_08.gif)

Punaluu Rain Gage at 240 ft (USGS 213335157540601 884.4) received over 1 in of rain between 2100 Sep 14 and 0300 Sep 15 (waterdata.usgs.gov) Flooding in area was evident.

Negative α, α′ diprydil test throughout soil profile.

WETLAND DETERMINATION DATA FORM—Hawaiʻi and Pacific Islands

Project/Site: Punaluʻu City: Punaluʻu Sampling Date: Sep 15, 2014 Time: 1130

Applicant/Owner: Kamehameha Schools State/Terr./Comm.: Hawaiʻi Island: Oʻahu Sampling Point: **SP 3-8**

Investigator(s): Susan Burr and Eric Guinther TMK/Parcel: 5-3-001:041

Landform (hillslope, coastal plain, etc.): coastal plain Local relief (concave, convex, none): concave

Lat: 21° 34'21.08711"N Long: 157° 52'41.51028 "W Datum: WGS 84 Slope (%): <1

Soil Map Unit Name: Mokuleia loam NWI classification: non-wetland (not on NWI map)

Are climactic/hydrologic conditions on the site typical for this time of year: Yes ____ No X‡ (If no, explain in Remarks)

Are Vegetation No , Soil No , or Hydrology No significantly disturbed? Are "Normal Circumstances" present? Yes X No ____

Are Vegetation No , Soil No , or Hydrology No naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS—Attach a site map showing sampling point locations transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X No ____	
Hydric Soil Present?	Yes ____ No X	**Is the Sampled Area**
Wetland Hydrology Present?	Yes ____ No X	**within a Wetland? Yes ____ No X**

Remarks:

‡ See Hydrology Remarks.

VEGETATION—Use scientific names of plants.

Tree Stratum (Plot size: 30-ft radius)	Absolute % Cover	Dominant Species?	Indicator Status
1. *Syzgium cumini*	85	Yes	FAC
2.			
3.			
4.			
5.			
	85 =Total Cover		
Sapling/Shrub Stratum (Plot size: 20-ft radius)			
1. *Syzgium cumini*	40	Yes	FAC
2.			
3.			
4.			
5.			
	40 =Total Cover		
Herb Stratum (Plot size: 5-ft radius)			
1. *Paspalum conjugatum*	5	Yes	FAC
2.			
3.			
4.			
5.			
6.			
7.			
8.			
	5 =Total Cover		
Woody Vine Stratum (Plot size: 5-ft radius)			
1. None			
2.			
	0 =Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 3 (A)

Total Number of Dominant Species Across All Strata: 3 **(B)**

Percent of Dominant Species That Are OBL, FACW, or FAC: 100 (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species ____	x1= ____
FACW species ____	x2= ____
FAC species ____	x3= ____
FACU species ____	x4= ____
UPL species ____	x5= ____
Column Totals: ____ (A)	____ (B)

Prevalence Index = B/A= ____

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- X 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ Problematic Hydrophytic Vegetation [1] (Explain in Remarks or in the delineation report)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes X No ____

Remarks: Pasture land, grazed by cattle. Remaining ground is bare.

SOIL

Sampling Point: 3-8

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks
0 – 8	2.5Y 2.55/1	97	10YR 5/4	3	C	M	sandy clay loam	
8	2.5Y 8/2	100	none				consolidated coral sand or reef limestone	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains [2]Location: PL=Pore Lining, M=Matrix

Hydric Soil Indicators:

___ Histisols (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Muck Presence (A8)
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Dark-Surface (S7)
___ Loamy Gleyed Matrix (F2)
___ Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

___ Stratified Layers (A5)
___ Sandy Mucky Mineral (S1)
___ Red Parent Material (TF2)
___ Very Shallow Dark Surface (TF12)
___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: consolidated reef

Depth (inches): 8

Hydric Soil Present: Yes____ No X

Remarks:

Mokuleia loam is not on the 2012 list of hydric soils. Soil profile generally confirms mapped soil type – depth to coral sand is shallower than described for the seriews.

Mottles appear to be more associated with iron masses (basalt fragments) in soil than as redox features – looks rusty along edges

HYDROLOGY

Wetland Hydrology Indicators: (Explain observations in Remarks, if needed.)

Primary Indicators (minimum of one required: check all that apply)

___ Surface Water (A1)
___ High Water Table (A2)
___ Saturation (A3)
___ Water Marks (B1)
___ Sediment Deposits (B2)
___ Drift Deposits (B3)
___ Algal Mat or Crust (B4)
___ Iron Deposits (B5)
___ Innundation Visible on Aerial Imagery (B7)
___ Water Stained Leaves (B9)
___ Aquatic Fauna (B13)
___ Tilapia Nests (B17)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres on Living Roots (C3)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Tiled Soils (C6)
___ Thin Muck Surface (C7)
___ Fiddler Crab Burrows (C10) (Guam, CNMI, and American Samoa)
___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

___ Surface Soil Cracks (B6)
___ Sparsely Vegetated Concave Surface (B8)
___ Drainage Patterns (B10)
___ Dry-Season Water Table (C2)
___ Salt Deposits (C5)
___ Stunted or Stressed Plants (D1)
___ Geomorphic Position (D2)
___ Shallow Aquitard (D3)
___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes____ No X Depth (inches): none

Water Table Present? Yes____ No X Depth (inches): >17

Saturation Present? (includes capillary fringe) Yes____ No X Depth (inches): >17

Wetland Hydrology Present? Yes____ No X

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:
As of Aug 2014, Punaluu Pump and Punaluu Stream rain gages were at 141% and 114% of year to date average (http://www.prh.noaa.gov/hnl/hydro/pages/oahu_ytd_08.gif)

Punaluu Rain Gage at 240 ft (USGS 213335157540601 884.4) received over 1 in of rain between 2100 Sep 14 and 0300 Sep 15 (waterdata.usgs.gov) Flooding in area was evident.

No SP 3-9

WETLAND DETERMINATION DATA FORM—Hawai'i and Pacific Islands

Project/Site: Punalu'u City: Punalu'u Sampling Date: Sep 17, 2014 Time: 1100

Applicant/Owner: Kamehameha Schools State/Terr./Comm.: Hawai'i Island: O'ahu Sampling Point: **SP 3-10**

Investigator(s): Susan Burr and Chad Linebaugh TMK/Parcel: 5-3-003:001

Landform (hillslope, coastal plain, etc.): coastal plain, adjacent to ditch Local relief (concave, convex, none): none

Lat: 21° 34'34.74642"N Long: 157° 53'10.73774 "W Datum: WGS 84 Slope (%): 0

Soil Map Unit Name: Hanalei stony silty clay, 2 to 6% slopes NWI classification: PEM1A (PEM1C on NWI map)

Are climactic/hydrologic conditions on the site typical for this time of year: Yes ____ No X‡ (If no, explain in Remarks)

Are Vegetation No, Soil No, or Hydrology No significantly disturbed? Are "Normal Circumstances" present? Yes X No ____

Are Vegetation No, Soil No, or Hydrology No naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS—Attach a site map showing sampling point locations transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X No ____	
Hydric Soil Present?	Yes X No ____	**Is the Sampled Area**
Wetland Hydrology Present?	Yes X No ____	**within a Wetland? Yes X No ____**

Remarks: † PEM1C = persistent, emergent, seasonally flooded palustrine wetland PEM1A = persistent, emergent, temporary flooded palustrine wetland

‡ See Hydrology Remarks.

VEGETATION—Use scientific names of plants.

Tree Stratum (Plot size: 30-ft radius)	Absolute % Cover	Dominant Species?	Indicator Status
1. None			
2.			
3.			
4.			
5.			
	0 =Total Cover		
Sapling/Shrub Stratum (Plot size: 20-ft radius)			
1. None			
2.			
3.			
4.			
5.			
	0 =Total Cover		
Herb Stratum (Plot size: 5-ft radius)			
1. *Megathyrsus maximus*	12	No	FAC
2. *Commelina diffusa*	75	Yes	FACW
3. *Calocasia* sp.	5	No	OBL
4. *Cyperus involucratus*	3	No	FACW
5. *Cois lachyma-jobi*	1	No	FACW
6. *Paederia foetida*	3	No	UPL
7. ?*Ipomoea alba*	3	No	FAC
8. *Sphagneticola trilobata*	2	No	FAC
	104 =Total Cover		
Woody Vine Stratum (Plot size: 5-ft radius)			
1. None			
2.			
	0 =Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: ____ (A)

Total Number of Dominant Species Across All Strata: ____ **(B)**

Percent of Dominant Species That Are OBL, FACW, or FAC: ____ (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species ____	x1= ____
FACW species ____	x2= ____
FAC species ____	x3= ____
FACU species ____	x4= ____
UPL species ____	x5= ____
Column Totals: ____ (A)	____ (B)

Prevalence Index = B/A= ____

Hydrophytic Vegetation Indicators:

X 1 - Rapid Test for Hydrophytic Vegetation

___ 2 - Dominance Test is >50%

___ 3 - Prevalence Index is $\leq$3.0[1]

___ Problematic Hydrophytic Vegetation [1] (Explain in Remarks or in the delineation report)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes X No ____

Remarks: *Trema orientalis* rooted at higher elevations.

SOIL

Sampling Point: 3-10

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	%	Redox Features Color (moist)	%	Type[1]	Loc[2]	Texture	Remarks
0 – 8	10YR 4/1	70	10YR 5/8	5	C	M	sandy clay loam	very high organic
	10YR 3/3	25	none					
8 – 13	10YR 4/1	85	10YR 3/3	15	D	M	sandy clay loam	very high organic prominent redox features

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains [2]Location: PL=Pore Lining, M=Matrix

Hydric Soil Indicators:

- ___ Histisols (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Muck Presence (A8)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Dark-Surface (S7)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- X Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ___ Stratified Layers (A5)
- ___ Sandy Mucky Mineral (S1)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type:

Depth (inches):

Hydric Soil Present? Yes X No ___

Remarks:

Hanalei stony silty clay, 2 to 6% slopes is on the 2012 list of hydric soils. Soil profile generally confirms mapped soil type, but sandier.

HYDROLOGY

Wetland Hydrology Indicators: (Explain observations in Remarks, if needed.)

Primary Indicators (minimum of one required: check all that apply)

- ___ Surface Water (A1)
- X High Water Table (A2)
- X Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Innundation Visible on Aerial Imagery (B7)
- ___ Water Stained Leaves (B9)
- ___ Aquatic Fauna (B13)
- ___ Tilapia Nests (B17)
- ___ Hydrogen Sulfide Odor (C1)
- X Oxidized Rhizospheres on Living Roots (C3)
- X Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tiled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Fiddler Crab Burrows (C10) (Guam, CNMI, and American Samoa)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Drainage Patterns (B10)
- X Dry-Season Water Table (C2)
- ___ Salt Deposits (C5)
- ___ Stunted or Stressed Plants (D1)
- ___ Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- X FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes ___ No X Depth (inches): none

Water Table Present? Yes X No ___ Depth (inches): 11

Saturation Present? (includes capillary fringe) Yes X No ___ Depth (inches): 8

Wetland Hydrology Present? Yes X No ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

As of Aug 2014, Punaluu Pump and Punaluu Stream rain gages were at 141% and 114% of year to date average (http://www.prh.noaa.gov/hnl/hydro/pages/oahu_ytd_08.gif)

Positive α, α′ diprydil test throughout soil profile.

WETLAND DETERMINATION DATA FORM—Hawai‘i and Pacific Islands

Project/Site: Punalu‘u City: Punalu‘u Sampling Date: Sep 17, 2014 Time: 1130

Applicant/Owner: Kamehameha Schools State/Terr./Comm.: Hawai‘i Island: O‘ahu Sampling Point: **SP 3-11**

Investigator(s): Susan Burr and Chad Linebaugh TMK/Parcel: 5-3-003:001

Landform (hillslope, coastal plain, etc.): coastal plain Local relief (concave, convex, none): none

Lat: 21° 34'34.58066"N Long: 157° 53'11.37183 "W Datum: WGS 84 Slope (%): 0

Soil Map Unit Name: Hanalei silty clay,0 to 2% slopes NWI classification: non-wetland (PF03A on NWI map)

Are climactic/hydrologic conditions on the site typical for this time of year: Yes ____ No X‡ (If no, explain in Remarks)

Are Vegetation No, Soil No, or Hydrology No significantly disturbed? Are "Normal Circumstances" present? Yes X No ____

Are Vegetation No, Soil No, or Hydrology No naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS—Attach a site map showing sampling point locations transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No ____	
Hydric Soil Present?	Yes ____	No X	**Is the Sampled Area**
Wetland Hydrology Present?	Yes ____	No X	**within a Wetland? Yes ____ No X**

Remarks: † PEM1C = persistent, emergent, seasonally flooded palustrine wetland

‡ See Hydrology Remarks.

VEGETATION—Use scientific names of plants.

Tree Stratum (Plot size: 30-ft radius)	Absolute % Cover	Dominant Species?	Indicator Status
1. *Trema orientalis*	70	Yes	FACU
2. *Aleurites moluccanus*	5	No	FACU
3. *Syzygium cumini*	3	No	FAC
4.			
5.			
	78 =Total Cover		
Sapling/Shrub Stratum (Plot size: 20-ft radius)			
1. None			
2.			
3.			
4.			
5.			
	0 =Total Cover		
Herb Stratum (Plot size: 5-ft radius)			
1. *Megathyrsus maximus*	70	Yes	FAC
2. *Macroptilium atropurpurea*	2	No	FAC
3. *Commelina diffusa*	5	No	FACW
4.			
5.			
6. *Paederia foetida*	2	No	UPL
7.			
8. *Sphagneticola trilobata*	20	Yes	FAC
	99 =Total Cover		
Woody Vine Stratum (Plot size: 5-ft radius)			
1. None			
2.			
	0 =Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 2 (A)

Total Number of Dominant Species Across All Strata: 3 **(B)**

Percent of Dominant Species That Are OBL, FACW, or FAC: 67 (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species		x1=
FACW species		x2=
FAC species		x3=
FACU species		x4=
UPL species		x5=
Column Totals:	(A)	(B)

Prevalence Index = B/A= ____

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- X 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ Problematic Hydrophytic Vegetation [1] (Explain in Remarks or in the delineation report)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes X No ____

Remarks: *Trema orientalis* rooted at higher elevations.

SOIL **Sampling Point: 3-11**

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks
0 – 13	7.5YR 3/3	100	none				silt loam	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains [2]Location: PL=Pore Lining, M=Matrix

Hydric Soil Indicators:

___ Histisols (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Muck Presence (A8)
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Dark-Surface (S7)
___ Loamy Gleyed Matrix (F2)
___ Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

___ Stratified Layers (A5)
___ Sandy Mucky Mineral (S1)
___ Red Parent Material (TF2)
___ Very Shallow Dark Surface (TF12)
___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type:

Depth (inches):

Hydric Soil Present: Yes____ No X

Remarks:

Hanalei silty clay, 0 to 2% slopes is on the 2012 list of hydric soils. Soil profile does not confirm mapped soil type.

HYDROLOGY

Wetland Hydrology Indicators: (Explain observations in Remarks, if needed.)

Primary Indicators (minimum of one required: check all that apply)

___ Surface Water (A1)
___ High Water Table (A2)
___ Saturation (A3)
___ Water Marks (B1)
___ Sediment Deposits (B2)
___ Drift Deposits (B3)
___ Algal Mat or Crust (B4)
___ Iron Deposits (B5)
___ Innundation Visible on Aerial Imagery (B7)
___ Water Stained Leaves (B9)
___ Aquatic Fauna (B13)
___ Tilapia Nests (B17)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres on Living Roots (C3)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Tiled Soils (C6)
___ Thin Muck Surface (C7)
___ Fiddler Crab Burrows (C10) (Guam, CNMI, and American Samoa)
___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

___ Surface Soil Cracks (B6)
___ Sparsely Vegetated Concave Surface (B8)
___ Drainage Patterns (B10)
___ Dry-Season Water Table (C2)
___ Salt Deposits (C5)
___ Stunted or Stressed Plants (D1)
___ Geomorphic Position (D2)
___ Shallow Aquitard (D3)
___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes____ No X Depth (inches): none

Water Table Present? Yes____ No X Depth (inches): >12

Saturation Present? (includes capillary fringe) Yes____ No X Depth (inches): >12

Wetland Hydrology Present? Yes____ No X

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

As of Aug 2014, Punaluu Pump and Punaluu Stream rain gages were at 141% and 114% of year to date average (http://www.prh.noaa.gov/hnl/hydro/pages/oahu_ytd_08.gif)

Wrack and recently bent grass (towards direction of stream) present.
Negative α, α′ diprydil test throughout soil profile.

WETLAND DETERMINATION DATA FORM—Hawaiʻi and Pacific Islands

Project/Site: Punaluʻu City: Punaluʻu Sampling Date: Sep 17, 2014 Time: 1145

Applicant/Owner: Kamehameha Schools State/Terr./Comm.: Hawaiʻi Island: Oʻahu Sampling Point: **SP 3-12**

Investigator(s): Susan Burr and Chad Linebaugh TMK/Parcel: 5-3-003:001

Landform (hillslope, coastal plain, etc.): coastal plain, stream berm Local relief (concave, convex, none): convex

Lat: 21° 34'34.98586"N Long: 157° 53'10.54950 "W Datum: WGS 84 Slope (%): <1

Soil Map Unit Name: Hanalei stony silty clay,0 to 6% slopes NWI classification: non-wetland (PEM1C on NWI map)

Are climactic/hydrologic conditions on the site typical for this time of year: Yes ____ No X‡ (If no, explain in Remarks)

Are Vegetation No , Soil No , or Hydrology No significantly disturbed? Are "Normal Circumstances" present? Yes X No ____

Are Vegetation No , Soil No , or Hydrology No naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS—Attach a site map showing sampling point locations transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X No ____	
Hydric Soil Present?	Yes ____ No X	**Is the Sampled Area**
Wetland Hydrology Present?	Yes ____ No X	**within a Wetland? Yes ____ No X**

Remarks: † PEM1C = persistent, emergent, seasonally flooded palustrine wetland. SP 3-12 is located on the berm along the left side of Punaluʻu Stream
‡ See Hydrology Remarks.

VEGETATION—Use scientific names of plants.

Tree Stratum (Plot size: 30-ft radius)	Absolute % Cover	Dominant Species?	Indicator Status
1. None			
2.			
3.			
4.			
5.			
	=Total Cover		
Sapling/Shrub Stratum (Plot size: 20-ft radius)			
1. None			
2.			
3.			
4.			
5.			
	0 =Total Cover		
Herb Stratum (Plot size: 5-ft radius)			
1. *Megathyrsus maximus*	100	Yes	FAC
2. *Paederia foetida*	5	No	UPL
3.			
4.			
5.			
6.			
7.			
8.			
	105 =Total Cover		
Woody Vine Stratum (Plot size: 5-ft radius)			
1. None			
2.			
	0 =Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 1 (A)

Total Number of Dominant Species Across All Strata: 1 **(B)**

Percent of Dominant Species That Are OBL, FACW, or FAC: 100 (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species ____	x1= ____
FACW species ____	x2= ____
FAC species ____	x3= ____
FACU species ____	x4= ____
UPL species ____	x5= ____
Column Totals: ____ (A)	____ (B)

Prevalence Index = B/A= ____

Hydrophytic Vegetation Indicators:

___ 1 - Rapid Test for Hydrophytic Vegetation

X 2 - Dominance Test is >50%

___ 3 - Prevalence Index is ≤3.0[1]

___ Problematic Hydrophytic Vegetation [1] (Explain in Remarks or in the delineation report)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes X No ____

Remarks: *Trema orientalis* rooted at higher elevations.

SOIL

Sampling Point: 3-12

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth	Matrix		Redox Features				Texture	Remarks
(inches)	Color (moist)	%	Color (moist)	%	Type [1]	Loc[2]		
0 – 18	7.5YR 3/3	100	none				loam	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains [2]Location: PL=Pore Lining, M=Matrix

Hydric Soil Indicators:

___ Histisols (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Muck Presence (A8)
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Dark-Surface (S7)
___ Loamy Gleyed Matrix (F2)
___ Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

___ Stratified Layers (A5)
___ Sandy Mucky Mineral (S1)
___ Red Parent Material (TF2)
___ Very Shallow Dark Surface (TF12)
___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type:________

Depth (inches):________

Hydric Soil Present: Yes___ No X

Remarks:

Hanalei stony silty clay, 2 to 6% slopes is on the 2012 list of hydric soils. Soil profile does not confirm mapped soil type.

HYDROLOGY

Wetland Hydrology Indicators: (Explain observations in Remarks, if needed.)

Primary Indicators (minimum of one required: check all that apply)

___ Surface Water (A1)
___ High Water Table (A2)
___ Saturation (A3)
___ Water Marks (B1)
___ Sediment Deposits (B2)
___ Drift Deposits (B3)
___ Algal Mat or Crust (B4)
___ Iron Deposits (B5)
___ Innundation Visible on Aerial Imagery (B7)
___ Water Stained Leaves (B9)
___ Aquatic Fauna (B13)
___ Tilapia Nests (B17)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres on Living Roots (C3)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Tiled Soils (C6)
___ Thin Muck Surface (C7)
___ Fiddler Crab Burrows (C10) (Guam, CNMI, and American Samoa)
___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

___ Surface Soil Cracks (B6)
___ Sparsely Vegetated Concave Surface (B8)
___ Drainage Patterns (B10)
___ Dry-Season Water Table (C2)
___ Salt Deposits (C5)
___ Stunted or Stressed Plants (D1)
___ Geomorphic Position (D2)
___ Shallow Aquitard (D3)
___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes___ No X Depth (inches): none

Water Table Present? Yes___ No X Depth (inches): >18

Saturation Present? (includes capillary fringe) Yes___ No X Depth (inches): >18

Wetland Hydrology Present? Yes___ No X

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:
As of Aug 2014, Punaluu Pump and Punaluu Stream rain gages were at 141% and 114% of year to date average (http://www.prh.noaa.gov/hnl/hydro/pages/oahu_ytd_08.gif)

No SP 4-1

No SP 4-2

No SP 4-3

WETLAND DETERMINATION DATA FORM—Hawaiʻi and Pacific Islands

Project/Site: Punaluʻu City: Punaluʻu Sampling Date: Sep 16, 2014 Time: 1350

Applicant/Owner: Kamehameha Schools State/Terr./Comm.: Hawaiʻi Island: Oʻahu Sampling Point: **SP 4-4**

Investigator(s): Susan Burr and Eric Guinther TMK/Parcel: 5-3-003:001

Landform (hillslope, coastal plain, etc.): coastal plain, river valley floodplain Local relief (concave, convex, none): none

Lat: 21° 34'31.54700"N Long: 157° 53'14.66304 "W Datum: WGS 84 Slope (%): 0

Soil Map Unit Name: Hanalei silty clay, 0 to 2% slopes NWI classification: PEM1A (non-wetland on NWI map)

Are climactic/hydrologic conditions on the site typical for this time of year: Yes ____ No X‡ (If no, explain in Remarks)

Are Vegetation No , Soil No , or Hydrology No significantly disturbed? Are "Normal Circumstances" present? Yes X No ____

Are Vegetation No , Soil No , or Hydrology No naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS—Attach a site map showing sampling point locations transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X No ____	
Hydric Soil Present?	Yes X No ____	**Is the Sampled Area**
Wetland Hydrology Present?	Yes X No ____	**within a Wetland? Yes X No ____** (weak hydrology)

Remarks: † PEM1A = persistent, emergent, temporary flooded palustrine wetland

‡ See Hydrology Remarks. SP 4-4 is located a little upslope from ponded open water

VEGETATION—Use scientific names of plants.

	Absolute % Cover	Dominant Species?	Indicator Status
Tree Stratum (Plot size: 30-ft radius)			
1. None			
2.			
3.			
4.			
5.			
	0 =Total Cover		
Sapling/Shrub Stratum (Plot size: 20-ft radius)			
1. None			
2.			
3.			
4.			
5.			
	0 =Total Cover		
Herb Stratum (Plot size: 5-ft radius)			
1. *Urochloa mutica*	95	Yes	FACW
2.			
3. *Paederia foetida*	5	No	UPL
4.			
5.			
6.			
7.			
8.			
	100 =Total Cover		
Woody Vine Stratum (Plot size: 20-ft radius)			
1. None			
2.			
	0 =Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: ____ (A)

Total Number of Dominant Species Across All Strata: ____ **(B)**

Percent of Dominant Species That Are OBL, FACW, or FAC: ____ (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species ____	x1= ____
FACW species ____	x2= ____
FAC species ____	x3= ____
FACU species ____	x4= ____
UPL species ____	x5= ____
Column Totals: ____ (A)	____ (B)

Prevalence Index = B/A= ____

Hydrophytic Vegetation Indicators:

X 1 - Rapid Test for Hydrophytic Vegetation

___ 2 - Dominance Test is >50%

___ 3 - Prevalence Index is ≤3.0[1]

___ Problematic Hydrophytic Vegetation [1] (Explain in Remarks or in the delineation report)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes X No ____

Remarks:

SOIL

Sampling Point: 4-4

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth	Matrix		Redox Features					
(inches)	Color (moist)	%	Color (moist)	%	Type [1]	Loc [2]	Texture	Remarks
0 – 6	10YR 3/3	100	none				clay loam	
6 – 8	7.5YR 3/1	80	5YR 5/8	20	C	PL & M	silty clay loam	prominent redox features
4 – 11	7.5YR 3/1	50	5YR 5/8	50	C	PL & M	silty clay loam	prominent redox features

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains [2]Location: PL=Pore Lining, M=Matrix

Hydric Soil Indicators:

- ___ Histisols (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Muck Presence (A8)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Dark-Surface (S7)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- _X_ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ___ Stratified Layers (A5)
- ___ Sandy Mucky Mineral (S1)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: ______

Depth (inches): ______

Hydric Soil Present: **Yes** X **No** ___

Remarks:

Hanalei silty clay, 0 to26% slopes is on the 2012 list of hydric soils. Soil profile generally confirms mapped soil type with loam at the surface.
Redox features have diffuse boundaries and may be relics
River rock at 11 in depth

HYDROLOGY

Wetland Hydrology Indicators: (Explain observations in Remarks, if needed.)

Primary Indicators (minimum of one required: check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Innundation Visible on Aerial Imagery (B7)
- ___ Water Stained Leaves (B9)
- ___ Aquatic Fauna (B13)
- ___ Tilapia Nests (B17)
- ___ Hydrogen Sulfide Odor (C1)
- _X_ Oxidized Rhizospheres on Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tiled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Fiddler Crab Burrows (C10) (Guam, CNMI, and American Samoa)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Salt Deposits (C5)
- ___ Stunted or Stressed Plants (D1)
- ___ Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- X___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes___ No X Depth (inches): none

Water Table Present? Yes X No___ Depth (inches): 36

Saturation Present? (includes capillary fringe) Yes X No___ Depth (inches): 36

But weak and questionable.

Wetland Hydrology Present? **Yes** X **No** ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

As of Aug 2014, Punaluu Pump and Punaluu Stream rain gages were at 141% and 114% of year to date average (http://www.prh.noaa.gov/hnl/hydro/pages/oahu_ytd_08.gif)

Negative α, α′ diprydil test throughout soil profile.

Very few oxidized rhizospheres on living root channels.

WETLAND DETERMINATION DATA FORM—Hawai'i and Pacific Islands

Project/Site: Punalu'u City: Punalu'u Sampling Date: Sep 16, 2014 Time: 1330

Applicant/Owner: Kamehameha Schools State/Terr./Comm.: Hawai'i Island: O'ahu Sampling Point: **SP 4-5**

Investigator(s): Susan Burr and Eric Guinther TMK/Parcel: 5-3-003:001

Landform (hillslope, coastal plain, etc.): coastal plain, river valley floodplain Local relief (concave, convex, none): none

Lat: 21° 34'30.23515"N Long: 157° 53'13.94580 "W Datum: WGS 84 Slope (%): 0

Soil Map Unit Name: Hanalei silty clay, 0 to 2% slopes NWI classification: non-wetland (non-wetland on NWI map)

Are climactic/hydrologic conditions on the site typical for this time of year: Yes ____ No X‡ (If no, explain in Remarks)

Are Vegetation No , Soil No , or Hydrology No significantly disturbed? Are "Normal Circumstances" present? Yes X No ____

Are Vegetation No , Soil No , or Hydrology No naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS—Attach a site map showing sampling point locations transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X No ____	
Hydric Soil Present?	Yes ____ No X	**Is the Sampled Area**
Wetland Hydrology Present?	Yes ____ No X	**within a Wetland? Yes ____ No X**

Remarks: ‡ See Hydrology Remarks.

VEGETATION—Use scientific names of plants.

Tree Stratum (Plot size: 30-ft radius)	Absolute % Cover	Dominant Species?	Indicator Status
1. None			
2.			
3.			
4.			
5.			
	0 =Total Cover		
Sapling/Shrub Stratum (Plot size: 20-ft radius)			
1. None			
2.			
3.			
4.			
5.			
	0 =Total Cover		
Herb Stratum (Plot size: 5-ft radius)			
1. *Paspalum conjugatum*	98	Yes	FAC
2. *Ricinus communis*	2	No	FACU
3.			
4.			
5.			
6.			
7.			
8.			
	100 =Total Cover		
Woody Vine Stratum (Plot size: 20-ft radius)			
1. None			
2.			
	0 =Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 1 (A)

Total Number of Dominant Species Across All Strata: 1 **(B)**

Percent of Dominant Species That Are OBL, FACW, or FAC: 100 (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species ____	x1= ____
FACW species ____	x2= ____
FAC species ____	x3= ____
FACU species ____	x4= ____
UPL species ____	x5= ____
Column Totals: ____ (A)	____ (B)

Prevalence Index = B/A= ____

Hydrophytic Vegetation Indicators:

- ____ 1 - Rapid Test for Hydrophytic Vegetation
- X 2 - Dominance Test is >50%
- ____ 3 - Prevalence Index is ≤3.0[1]
- ____ Problematic Hydrophytic Vegetation [1] (Explain in Remarks or in the delineation report)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes X No ____

Remarks:

SOIL

Sampling Point: 4-5

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0 – 13	10YR 3/3	100	none				clay loam	
13 – 17	10YR 3/3	92	5YR 3/4	8	C	M	clay loam	faint redox features
17 – 20	10YR 4/1	90	7.5YR 3/3	10	C	M	clay loam	distinct redox features

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains

[2]Location: PL=Pore Lining, M=Matrix

Hydric Soil Indicators:

___ Histisols (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Muck Presence (A8)
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Dark-Surface (S7)
___ Loamy Gleyed Matrix (F2)
___ Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

___ Stratified Layers (A5)
___ Sandy Mucky Mineral (S1)
___ Red Parent Material (TF2)
___ Very Shallow Dark Surface (TF12)
___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: ______

Depth (inches): ______

Hydric Soil Present: **Yes** ___ **No** X

Remarks:

Hanalei silty clay, 0 to2% slopes is on the 2012 list of hydric soils. Soil profile does not confirm mapped soil type. Loamier and colors match only >17 in.

HYDROLOGY

Wetland Hydrology Indicators: (Explain observations in Remarks, if needed.)

Primary Indicators (minimum of one required: check all that apply)

___ Surface Water (A1)
___ High Water Table (A2)
___ Saturation (A3)
___ Water Marks (B1)
___ Sediment Deposits (B2)
___ Drift Deposits (B3)
___ Algal Mat or Crust (B4)
___ Iron Deposits (B5)
___ Innundation Visible on Aerial Imagery (B7)
___ Water Stained Leaves (B9)
___ Aquatic Fauna (B13)
___ Tilapia Nests (B17)
___ Hydrogen Sulfide Odor (C1)
X Oxidized Rhizospheres on Living Roots (C3)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Tiled Soils (C6)
___ Thin Muck Surface (C7)
___ Fiddler Crab Burrows (C10) (Guam, CNMI, and American Samoa)
___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

___ Surface Soil Cracks (B6)
___ Sparsely Vegetated Concave Surface (B8)
___ Drainage Patterns (B10)
___ Dry-Season Water Table (C2)
___ Salt Deposits (C5)
___ Stunted or Stressed Plants (D1)
___ Geomorphic Position (D2)
___ Shallow Aquitard (D3)
X FAC-Neutral Test (D5)

Field Observations:

Surface Water Present?	Yes ___	No X	Depth (inches): none
Water Table Present?	Yes X	No ___	Depth (inches): 30
Saturation Present? (includes capillary fringe)	Yes X	No ___	Depth (inches): 29

Wetland Hydrology Present? **Yes** ___ **No** X

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

As of Aug 2014, Punaluu Pump and Punaluu Stream rain gages were at 141% and 114% of year to date average (http://www.prh.noaa.gov/hnl/hydro/pages/oahu_ytd_08.gif)

WETLAND DETERMINATION DATA FORM—Hawai'i and Pacific Islands

Project/Site: Punalu'u City: Punalu'u Sampling Date: Sep 16, 2014 Time: 1100

Applicant/Owner: Kamehameha Schools State/Terr./Comm.: Hawai'i Island: O'ahu Sampling Point: **SP 4-6**

Investigator(s): Susan Burr and Eric Guinther TMK/Parcel: 5-3-003:001

Landform (hillslope, coastal plain, etc.): riverine pasture, separated by berm Local relief (concave, convex, none): none

Lat: 21° 34'31.39646"N Long: 157° 53'12.71957 "W Datum: WGS 84 Slope (%): 0

Soil Map Unit Name: Hanalei silty clay, 0 to 2% slopes NWI classification: PEM1A (non-wetland on NWI map)

Are climactic/hydrologic conditions on the site typical for this time of year: Yes ____ No X‡ (If no, explain in Remarks)

Are Vegetation No , Soil No , or Hydrology No significantly disturbed? Are "Normal Circumstances" present? Yes X No ____

Are Vegetation No , Soil No , or Hydrology No naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS—Attach a site map showing sampling point locations transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X No ____	**Is the Sampled Area within a Wetland? Yes X No ____**
Hydric Soil Present?	Yes X No ____	
Wetland Hydrology Present?	Yes X No ____	

Remarks: † PEM1A = persistent, emergent, temporary flooded palustrine wetland. ‡ See Hydrology Remarks.

VEGETATION—Use scientific names of plants.

Tree Stratum (Plot size: 30-ft radius)	Absolute % Cover	Dominant Species?	Indicator Status
1. None			
2.			
3.			
4.			
5.			
	0 =Total Cover		
Sapling/Shrub Stratum (Plot size: 20-ft radius)			
1. None			
2.			
3.			
4.			
5.			
	0 =Total Cover		
Herb Stratum (Plot size: 5-ft radius)			
1. *Urochloa mutica*	92	Yes	FACW
2. *Commelina diffusa*	5	No	FACW
3. *Paederia foetida*	3	No	UPL
4.			
5.			
6.			
7.			
8.			
	100 =Total Cover		
Woody Vine Stratum (Plot size: 20-ft radius)			
1. None			
2.			
	0 =Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: ____ (A)

Total Number of Dominant Species Across All Strata: ____ **(B)**

Percent of Dominant Species That Are OBL, FACW, or FAC: ____ (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species ____	x1= ____
FACW species ____	x2= ____
FAC species ____	x3= ____
FACU species ____	x4= ____
UPL species ____	x5= ____
Column Totals: ____ (A)	____ (B)

Prevalence Index = B/A= ____

Hydrophytic Vegetation Indicators:

X 1 - Rapid Test for Hydrophytic Vegetation

____ 2 - Dominance Test is >50%

____ 3 - Prevalence Index is ≤3.0[1]

____ Problematic Hydrophytic Vegetation [1] (Explain in Remarks or in the delineation report)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes X No ____

Remarks:

SOIL Sampling Point: 4-6

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	%	Redox Features Color (moist)	%	Type[1]	Loc[2]	Texture	Remarks
0 – 6	10YR 3/1	60	5YR 5/8	20	C	PL	sandy loam	very high in organics
	10YR 3/3	20						prominent redox features
6 – 20	2.5Y 3/1	90	7.5YR 5/6	10	C	M	mucky mineral	with sand
								prominent redox features

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains [2]Location: PL=Pore Lining, M=Matrix

Hydric Soil Indicators:
- ___ Histisols (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Muck Presence (A8)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Dark-Surface (S7)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- X Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:
- ___ Stratified Layers (A5)
- ___ Sandy Mucky Mineral (S1)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: ______

Depth (inches): ______

Hydric Soil Present: Yes X No ___

Remarks:

Hanalei silty clay, 0 to 2% slopes is on the 2012 list of hydric soils. Soil profile does not confirm mapped soil type. Loamier and colors match only >17 in.
+1 - +7 in: California grass stems
0 - +1 in: duff
River rocks at 20 in.

HYDROLOGY

Wetland Hydrology Indicators: (Explain observations in Remarks, if needed.)

Primary Indicators (minimum of one required: check all that apply)
- ___ Surface Water (A1)
- X High Water Table (A2)
- X Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Innundation Visible on Aerial Imagery (B7)
- ___ Water Stained Leaves (B9)
- ___ Aquatic Fauna (B13)
- ___ Tilapia Nests (B17)
- ___ Hydrogen Sulfide Odor (C1)
- X Oxidized Rhizospheres on Living Roots (C3)
- X Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tiled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Fiddler Crab Burrows (C10) (Guam, CNMI, and American Samoa)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)
- ___ Surface Soil Cracks (B6)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Drainage Patterns (B10)
- X Dry-Season Water Table (C2)
- ___ Salt Deposits (C5)
- ___ Stunted or Stressed Plants (D1)
- ___ Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- X FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes ___ No X Depth (inches): none

Water Table Present? Yes X No ___ Depth (inches): 7

Saturation Present? (includes capillary fringe) Yes X No ___ Depth (inches): 6

Wetland Hydrology Present? Yes X No ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

As of Aug 2014, Punaluu Pump and Punaluu Stream rain gages were at 141% and 114% of year to date average (http://www.prh.noaa.gov/hnl/hydro/pages/oahu_ytd_08.gif)

Positive α, α′ diprydil test throughout soil profile..

WETLAND DETERMINATION DATA FORM—Hawai'i and Pacific Islands

Project/Site: Punalu'u City: Punalu'u Sampling Date: Sep 16, 2014 Time: 1100

Applicant/Owner: Kamehameha Schools State/Terr./Comm.: Hawai'i Island: O'ahu Sampling Point: **SP 4-7**

Investigator(s): Susan Burr and Eric Guinther TMK/Parcel: 5-3-001:041

Landform (hillslope, coastal plain, etc.): coastal plain at toe of slope Local relief (concave, convex, none): none

Lat: 21° 34'21.07381"N Long: 157° 52'46.39021 "W Datum: WGS 84 Slope (%): 0

Soil Map Unit Name: Keaau clay, 0 to 2% slopes NWI classification: non-wetland (non-wetland on NWI map)

Are climactic/hydrologic conditions on the site typical for this time of year: Yes ____ No X‡ (If no, explain in Remarks)

Are Vegetation No , Soil No , or Hydrology No significantly disturbed? Are "Normal Circumstances" present? Yes X No ____

Are Vegetation No , Soil No , or Hydrology No naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS—Attach a site map showing sampling point locations transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X No ____	
Hydric Soil Present?	Yes ____ No X	**Is the Sampled Area**
Wetland Hydrology Present?	Yes X No ____	**within a Wetland? Yes ____ No X**

Remarks: † PEM1A = persistent, emergent, temporary flooded palustrine wetland

‡ See Hydrology Remarks. SP 4-7 is about 50 ft from *Ludwigia* wetland--separated by a berm

VEGETATION—Use scientific names of plants.

Tree Stratum (Plot size: 30-ft radius)	Absolute % Cover	Dominant Species?	Indicator Status
1. *Trema orientalis* (tree)	2	Yes	FACU
2. *Trema orientalis* (sapling)	2	Yes	FACU
3.			
4.			
5.			
	4 =Total Cover		
Sapling/Shrub Stratum (Plot size: 20-ft radius)			
1. (*Trema* with trees)			
2.			
3.			
4.			
5.			
	0 =Total Cover		
Herb Stratum (Plot size: 5-ft radius)			
1. *Urochloa mutica*	20	Yes	FACW
2. *Commelina diffusa*	30	Yes	FACW
3. *Paederia foetida*	20	Yes	UPL
4. *Sphagneticola trilobata*	10	No	FAC
5. *Paspalum conjugatum*	20	Yes	FAC
6.			
7.			
8.			
	100 =Total Cover		
Woody Vine Stratum (Plot size: 20-ft radius)			
1. None			
2.			
	0 =Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 4 (A)

Total Number of Dominant Species Across All Strata: 6 **(B)**

Percent of Dominant Species That Are OBL, FACW, or FAC: 67 (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species ____	x1= ____
FACW species ____	x2= ____
FAC species ____	x3= ____
FACU species ____	x4= ____
UPL species ____	x5= ____
Column Totals: ____ (A)	____ (B)

Prevalence Index = B/A= ____

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- X 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ Problematic Hydrophytic Vegetation [1] (Explain in Remarks or in the delineation report)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes X No ____

Remarks:

SOIL

Sampling Point: 4-7

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0 – 1	2.5Y 2.5/1	100	none				loam	very high in organics
1 – 10	7.5YR 4/2	100	none				sandy loam	
10 – 12	7.5YR 4/1	98	7.5YR 5/8	2	C	PL	sandy loam	
12 - 14	7.5YR 8/2	100	none				sandy	moist

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains [2]Location: PL=Pore Lining, M=Matrix

Hydric Soil Indicators:

___ Histisols (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Muck Presence (A8)
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Dark-Surface (S7)
___ Loamy Gleyed Matrix (F2)
___ Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

___ Stratified Layers (A5)
___ Sandy Mucky Mineral (S1)
___ Red Parent Material (TF2)
___ Very Shallow Dark Surface (TF12)
___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type:______

Depth (inches):______

Hydric Soil Present: Yes___ No X

Remarks:

Keaau clay, 0 to 2% slopes is on the 2012 list of hydric soils. Soil profile does not confirm mapped soil type. Loamier and limestone layer is too shallow.

10 – 12 in layer is not thick enough to meet F3.

HYDROLOGY

Wetland Hydrology Indicators: (Explain observations in Remarks, if needed.)

Primary Indicators (minimum of one required: check all that apply)

___ Surface Water (A1)
___ High Water Table (A2)
___ Saturation (A3)
___ Water Marks (B1)
___ Sediment Deposits (B2)
___ Drift Deposits (B3)
___ Algal Mat or Crust (B4)
___ Iron Deposits (B5)
___ Innundation Visible on Aerial Imagery (B7)
___ Water Stained Leaves (B9)
___ Aquatic Fauna (B13)
___ Tilapia Nests (B17)
___ Hydrogen Sulfide Odor (C1)
_X_ Oxidized Rhizospheres on Living Roots (C3)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Tiled Soils (C6)
___ Thin Muck Surface (C7)
___ Fiddler Crab Burrows (C10) (Guam, CNMI, and American Samoa)
___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

___ Surface Soil Cracks (B6)
___ Sparsely Vegetated Concave Surface (B8)
___ Drainage Patterns (B10)
___ Dry-Season Water Table (C2)
___ Salt Deposits (C5)
___ Stunted or Stressed Plants (D1)
X__ Geomorphic Position (D2)
___ Shallow Aquitard (D3)
___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes___ No X Depth (inches): none

Water Table Present? Yes___ No X Depth (inches): >14

Saturation Present? (includes capillary fringe) Yes___ No X Depth (inches): >14

Wetland Hydrology Present? Yes X No___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

As of Aug 2014, Punaluu Pump and Punaluu Stream rain gages were at 141% and 114% of year to date average (http://www.prh.noaa.gov/hnl/hydro/pages/oahu_ytd_08.gif)

C3 met in 10 – 12 inch layer

WETLAND DETERMINATION DATA FORM—Hawaiʻi and Pacific Islands

Project/Site: Punaluʻu City: Punaluʻu Sampling Date: Sep 16, 2014 Time: 1010

Applicant/Owner: Kamehameha Schools State/Terr./Comm.: Hawaiʻi Island: Oʻahu Sampling Point: **SP 4-8**

Investigator(s): Susan Burr and Eric Guinther TMK/Parcel: 5-3-001:041

Landform (hillslope, coastal plain, etc.): coastal plain at toe of slope Local relief (concave, convex, none): concave

Lat: 21° 34'20.72972"N Long: 157° 52'45.41848 "W Datum: WGS 84 Slope (%): <1

Soil Map Unit Name: Keaau clay, 0 to 2% slopes NWI classification: non-wetland (non-wetland on NWI map)

Are climactic/hydrologic conditions on the site typical for this time of year: Yes ___ No X‡ (If no, explain in Remarks)

Are Vegetation No , Soil No , or Hydrology No significantly disturbed? Are "Normal Circumstances" present? Yes X No ___

Are Vegetation No , Soil No , or Hydrology No naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS—Attach a site map showing sampling point locations transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X No ___	
Hydric Soil Present?	Yes ___ No X	**Is the Sampled Area**
Wetland Hydrology Present?	Yes X No ___	**within a Wetland? Yes ___ No X**

Remarks: ‡ See Hydrology Remarks.

VEGETATION—Use scientific names of plants.

Tree Stratum (Plot size: 30-ft radius)	Absolute % Cover	Dominant Species?	Indicator Status
1. None			
2.			
3.			
4.			
5.			
	0 =Total Cover		
Sapling/Shrub Stratum (Plot size: 20-ft radius)			
1. None			
2.			
3.			
4.			
5.			
	0 =Total Cover		
Herb Stratum (Plot size: 5-ft radius)			
1. *Urochloa mutica*	10	No	FACW
2. *Commelina diffusa*	95	Yes	FACW
3. *Paederia foetida*	2	No	UPL
4. *Sphagneticola trilobata*	3	No	FAC
5. *Megathyrsus maximus*	1	No	FAC
6.			
7.			
8.			
	111 =Total Cover		
Woody Vine Stratum (Plot size: 20-ft radius)			
1. None			
2.			
	0 =Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: ___ (A)

Total Number of Dominant Species Across All Strata: ___ **(B)**

Percent of Dominant Species That Are OBL, FACW, or FAC: ___ (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species ___	x1= ___
FACW species ___	x2= ___
FAC species ___	x3= ___
FACU species ___	x4= ___
UPL species ___	x5= ___
Column Totals: ___ (A)	___ (B)

Prevalence Index = B/A= ___

Hydrophytic Vegetation Indicators:

X 1 - Rapid Test for Hydrophytic Vegetation

___ 2 - Dominance Test is >50%

___ 3 - Prevalence Index is ≤3.0[1]

___ Problematic Hydrophytic Vegetation [1] (Explain in Remarks or in the delineation report)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes X No ___

Remarks:

SOIL

Sampling Point: 4-8

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	%	Redox Features Color (moist)	%	Type[1]	Loc[2]	Texture	Remarks
0 – 10	10YR 2/2	100	none				sandy clay loam	with shells (very little clay)
10 – 12	10YR 2/2	98	7.5YR 4/4	2	C	M	sandy clay loam	distinct redox features
12 – 13	2.5Y 5/1	90	5YR 3/4	10	C	PL	sandy clay loam	prominent redox features
13 – 16	7.5YR 8/2	95	2.5Y 5/1	3	C	M	sandy clay loam	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains
[2]Location: PL=Pore Lining, M=Matrix

Hydric Soil Indicators:

- ___ Histisols (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Muck Presence (A8)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Dark-Surface (S7)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ___ Stratified Layers (A5)
- ___ Sandy Mucky Mineral (S1)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: ____________

Depth (inches): ____________

Hydric Soil Present: Yes ____ **No** X

Remarks:

Keaau clay, 0 to 2% slopes is on the 2012 list of hydric soils. Soil profile does not confirm mapped soil type. Loamier and limestone layer is too shallow.

0 - +4 in: stems

HYDROLOGY

Wetland Hydrology Indicators: (Explain observations in Remarks, if needed.)

Primary Indicators (minimum of one required: check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Innundation Visible on Aerial Imagery (B7)
- ___ Water Stained Leaves (B9)
- ___ Aquatic Fauna (B13)
- ___ Tilapia Nests (B17)
- ___ Hydrogen Sulfide Odor (C1)
- X Oxidized Rhizospheres on Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tiled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Fiddler Crab Burrows (C10) (Guam, CNMI, and American Samoa)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Salt Deposits (C5)
- ___ Stunted or Stressed Plants (D1)
- X Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- X FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes ____ No X Depth (inches): none

Water Table Present? Yes ____ No X Depth (inches): >16

Saturation Present? (includes capillary fringe) Yes ____ No X Depth (inches): >16

Wetland Hydrology Present? Yes X **No** ____

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

As of Aug 2014, Punaluu Pump and Punaluu Stream rain gages were at 141% and 114% of year to date average (http://www.prh.noaa.gov/hnl/hydro/pages/oahu_ytd_08.gif)

oxidized rhizospheres on living roots only deeper than 12 inches – C3 not met.

WETLAND DETERMINATION DATA FORM—Hawaiʻi and Pacific Islands

Project/Site: Punaluʻu City: Punaluʻu Sampling Date: Sep 15, 2014 Time: 1230

Applicant/Owner: Kamehameha Schools State/Terr./Comm.: Hawaiʻi Island: Oʻahu Sampling Point: **SP 4-9**

Investigator(s): Susan Burr and Eric Guinther TMK/Parcel: 5-3-001:041

Landform (hillslope, coastal plain, etc.): coastal plain Local relief (concave, convex, none): none

Lat: 21° 34'22.94036"N Long: 157° 52'46.48777 "W Datum: WGS 84 Slope (%): 0

Soil Map Unit Name: Keaau clay, 0 to 2% slopes NWI classification: non-wetland (non-wetland on NWI map)

Are climactic/hydrologic conditions on the site typical for this time of year: Yes ____ No X‡ (If no, explain in Remarks)

Are Vegetation No , Soil No , or Hydrology No significantly disturbed? Are "Normal Circumstances" present? Yes X No ____

Are Vegetation No , Soil No , or Hydrology No naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS—Attach a site map showing sampling point locations transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No ____
Hydric Soil Present?	Yes ____	No X
Wetland Hydrology Present?	Yes ____	No X

Is the Sampled Area within a Wetland? Yes ____ No X

Remarks:

‡ See Hydrology Remarks.

VEGETATION—Use scientific names of plants.

Tree Stratum (Plot size: 30-ft radius)	Absolute % Cover	Dominant Species?	Indicator Status
1. None			
2.			
3.			
4.			
5.			
	0 =Total Cover		
Sapling/Shrub Stratum (Plot size: 20-ft radius)			
1. *Terminalia catappa*	2	Yes	FAC
2.			
3.			
4.			
5.			
	2 =Total Cover		
Herb Stratum (Plot size: 5-ft radius)			
1. *Paspalum conjugatum*	20	Yes	FAC
2. *Commelina diffusa*	40	Yes	FACW
3. *Paederia foetida*	10	No	UPL
4. *Sphagneticola trilobata*	30	Yes	FAC
5.			
6.			
7.			
8.			
	100 =Total Cover		
Woody Vine Stratum (Plot size: 20-ft radius)			
1. None			
2.			
	0 =Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 4 (A)

Total Number of Dominant Species Across All Strata: 4 **(B)**

Percent of Dominant Species That Are OBL, FACW, or FAC: 100 (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species ____	x1= ____
FACW species ____	x2= ____
FAC species ____	x3= ____
FACU species ____	x4= ____
UPL species ____	x5= ____
Column Totals: ____ (A)	____ (B)

Prevalence Index = B/A= ____

Hydrophytic Vegetation Indicators:

___ 1 - Rapid Test for Hydrophytic Vegetation

X 2 - Dominance Test is >50%

___ 3 - Prevalence Index is ≤3.0[1]

___ Problematic Hydrophytic Vegetation [1] (Explain in Remarks or in the delineation report)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes X No ____

Remarks:

SOIL **Sampling Point: 4-9**

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks
0 – 12	2.5Y 3/1	100	none				sandy loam	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains [2]Location: PL=Pore Lining, M=Matrix

Hydric Soil Indicators:

___ Histisols (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Muck Presence (A8)
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Dark-Surface (S7)
___ Loamy Gleyed Matrix (F2)
___ Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

___ Stratified Layers (A5)
___ Sandy Mucky Mineral (S1)
___ Red Parent Material (TF2)
___ Very Shallow Dark Surface (TF12)
___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type:______

Depth (inches):______

Hydric Soil Present: **Yes**_____ **No** X

Remarks:

Keaau clay, 0 to 2% slopes is on the 2012 list of hydric soils. Soil profile does not confirm mapped soil type.

0 - +6 in: stems

HYDROLOGY

Wetland Hydrology Indicators: (Explain observations in Remarks, if needed.)

Primary Indicators (minimum of one required: check all that apply)

___ Surface Water (A1)
___ High Water Table (A2)
___ Saturation (A3)
___ Water Marks (B1)
___ Sediment Deposits (B2)
___ Drift Deposits (B3)
___ Algal Mat or Crust (B4)
___ Iron Deposits (B5)
___ Inundation Visible on Aerial Imagery (B7)
___ Water Stained Leaves (B9)
___ Aquatic Fauna (B13)
___ Tilapia Nests (B17)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres on Living Roots (C3)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Tiled Soils (C6)
___ Thin Muck Surface (C7)
___ Fiddler Crab Burrows (C10) (Guam, CNMI, and American Samoa)
___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

___ Surface Soil Cracks (B6)
___ Sparsely Vegetated Concave Surface (B8)
___ Drainage Patterns (B10)
___ Dry-Season Water Table (C2)
___ Salt Deposits (C5)
___ Stunted or Stressed Plants (D1)
___ Geomorphic Position (D2)
___ Shallow Aquitard (D3)
X FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes_____ No X Depth (inches): none

Water Table Present? Yes_____ No X Depth (inches): >12

Saturation Present? (includes capillary fringe) Yes_____ No X Depth (inches): >12

Wetland Hydrology Present? **Yes**_____ **No** X

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

As of Aug 2014, Punaluu Pump and Punaluu Stream rain gages were at 141% and 114% of year to date average (http://www.prh.noaa.gov/hnl/hydro/pages/oahu_ytd_08.gif)

oxidized rhizospheres on living roots only deeper than 12 inches – C3 not met.

WETLAND DETERMINATION DATA FORM—Hawaiʻi and Pacific Islands

Project/Site: Punaluʻu City: Punaluʻu Sampling Date: Sep 15, 2014 Time: 1230

Applicant/Owner: Kamehameha Schools State/Terr./Comm.: Hawaiʻi Island: Oʻahu Sampling Point: **SP 4-10**

Investigator(s): Susan Burr and Eric Guinther TMK/Parcel: 5-3-001:041

Landform (hillslope, coastal plain, etc.): coastal plain Local relief (concave, convex, none): concave

Lat: 21° 34'23.66888"N Long: 157° 52'50.25526 "W Datum: WGS 84 Slope (%): <1

Soil Map Unit Name: Keaau clay, 0 to 2% slopes NWI classification: non-wetland (non-wetland on NWI map)

Are climactic/hydrologic conditions on the site typical for this time of year: Yes ____ No X‡ (If no, explain in Remarks)

Are Vegetation No , Soil No , or Hydrology No significantly disturbed? Are "Normal Circumstances" present? Yes X No ____

Are Vegetation No , Soil No , or Hydrology No naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS—Attach a site map showing sampling point locations transects, important features, etc.

Hydrophytic Vegetation Present? Yes X No ____	
Hydric Soil Present? Yes X No ____	**Is the Sampled Area**
Wetland Hydrology Present? Yes X No ____	**within a Wetland? Yes X No ____**

Remarks: A berm is present on the *makai* side of this wetland. The wetland transitions to *hau* on the *mauka* side. Boundary is in the *hau*.

‡ See Hydrology Remarks.

VEGETATION—Use scientific names of plants.

Tree Stratum (Plot size: 30-ft radius)	Absolute % Cover	Dominant Species?	Indicator Status
1. None			
2.			
3.			
4.			
5.			
	0 =Total Cover		
Sapling/Shrub Stratum (Plot size: 20-ft radius)			
1. Ardisia eliptica	30	Yes	FACU
2. *Ludwigia octovalvis*	70	Yes	OBL
3. *Pluchea carolinensis*	5	No	FAC
4.			
5.			
	105 =Total Cover		
Herb Stratum (Plot size: 5-ft radius)			
1. .*Ludwigia octovalvis*	5	Yes	OBL
2. *Kyllinga brevifolia*	5	Yes	FAC
3.			
4.			
5.			
6.			
7.			
8.			
	10 =Total Cover		
Woody Vine Stratum (Plot size: 20-ft radius)			
1. None			
2.			
	0 =Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 3 (A)

Total Number of Dominant Species Across All Strata: 4 **(B)**

Percent of Dominant Species That Are OBL, FACW, or FAC: 75 (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species ____	x1= ____
FACW species ____	x2= ____
FAC species ____	x3= ____
FACU species ____	x4= ____
UPL species ____	x5= ____
Column Totals: ____ (A)	____ (B)

Prevalence Index = B/A= ____

Hydrophytic Vegetation Indicators:

___ 1 - Rapid Test for Hydrophytic Vegetation

X 2 - Dominance Test is >50%

___ 3 - Prevalence Index is ≤3.0[1]

___ Problematic Hydrophytic Vegetation [1] (Explain in Remarks or in the delineation report)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes X No ____

Remarks:

SOIL

Sampling Point: 4-10

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks
0 – 11	2.5Y 3/1	90	7.5YR 4/3	10	C	PL	silt loam	high in organics
								prominent redox concentrations

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains [2]Location: PL=Pore Lining, M=Matrix

Hydric Soil Indicators:

- ___ Histisols (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Muck Presence (A8)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Dark-Surface (S7)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- _X_ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ___ Stratified Layers (A5)
- ___ Sandy Mucky Mineral (S1)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: ______

Depth (inches): ______

Hydric Soil Present? **Yes** _X_ **No** ___

Remarks:

Keaau clay, 0 to 2% slopes is on the 2012 list of hydric soils. Soil profile does not confirm mapped soil type.

HYDROLOGY

Wetland Hydrology Indicators: (Explain observations in Remarks, if needed.)

Primary Indicators (minimum of one required: check all that apply)

- ___ Surface Water (A1)
- _X_ High Water Table (A2)
- _X_ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Innundation Visible on Aerial Imagery (B7)
- _X_ Water Stained Leaves (B9)
- ___ Aquatic Fauna (B13)
- ___ Tilapia Nests (B17)
- ___ Hydrogen Sulfide Odor (C1)
- _X_ Oxidized Rhizospheres on Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tiled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Fiddler Crab Burrows (C10) (Guam, CNMI, and American Samoa)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ___ Sparsely Vegetated Concave Surface (B8)
- _X_ Drainage Patterns (B10)
- _X_ Dry-Season Water Table (C2)
- ___ Salt Deposits (C5)
- ___ Stunted or Stressed Plants (D1)
- _X_ Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- _X_ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes ___ No _X_ Depth (inches): none

Water Table Present? Yes _X_ No ___ Depth (inches): 5

Saturation Present? (includes capillary fringe) Yes _X_ No ___ Depth (inches): 2

Wetland Hydrology Present? **Yes** _X_ **No** ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

As of Aug 2014, Punaluu Pump and Punaluu Stream rain gages were at 141% and 114% of year to date average (http://www.prh.noaa.gov/hnl/hydro/pages/oahu_ytd_08.gif)

Tree branches present on ground – water logged, had recently been floating. Bridges present throughout wetland.
Spring-fed wetland.

WETLAND DETERMINATION DATA FORM—Hawaiʻi and Pacific Islands

Project/Site: Punaluʻu City: Punaluʻu Sampling Date: Oct 2, 2014 Time: 1140

Applicant/Owner: Kamehameha Schools State/Terr./Comm.: Hawaiʻi Island: Oʻahu Sampling Point: **SP 4-11**

Investigator(s): Susan Burr and Chad Linebaugh TMK/Parcel: 5-3-001:041

Landform (hillslope, coastal plain, etc.): coastal plain floodplain Local relief (concave, convex, none): none

Lat: 21° 34'31.17782"N Long: 157° 53'12x46459"W Datum: WGS 84 Slope (%): 0

Soil Map Unit Name: Hanalei silty clay, 0 to 2% slopes NWI classification: PEM1A (non-wetland on NWI map)

Are climactic/hydrologic conditions on the site typical for this time of year: Yes____ No X‡ (If no, explain in Remarks)

Are Vegetation No , Soil No , or Hydrology No significantly disturbed? Are "Normal Circumstances" present? Yes X No____

Are Vegetation No , Soil No , or Hydrology No naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS—Attach a site map showing sampling point locations transects, important features, etc.

Hydrophytic Vegetation Present? Yes X No ____	
Hydric Soil Present? Yes X No ____	**Is the Sampled Area**
Wetland Hydrology Present? Yes X No ____	**within a Wetland? Yes X No____**

Remarks: † PEM1A = persistent, emergent, temprarily flooded palustrine wetland.

‡ See Hydrology Remarks.

VEGETATION—Use scientific names of plants.

Tree Stratum (Plot size: 30-ft radius)	Absolute % Cover	Dominant Species?	Indicator Status
1. None			
2.			
3.			
4.			
5.			
	0 =Total Cover		
Sapling/Shrub Stratum (Plot size: 20-ft radius)			
1. None			
2.			
3.			
4.			
5.			
	0 =Total Cover		
Herb Stratum (Plot size: 5-ft radius)			
1. *Urochloa mutica*	78	Yes	FACW
2. *Commelina diffusa*	20	Yes	FACW
3. *Paederia foetida*	2	No	UPL
4.			
5.			
6.			
7.			
8.			
	100 =Total Cover		
Woody Vine Stratum (Plot size: 5-ft radius)			
1. None			
2.			
	0 =Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: ______ (A)

Total Number of Dominant Species Across All Strata: ______ **(B)**

Percent of Dominant Species That Are OBL, FACW, or FAC: ______ (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species	x1=
FACW species	x2=
FAC species	x3=
FACU species	x4=
UPL species	x5=
Column Totals: (A)	(B)

Prevalence Index = B/A=______

Hydrophytic Vegetation Indicators:

X 1 - Rapid Test for Hydrophytic Vegetation

___ 2 - Dominance Test is >50%

___ 3 - Prevalence Index is ≤3.0[1]

___ Problematic Hydrophytic Vegetation [1] (Explain in Remarks or in the delineation report)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes X No____

Remarks:.

SOIL

Sampling Point: 4-11

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0 – 4	10YR 4/2	95	7.5YR 5/6	5	C	PL	clay loam	high organic
								prominent redox features
4 – 16	2.5YR 4/1	85	5YR 4/6	15	C	PL	muck	
								prominent redox features

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains

[2]Location: PL=Pore Lining, M=Matrix

Hydric Soil Indicators:

- ___ Histisols (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Muck Presence (A8)
- X Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Dark-Surface (S7)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ___ Stratified Layers (A5)
- ___ Sandy Mucky Mineral (S1)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: ___

Depth (inches): ___

Hydric Soil Present: **Yes** X **No** ___

Remarks:

Hanalei stony silty clay, 0 to 2% slopes is on the 2012 list of hydric soils. Soil profile generally confirms mapped soil type.

River rock at 16 in depth

HYDROLOGY

Wetland Hydrology Indicators: (Explain observations in Remarks, if needed.)

Primary Indicators (minimum of one required: check all that apply)

- ___ Surface Water (A1)
- X High Water Table (A2)
- X Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Innundation Visible on Aerial Imagery (B7)
- ___ Water Stained Leaves (B9)
- ___ Aquatic Fauna (B13)
- ___ Tilapia Nests (B17)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres on Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tiled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Fiddler Crab Burrows (C10) (Guam, CNMI, and American Samoa)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ___ Sparsely Vegetated Concave Surface (B8)
- X Drainage Patterns (B10)
- X Dry-Season Water Table (C2)
- ___ Salt Deposits (C5)
- ___ Stunted or Stressed Plants (D1)
- ___ Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- ___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present?	Yes ___	No X	Depth (inches): none
Water Table Present?	Yes X	No ___	Depth (inches): 8
Saturation Present? (includes capillary fringe)	Yes X	No ___	Depth (inches): 6

Wetland Hydrology Present? **Yes** X **No** ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

As of Aug 2014, Punaluu Pump and Punaluu Stream rain gages were at 141% and 114% of year to date average (http://www.prh.noaa.gov/hnl/hydro/pages/oahu_ytd_08.gif)

WETLAND DETERMINATION DATA FORM—Hawaiʻi and Pacific Islands

Project/Site: Punaluʻu City: Punaluʻu Sampling Date: Oct 2, 2014 Time: 1150

Applicant/Owner: Kamehameha Schools State/Terr./Comm.: Hawaiʻi Island: Oʻahu Sampling Point: **SP 4-12**

Investigator(s): Susan Burr and Chad Linebaugh TMK/Parcel: 5-3-003:001

Landform (hillslope, coastal plain, etc.): coastal flood plain Local relief (concave, convex, none): none

Lat: 21° 34'30.41296"N Long: 157° 53'13x28745"W Datum: WGS 84 Slope (%): 0

Soil Map Unit Name: Hanalei stony silty clay, 0 to 2% slopes NWI classification: PEM1A (PEM1C on NWI map)

Are climactic/hydrologic conditions on the site typical for this time of year: Yes ____ No X‡ (If no, explain in Remarks)

Are Vegetation No , Soil No , or Hydrology No significantly disturbed? Are "Normal Circumstances" present? Yes X No ____

Are Vegetation No , Soil No , or Hydrology No naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS—Attach a site map showing sampling point locations transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X No ____	
Hydric Soil Present?	Yes X No ____	**Is the Sampled Area**
Wetland Hydrology Present?	Yes X No ____	**within a Wetland? Yes X No ____**

Remarks: † PEM1C = persistent, emergent, seasonally flooded palustrine wetland

PEM1A = = persistent, emergent, temporary flooded palustrine wetland. ‡ See Hydrology Remarks.

VEGETATION—Use scientific names of plants.

Tree Stratum (Plot size: 30-ft radius)	Absolute % Cover	Dominant Species?	Indicator Status
1. None			
2.			
3.			
4.			
5.			
	0 =Total Cover		
Sapling/Shrub Stratum (Plot size: 20-ft radius)			
1. None			
2.			
3.			
4.			
5.			
	0 =Total Cover		
Herb Stratum (Plot size: 5-ft radius)			
1. *Urochloa mutica*	60	Yes	FACW
2. *Cenchurus purpureus*	35	Yes	FAC
3. *Paederia foetida*	2	No	UPL
4. *Melastoma septemnervium*	3	No	UPL
5.			
6.			
7.			
8.			
	100 =Total Cover		
Woody Vine Stratum (Plot size: 5-ft radius)			
1. None			
2.			
	0 =Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 2 (A)

Total Number of Dominant Species Across All Strata: 2 **(B)**

Percent of Dominant Species That Are OBL, FACW, or FAC: 100 (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species ____	x1= ____
FACW species ____	x2= ____
FAC species ____	x3= ____
FACU species ____	x4= ____
UPL species ____	x5= ____
Column Totals: ____ (A)	____ (B)

Prevalence Index = B/A= ____

Hydrophytic Vegetation Indicators:

___ 1 - Rapid Test for Hydrophytic Vegetation

X 2 - Dominance Test is >50%

___ 3 - Prevalence Index is ≤3.0[1]

___ Problematic Hydrophytic Vegetation [1] (Explain in Remarks or in the delineation report)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes X No ____

Remarks:

SOIL — **Sampling Point: 4-12**

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type [1]	Loc [2]	Texture	Remarks
0 – 8	10YR 3/3	100	none				sandy clay loam	
8 – 17	10YR 4/1	85	5YR 4/6	15	C	PL	sandy clay	prominent redox features

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains — [2]Location: PL=Pore Lining, M=Matrix

Hydric Soil Indicators:

- ___ Histisols (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Muck Presence (A8)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Dark-Surface (S7)
- ___ Loamy Gleyed Matrix (F2)
- _X_ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ___ Stratified Layers (A5)
- ___ Sandy Mucky Mineral (S1)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type:__________

Depth (inches):__________

Hydric Soil Present: Yes _X_ No ___

Remarks:

Hanalei stony silty clay, 0 to 2% slopes is on the 2012 list of hydric soils. Soil profile generally confirms mapped soil type, but sandier.

River rock at 16 in depth

HYDROLOGY

Wetland Hydrology Indicators: (Explain observations in Remarks, if needed.)

Primary Indicators (minimum of one required: check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- _X_ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Innundation Visible on Aerial Imagery (B7)
- ___ Water Stained Leaves (B9)
- ___ Aquatic Fauna (B13)
- ___ Tilapia Nests (B17)
- ___ Hydrogen Sulfide Odor (C1)
- _X_ Oxidized Rhizospheres on Living Roots (C3)
- _X_ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tiled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Fiddler Crab Burrows (C10) (Guam, CNMI, and American Samoa)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Salt Deposits (C5)
- ___ Stunted or Stressed Plants (D1)
- ___ Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- X___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes ___ No _X_ Depth (inches): none

Water Table Present? Yes _X_ No ___ Depth (inches): 14

Saturation Present? (includes capillary fringe) Yes _X_ No ___ Depth (inches): surface

Wetland Hydrology Present? Yes _X_ No ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

As of Aug 2014, Punaluu Pump and Punaluu Stream rain gages were at 141% and 114% of year to date average (http://www.prh.noaa.gov/hnl/hydro/pages/oahu_ytd_08.gif)

Positive α, α′ diprydil test at 8 in.

WETLAND DETERMINATION DATA FORM—Hawaiʻi and Pacific Islands

Project/Site: Punaluʻu City: Punaluʻu Sampling Date: Oct 2, 2014 Time: 1200

Applicant/Owner: Kamehameha Schools State/Terr./Comm.: Hawaiʻi Island: Oʻahu Sampling Point: **SP 4-13**

Investigator(s): Susan Burr and Chad Linebaugh TMK/Parcel: 5-3-003:001

Landform (hillslope, coastal plain, etc.): coastal flood plain Local relief (concave, convex, none): none

Lat: 21° 34'29.23507"N Long: 157° 53'14.39008 "W Datum: WGS 84 Slope (%): 0

Soil Map Unit Name: Hanalei stony silty clay, 0 to 2% slopes NWI classification: upland

Are climactic/hydrologic conditions on the site typical for this time of year: Yes ____ No X‡ (If no, explain in Remarks)

Are Vegetation No , Soil No , or Hydrology No significantly disturbed? Are "Normal Circumstances" present? Yes X No ____

Are Vegetation No , Soil No , or Hydrology No naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS—Attach a site map showing sampling point locations transects, important features, etc.

Hydrophytic Vegetation Present?	Yes ____ No X	
Hydric Soil Present?	Yes ____ No X	**Is the Sampled Area**
Wetland Hydrology Present?	Yes ____ No X	**within a Wetland? Yes ____ No X**

Remarks: † PEM1A = persistent, emergent, temporarily flooded palustrine wetland. ‡ See Hydrology Remarks.

VEGETATION—Use scientific names of plants.

Tree Stratum (Plot size: 30-ft radius)	Absolute % Cover	Dominant Species?	Indicator Status
1. *Psidium guajava*	10	Yes	FACU
2. *Leucaena leucocephala*	2	Yes	UPL
3.			
4.			
5.			
	12 =Total Cover		
Sapling/Shrub Stratum (Plot size: 20-ft radius)			
1. *Musa* x *paradisiaca*	5	Yes	FACU
2.			
3.			
4.			
5.			
	5 =Total Cover		
Herb Stratum (Plot size: 5-ft radius)			
1. *Paspalum conjugatum*	85	Yes	FAC
2. *Commelina diffusa*	10	No	FACW
3. *Paederia foetida*	2	No	UPL
4. *Sphagneticola trilobata*	3	No	FAC
5.			
6.			
7.			
8.			
	100 =Total Cover		
Woody Vine Stratum (Plot size: 5-ft radius)			
1. None			
2.			
	0 =Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 1 (A)

Total Number of Dominant Species Across All Strata: 4 **(B)**

Percent of Dominant Species That Are OBL, FACW, or FAC: 25 (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species	0	x1= 0
FACW species	10	x2= 20
FAC species	88	x3= 264
FACU species	15	x4= 60
UPL species	42	x5= 20
Column Totals:	117 (A)	364 (B)

Prevalence Index = B/A= 3.1

Hydrophytic Vegetation Indicators:

___ 1 - Rapid Test for Hydrophytic Vegetation

___ 2 - Dominance Test is >50%

___ 3 - Prevalence Index is ≤3.0[1]

___ Problematic Hydrophytic Vegetation [1] (Explain in Remarks or in the delineation report)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes ____ No X

Remarks:

SOIL

Sampling Point: 4-13

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0 – 13	10YR 3/3	100	none				clay	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains   [2]Location: PL=Pore Lining, M=Matrix

Hydric Soil Indicators:

- ___ Histisols (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Muck Presence (A8)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Dark-Surface (S7)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- X Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ___ Stratified Layers (A5)
- ___ Sandy Mucky Mineral (S1)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: ______

Depth (inches): ______

Hydric Soil Present? Yes ___ No X

Remarks:

Hanalei stony silty clay, 0 to 2% slopes is on the 2012 list of hydric soils. Soil profile generally confirms mapped soil type, but sandier.

River rock at 12 in depth

HYDROLOGY

Wetland Hydrology Indicators: (Explain observations in Remarks, if needed.)

Primary Indicators (minimum of one required: check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- X Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Innundation Visible on Aerial Imagery (B7)
- ___ Water Stained Leaves (B9)
- ___ Aquatic Fauna (B13)
- ___ Tilapia Nests (B17)
- ___ Hydrogen Sulfide Odor (C1)
- X Oxidized Rhizospheres on Living Roots (C3)
- X Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tiled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Fiddler Crab Burrows (C10) (Guam, CNMI, and American Samoa)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Salt Deposits (C5)
- ___ Stunted or Stressed Plants (D1)
- ___ Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- X FAC-Neutral Test (D5)

Field Observations:

Surface Water Present?	Yes ___	No X	Depth (inches): none
Water Table Present?	Yes ___	No X	Depth (inches): >13
Saturation Present? (includes capillary fringe)	Yes ___	No X	Depth (inches): >13

Wetland Hydrology Present? Yes ___ No X

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

As of Aug 2014, Punaluu Pump and Punaluu Stream rain gages were at 141% and 114% of year to date average (http://www.prh.noaa.gov/hnl/hydro/pages/oahu_ytd_08.gif)

Negative α, α′ diprydil test throughout profile.

WETLAND DETERMINATION DATA FORM—Hawai‘i and Pacific Islands

Project/Site: Punalu‘u City: Punalu‘u Sampling Date: Oct 2, 2014 Time: 1346

Applicant/Owner: Kamehameha Schools State/Terr./Comm.: Hawai‘i Island: O‘ahu Sampling Point: **SP 4-14**

Investigator(s): Susan Burr and Chad Linebaugh TMK/Parcel: 5-3-003:001

Landform (hillslope, coastal plain, etc.): coastal flood plain Local relief (concave, convex, none): none

Lat: 21° 34’21.20402”N Long: 157° 52’48.27255 ”W Datum: WGS 84 Slope (%): 0

Soil Map Unit Name: Keaau clay, 0 to 2% slopes NWI classification: PEM1A

Are climactic/hydrologic conditions on the site typical for this time of year: Yes ____ No X‡ (If no, explain in Remarks)

Are Vegetation No , Soil No , or Hydrology No significantly disturbed? Are “Normal Circumstances” present? Yes X No ____

Are Vegetation No , Soil No , or Hydrology No naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS—Attach a site map showing sampling point locations transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X No ____	
Hydric Soil Present?	Yes X No ____	**Is the Sampled Area**
Wetland Hydrology Present?	Yes X No ____	**within a Wetland? Yes X No ____**

Remarks: † PEM1A = persistent, emergent, temporarily flooded palustrine wetland

‡ See Hydrology Remarks.

VEGETATION—Use scientific names of plants.

Tree Stratum (Plot size: 30-ft radius)	Absolute % Cover	Dominant Species?	Indicator Status
1. None			
2.			
3.			
4.			
5.			
	=Total Cover		
Sapling/Shrub Stratum (Plot size: 20-ft radius)			
1.			
2.			
3.			
4.			
5.			
	=Total Cover		
Herb Stratum (Plot size: 5-ft radius)			
1. *Urochloa mutica*	99	Yes	FACW
2. *Sphagneticola trilobata*	1	No	FAC
3.			
4.			
5.			
6.			
7.			
8.			
	100 =Total Cover		
Woody Vine Stratum (Plot size: 5-ft radius)			
1. None			
2.			
	0 =Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: ____ (A)

Total Number of Dominant Species Across All Strata: ____ **(B)**

Percent of Dominant Species That Are OBL, FACW, or FAC: ____ (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species ____	x1= ____
FACW species ____	x2= ____
FAC species ____	x3= ____
FACU species ____	x4= ____
UPL species ____	x5= ____
Column Totals: ____ (A)	____ (B)

Prevalence Index = B/A= ____

Hydrophytic Vegetation Indicators:

X 1 - Rapid Test for Hydrophytic Vegetation

___ 2 - Dominance Test is >50%

___ 3 - Prevalence Index is ≤3.0[1]

___ Problematic Hydrophytic Vegetation [1] (Explain in Remarks or in the delineation report)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes X No ____

Remarks:

SOIL

Sampling Point: 4-14

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type [1]	Loc [2]	Texture	Remarks
0 – 8	Gley 1 2.5/N	85	5YR 3/4	15	C	M	Muck	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains [2]Location: PL=Pore Lining, M=Matrix

Hydric Soil Indicators:

- ___ Histisols (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- X Muck Presence (A8)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Dark-Surface (S7)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ___ Stratified Layers (A5)
- ___ Sandy Mucky Mineral (S1)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: ______

Depth (inches): ______

Hydric Soil Present? Yes X No ___

Remarks:

Keaau clay, 0 to 2% slopes is on the 2012 list of hydric soils. Soil profile does not confirm mapped soil type.

8 in layer of stems above soil surface

HYDROLOGY

Wetland Hydrology Indicators: (Explain observations in Remarks, if needed.)

Primary Indicators (minimum of one required: check all that apply)

- ___ Surface Water (A1)
- X High Water Table (A2)
- X Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Innundation Visible on Aerial Imagery (B7)
- ___ Water Stained Leaves (B9)
- ___ Aquatic Fauna (B13)
- ___ Tilapia Nests (B17)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres on Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tiled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Fiddler Crab Burrows (C10) (Guam, CNMI, and American Samoa)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Salt Deposits (C5)
- ___ Stunted or Stressed Plants (D1)
- ___ Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- X FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes ___ No X Depth (inches): none

Water Table Present? Yes X No ___ Depth (inches): at surface

Saturation Present? (includes capillary fringe) Yes X No ___ Depth (inches): at surface

Wetland Hydrology Present? Yes X No ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

As of Aug 2014, Punaluu Pump and Punaluu Stream rain gages were at 141% and 114% of year to date average (http://www.prh.noaa.gov/hnl/hydro/pages/oahu_ytd_08.gif)

WETLAND DETERMINATION DATA FORM—Hawaiʻi and Pacific Islands

Project/Site: Punaluʻu City: Punaluʻu Sampling Date: Sept 18, 2014 Time: 1030

Applicant/Owner: Kamehameha Schools State/Terr./Comm.: Hawaiʻi Island: Oʻahu Sampling Point: **SP 5-1**

Investigator(s): Susan Burr and Chad Linebaugh TMK/Parcel: 5-3-003:001

Landform (hillslope, coastal plain, etc.): flood plain Local relief (concave, convex, none): none

Lat: 21° 34'27.79645"N Long: 157° 53'16.63835 "W Datum: WGS 84 Slope (%): 0

Soil Map Unit Name: Hanalei silty clay, 0 to 2% slopes NWI classification: not wetland (non-wetland on NWI map)

Are climactic/hydrologic conditions on the site typical for this time of year: Yes ____ No X‡ (If no, explain in Remarks)

Are Vegetation No , Soil No , or Hydrology No significantly disturbed? Are "Normal Circumstances" present? Yes X No ____

Are Vegetation No , Soil No , or Hydrology No naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS—Attach a site map showing sampling point locations transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X No ____	
Hydric Soil Present?	Yes ____ No X	**Is the Sampled Area**
Wetland Hydrology Present?	Yes ____ No X	**within a Wetland? Yes ____ No X**

Remarks: SP 5-1 is at an existing archaeology trench

‡ See Hydrology Remarks.

VEGETATION—Use scientific names of plants.

	Absolute % Cover	Dominant Species?	Indicator Status
Tree Stratum (Plot size: 30-ft radius)			
1. None			
2.			
3.			
4.			
5.			
	=Total Cover		
Sapling/Shrub Stratum (Plot size: 20-ft radius)			
1.			
2.			
3.			
4.			
5.			
	=Total Cover		
Herb Stratum (Plot size: 5-ft radius)			
1. *Paspalum conjugatum*	80	Yes	FAC
2. *Commelina diffusa*	20	Yes	FACW
3. *Ricinus communis* (shrub)	2	No	FACU
4.			
5.			
6.			
7.			
8.			
	102 =Total Cover		
Woody Vine Stratum (Plot size: 5-ft radius)			
1. None			
2.			
	0 =Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 2 (A)

Total Number of Dominant Species Across All Strata: 2 **(B)**

Percent of Dominant Species That Are OBL, FACW, or FAC: 100 (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species ____	x1= ____
FACW species ____	x2= ____
FAC species ____	x3= ____
FACU species ____	x4= ____
UPL species ____	x5= ____
Column Totals: ____ (A)	____ (B)

Prevalence Index = B/A= ____

Hydrophytic Vegetation Indicators:

___ 1 - Rapid Test for Hydrophytic Vegetation

X 2 - Dominance Test is >50%

___ 3 - Prevalence Index is ≤3.0[1]

___ Problematic Hydrophytic Vegetation [1] (Explain in Remarks or in the delineation report)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes X No ____

Remarks:

SOIL **Sampling Point: 5-1**

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0 – 19	7.5 YR 3/4	100	none				silt loam	
19 – 22	7.5YR 2/2	93	2.5YR 4/6	2	C	M	sandy clay loam	
22 -2 4	7.5YR 2/2	46	2.5YR 4/6	1	C	M	sandy clay loam	
		50					gravel and river rocks	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains [2]Location: PL=Pore Lining, M=Matrix

Hydric Soil Indicators:

___ Histisols (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Muck Presence (A8)
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Dark-Surface (S7)
___ Loamy Gleyed Matrix (F2)
___ Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

___ Stratified Layers (A5)
___ Sandy Mucky Mineral (S1)
___ Red Parent Material (TF2)
___ Very Shallow Dark Surface (TF12)
___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type:________

Depth (inches):________

Hydric Soil Present? **Yes**____ **No** X

Remarks:

Hanalei stony silty clay, 2 to 6% slopes is on the 2012 list of hydric soils. Soil profile does not confirm mapped soil type.

HYDROLOGY

Wetland Hydrology Indicators: (Explain observations in Remarks, if needed.)

Primary Indicators (minimum of one required: check all that apply)

___ Surface Water (A1)
___ High Water Table (A2)
___ Saturation (A3)
___ Water Marks (B1)
___ Sediment Deposits (B2)
___ Drift Deposits (B3)
___ Algal Mat or Crust (B4)
___ Iron Deposits (B5)
___ Innundation Visible on Aerial Imagery (B7)
___ Water Stained Leaves (B9)
___ Aquatic Fauna (B13)
___ Tilapia Nests (B17)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres on Living Roots (C3)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Tiled Soils (C6)
___ Thin Muck Surface (C7)
___ Fiddler Crab Burrows (C10) (Guam, CNMI, and American Samoa)
___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

___ Surface Soil Cracks (B6)
___ Sparsely Vegetated Concave Surface (B8)
___ Drainage Patterns (B10)
___ Dry-Season Water Table (C2)
___ Salt Deposits (C5)
___ Stunted or Stressed Plants (D1)
___ Geomorphic Position (D2)
___ Shallow Aquitard (D3)
___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes____ No X Depth (inches): none

Water Table Present? Yes X No____ Depth (inches): 24

Saturation Present? (includes capillary fringe) Yes X No____ Depth (inches): 22

Wetland Hydrology Present? **Yes**____ **No** X

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

As of Aug 2014, Punaluu Pump and Punaluu Stream rain gages were at 141% and 114% of year to date average (http://www.prh.noaa.gov/hnl/hydro/pages/oahu_ytd_08.gif)

WETLAND DETERMINATION DATA FORM—Hawai‘i and Pacific Islands

Project/Site: Punalu‘u City: Punalu‘u Sampling Date: Sept 18, 2014 Time: 1055

Applicant/Owner: Kamehameha Schools State/Terr./Comm.: Hawai‘i Island: O‘ahu Sampling Point: **SP 5-2**

Investigator(s): Susan Burr and Chad Linebaugh TMK/Parcel: 5-3-003:001

Landform (hillslope, coastal plain, etc.): flood plain Local relief (concave, convex, none): none

Lat: 21° 34’26.31”N Long: 157° 53’18.07”W Datum: WGS 84 Slope (%): 0

Soil Map Unit Name: Hanalei silty clay, 0 to 2% slopes NWI classification: not-wetland (not on NWI map)

Are climactic/hydrologic conditions on the site typical for this time of year: Yes____ No X‡ (If no, explain in Remarks)

Are Vegetation No, Soil No, or Hydrology No significantly disturbed? Are “Normal Circumstances” present? Yes X No____

Are Vegetation No, Soil No, or Hydrology No naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS—Attach a site map showing sampling point locations transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X No ____	
Hydric Soil Present?	Yes ____ No X	**Is the Sampled Area**
Wetland Hydrology Present?	Yes ____ No X	**within a Wetland? Yes____ No X**

Remarks: † PEM1A = persistent, emergent, temporarily flooded palustrine wetland

‡ See Hydrology Remarks.

VEGETATION—Use scientific names of plants.

Tree Stratum (Plot size: 30-ft radius)	Absolute % Cover	Dominant Species?	Indicator Status
1. None			
2.			
3.			
4.			
5.			
	=Total Cover		
Sapling/Shrub Stratum (Plot size: 20-ft radius)			
1. *Syzygium cumini*	2	Yes	FAC
2. *Indigofera suffruticosa*	2	Yes	UPL
3.			
4.			
5.			
	4 =Total Cover		
Herb Stratum (Plot size: 5-ft radius)			
1. *Urochloa mutica*	10	No	FACW
2. *Sphagneticola trilobata*	12	No	FAC
3. *Paspalum conjugatum*	74	Yes	FAC
4. *Paederia foetida*	2	No	UPL
5. *Mimosa pudica*	2	No	FACU
6.			
7.			
8.			
	100 =Total Cover		
Woody Vine Stratum (Plot size: 5-ft radius)			
1. None			
2.			
	0 =Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 2 (A)

Total Number of Dominant Species Across All Strata: 3 **(B)**

Percent of Dominant Species That Are OBL, FACW, or FAC: 67 (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species ____	x1= ____
FACW species ____	x2= ____
FAC species ____	x3= ____
FACU species ____	x4= ____
UPL species ____	x5= ____
Column Totals: ____ (A)	____ (B)

Prevalence Index = B/A= ____

Hydrophytic Vegetation Indicators:

X 1 - Rapid Test for Hydrophytic Vegetation

___ 2 - Dominance Test is >50%

___ 3 - Prevalence Index is ≤3.0[1]

___ Problematic Hydrophytic Vegetation [1] (Explain in Remarks or in the delineation report)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes X No____

Remarks:

SOIL

Sampling Point: 5-2

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0 – 10	7.5YR 3/2	100	none				silty cay loam	
10 – 12							river rock	cobble layer
12 – 21	2.5Y 3/1+	100	none				silty cay loam	
21 – 29	2.5Y 3/3	100	none				sandy loam	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains   [2]Location: PL=Pore Lining, M=Matrix

Hydric Soil Indicators:

___ Histisols (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Muck Presence (A8)
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Dark-Surface (S7)
___ Loamy Gleyed Matrix (F2)
___ Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

___ Stratified Layers (A5)
___ Sandy Mucky Mineral (S1)
___ Red Parent Material (TF2)
___ Very Shallow Dark Surface (TF12)
___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type:____________

Depth (inches):____________

Hydric Soil Present: Yes_____ **No** X

Remarks:

Hanalei stony silty clay, 2 to 6% slopes is on the 2012 list of hydric soils. Soil profile does not confirm mapped soil type.

HYDROLOGY

Wetland Hydrology Indicators: (Explain observations in Remarks, if needed.)

Primary Indicators (minimum of one required: check all that apply)

___ Surface Water (A1)
___ High Water Table (A2)
___ Saturation (A3)
___ Water Marks (B1)
___ Sediment Deposits (B2)
___ Drift Deposits (B3)
___ Algal Mat or Crust (B4)
___ Iron Deposits (B5)
___ Inundation Visible on Aerial Imagery (B7)
___ Water Stained Leaves (B9)
___ Aquatic Fauna (B13)
___ Tilapia Nests (B17)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres on Living Roots (C3)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Tiled Soils (C6)
___ Thin Muck Surface (C7)
___ Fiddler Crab Burrows (C10) (Guam, CNMI, and American Samoa)
___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

___ Surface Soil Cracks (B6)
___ Sparsely Vegetated Concave Surface (B8)
___ Drainage Patterns (B10)
___ Dry-Season Water Table (C2)
___ Salt Deposits (C5)
___ Stunted or Stressed Plants (D1)
___ Geomorphic Position (D2)
___ Shallow Aquitard (D3)
___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes_____ No X Depth (inches): none

Water Table Present? Yes X No_____ Depth (inches): 22

Saturation Present? (includes capillary fringe) Yes X No_____ Depth (inches): 19

Wetland Hydrology Present? Yes_____ **No** X

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

As of Aug 2014, Punaluu Pump and Punaluu Stream rain gages were at 141% and 114% of year to date average (http://www.prh.noaa.gov/hnl/hydro/pages/oahu_ytd_08.gif)

Negative α, α′ diprydil test throughout profile.
Some patches of soil at 12-20 inch layer have redox features, but these are not consistent throughout layer in trench.

WETLAND DETERMINATION DATA FORM—Hawai‘i and Pacific Islands

Project/Site: Punalu‘u City: Punalu‘u Sampling Date: Sept 4, 2014 Time: 1230

Applicant/Owner: Kamehameha Schools State/Terr./Comm.: Hawai‘i Island: O‘ahu Sampling Point: **P-1**

Investigator(s): Susan Burr and Chad Linebaugh TMK/Parcel: 5-3-003:001

Landform (hillslope, coastal plain, etc.): depression Local relief (concave, convex, none): concave

Lat: 21° 34’27.56120”N Long: 157° 53’09.78628 ”W Datum: WGS 84 Slope (%): 0

Soil Map Unit Name: Kaloko clay, noncalcareous variant NWI classification: PEM1KFh (also on NWI map)

Are climactic/hydrologic conditions on the site typical for this time of year: Yes ____ No X‡ (If no, explain in Remarks)

Are Vegetation No , Soil No , or Hydrology No significantly disturbed? Are “Normal Circumstances” present? Yes X No ____

Are Vegetation No , Soil No , or Hydrology No naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS—Attach a site map showing sampling point locations transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X No ____	
Hydric Soil Present?	Yes X No ____	**Is the Sampled Area**
Wetland Hydrology Present?	Yes X No ____	**within a Wetland? Yes X No ____** (hydrology is relict)

Remarks: † PEM1KFh = persistent, emergent, semiprmanently, artificially flooded, diked/impounded palustrine wetland. Not flooded. ‡ See Hydrology Remarks.

VEGETATION—Use scientific names of plants.

Tree Stratum (Plot size: app. 250 ft x 50 ft)	Absolute % Cover	Dominant Species?	Indicator Status
1. None			
3.			
4.			
5.			
	=Total Cover		
Sapling/Shrub Stratum (Plot size: app. 250 ft x 50 ft)			
1. *Pluchea carolinensis*	10	Yes	FAC
2. *Trema orientalis*	3	Yes	FACU
3. *Leucaena leucocephala*	2	No	UPL
	15 =Total Cover		
Herb Stratum (Plot size: app. 250 ft x 50 ft)			
1. *Bacopa moneri*	<5	No	OBL
2. *Paspalum finbriatum*	5	No	FAC
3. *Diplachne fusca*	5	No	FACW
4. *Echinocloa crus-gali*	15	Yes	FACW
5. *Cyperus polystachos*	15	Yes	FACW
6. *Cyperus involucratus*	<2	No	FACW
7. *Paspalum conjugatum*	15	Yes	FAC
8. *Emilia fosbergii*	<2	No	FACU
9. Ludwigia octovalvis	2	No	OBL
10. *Bidens alba*	15	Yes	UPL
11. *Typha latifolia*	5	No	OBL
12. *Megathyrsus maximus*	<2	No	FAC
	100 =Total Cover		
Woody Vine Stratum (Plot size: app. 250 ft x 50 ft)			
1. None			
	0 =Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 4 (A)

Total Number of Dominant Species Across All Strata: 6 **(B)**

Percent of Dominant Species That Are OBL, FACW, or FAC: 67 (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species ____	x1= ____
FACW species ____	x2= ____
FAC species ____	x3= ____
FACU species ____	x4= ____
UPL species ____	x5= ____
Column Totals: ____ (A)	____ (B)

Prevalence Index = B/A= ____

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- X 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ Problematic Hydrophytic Vegetation [1] (Explain in Remarks or in the delineation report)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes X No ____

Remarks:

SOIL **Sampling Point: P-1**

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0 – 3	2.5Y 3/2	100	none				muck	
3 – 12	2.5Y 3/2	60	black	10	D	M	clay	platey
			10YR 5/8	30				

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains [2]Location: PL=Pore Lining, M=Matrix

Hydric Soil Indicators:

- ___ Histisols (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Muck Presence (A8)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Dark-Surface (S7)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- X Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ___ Stratified Layers (A5)
- ___ Sandy Mucky Mineral (S1)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: ________

Depth (inches): ________

Hydric Soil Present: Yes X **No** ___

Remarks:

Kaloko clay, noncalcarous variant is on the 2012 list of hydric soils. Soil profile does not confirm mapped soil type.

HYDROLOGY

Wetland Hydrology Indicators: (Explain observations in Remarks, if needed.)

Primary Indicators (minimum of one required: check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Innundation Visible on Aerial Imagery (B7)
- ___ Water Stained Leaves (B9)
- ___ Aquatic Fauna (B13)
- ___ Tilapia Nests (B17)
- ___ Hydrogen Sulfide Odor (C1)
- X Oxidized Rhizospheres on Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tiled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Fiddler Crab Burrows (C10) (Guam, CNMI, and American Samoa)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Salt Deposits (C5)
- ___ Stunted or Stressed Plants (D1)
- X Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- ___ FAC-Neutral Test (D5)

Field Observations:

	Yes	No	Depth (inches)
Surface Water Present?		X	none
Water Table Present?		X	
Saturation Present? (includes capillary fringe)		X	

Wetland Hydrology Present? Yes X **No** ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

As of Aug 2014, Punaluu Pump and Punaluu Stream rain gages were at 141% and 114% of year to date average (http://www.prh.noaa.gov/hnl/hydro/pages/oahu_ytd_08.gif)

WETLAND DETERMINATION DATA FORM—Hawai‘i and Pacific Islands

Project/Site: Punalu‘u City: Punalu‘u Sampling Date: Sept 4, 2014 Time: 1310

Applicant/Owner: Kamehameha Schools State/Terr./Comm.: Hawai‘i Island: O‘ahu Sampling Point: **P-2**

Investigator(s): Susan Burr and Chad Linebaugh TMK/Parcel: 5-3-003:001

Landform (hillslope, coastal plain, etc.): depression Local relief (concave, convex, none): concave

Lat: 21° 34’28.25136”N Long: 157° 53’08.44498 ”W Datum: WGS 84 Slope (%): 0

Soil Map Unit Name: Kaloko clay, noncalcareous variant NWI classification: PEM1KFh (also on NWI map)

Are climactic/hydrologic conditions on the site typical for this time of year: Yes___ No X‡ (If no, explain in Remarks)

Are Vegetation No , Soil No , or Hydrology No significantly disturbed? Are “Normal Circumstances” present? Yes X No___

Are Vegetation No , Soil No , or Hydrology No naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS—Attach a site map showing sampling point locations transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X No ___	
Hydric Soil Present?	Yes X No ___	**Is the Sampled Area**
Wetland Hydrology Present?	Yes X No ___	**within a Wetland? Yes X No___** (hydrology is relict)

Remarks: † PEM1KFh = persistent, emergent, semiprmanently, artificially flooded, diked/impounded palustrine wetland. Not flooded. ‡ See Hydrology Remarks.

VEGETATION—Use scientific names of plants.

Tree Stratum (Plot size: app. 250 ft x 50 ft)	Absolute % Cover	Dominant Species?	Indicator Status
1. None			
3.			
4.			
	=Total Cover		
Sapling/Shrub Stratum (Plot size: app. 250 ft x 50 ft)			
1. *Pluchea carolinensis*	5	Yes	FAC
2.			
3. *Leucaena leucocephala* (tree)	<2	Yes	UPL
	<7 =Total Cover		
Herb Stratum (Plot size: app. 250 ft x 50 ft)			
1. *Urochloa mutica*	10	No	FACW
2. *Paspalum conjugatum*	25	Yes	FAC
3. *Diplachne fusca*	5	No	FACW
4. *Ludwigia octovalvis*	10	No	OBL
5. *Echinochloa crus-gali*	20	No	FACW
6. *Echinochloa* (long awn)	5	No	--
7. *Coix lachrymal-jobi*	5	No	FACW
10. *Bidens alba*	20	No	UPL
9. unidentified grass (no flowers)	5	No	--
12.			
	105 =Total Cover		
Woody Vine Stratum (Plot size: app. 250 ft x 50 ft)			
1. None			
	0 =Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 2 (A)

Total Number of Dominant Species Across All Strata: 3 **(B)**

Percent of Dominant Species That Are OBL, FACW, or FAC: 67 (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species	10	x1= 10
FACW species	40	x2= 80
FAC species	30	x3= 90
FACU species	0	x4= 0
UPL species	21	x5= 105
Column Totals:	101 (A)	285 (B)

Prevalence Index = B/A= 2.8

Hydrophytic Vegetation Indicators:

___ 1 - Rapid Test for Hydrophytic Vegetation

___ 2 - Dominance Test is >50%

X 3 - Prevalence Index is ≤3.0[1]

___ Problematic Hydrophytic Vegetation [1] (Explain in Remarks or in the delineation report)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes X No___

Remarks:

SOIL Sampling Point: P-2

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0 – 5	10YR 3/1	100	none				muck	
5 – 14	2.5Y 3/1	85	5YR 5/8	15	C	M	mucky mineral	platey, clay

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains [2]Location: PL=Pore Lining, M=Matrix

Hydric Soil Indicators:
- ___ Histisols (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- X Muck Presence (A8)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Dark-Surface (S7)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:
- ___ Stratified Layers (A5)
- ___ Sandy Mucky Mineral (S1)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: ______

Depth (inches): ______

Hydric Soil Present? Yes X No ___

Remarks:

Kaloko clay, noncalcarous variant is on the 2012 list of hydric soils. Soil profile does not confirm mapped soil type.

HYDROLOGY

Wetland Hydrology Indicators: (Explain observations in Remarks, if needed.)

Primary Indicators (minimum of one required: check all that apply)
- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Innundation Visible on Aerial Imagery (B7)
- ___ Water Stained Leaves (B9)
- ___ Aquatic Fauna (B13)
- ___ Tilapia Nests (B17)
- ___ Hydrogen Sulfide Odor (C1)
- X Oxidized Rhizospheres on Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tiled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Fiddler Crab Burrows (C10) (Guam, CNMI, and American Samoa)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)
- ___ Surface Soil Cracks (B6)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Salt Deposits (C5)
- ___ Stunted or Stressed Plants (D1)
- X Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- ___ FAC-Neutral Test (D5)

Field Observations:

	Yes	No	Depth (inches)
Surface Water Present?		X	none
Water Table Present?		X	
Saturation Present? (includes capillary fringe)		X	

Wetland Hydrology Present? Yes X No ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

As of Aug 2014, Punaluu Pump and Punaluu Stream rain gages were at 141% and 114% of year to date average (http://www.prh.noaa.gov/hnl/hydro/pages/oahu_ytd_08.gif)

WETLAND DETERMINATION DATA FORM—Hawai'i and Pacific Islands

Project/Site: Punalu'u City: Punalu'u Sampling Date: Sept 4, 2014 Time: 1330

Applicant/Owner: Kamehameha Schools State/Terr./Comm.: Hawai'i Island: O'ahu Sampling Point: **P- 3**

Investigator(s): Susan Burr and Chad Linebaugh TMK/Parcel: 5-3-003:001

Landform (hillslope, coastal plain, etc.): depression Local relief (concave, convex, none): concave

Lat: 21° 34'28.56305"N Long: 157° 53'07.48690 "W Datum: WGS 84 Slope (%): 0

Soil Map Unit Name: Kaloko clay, noncalcareous variant NWI classification: PEM1KFh (also on NWI map)

Are climactic/hydrologic conditions on the site typical for this time of year: Yes ____ No X‡ (If no, explain in Remarks)

Are Vegetation No , Soil No , or Hydrology No significantly disturbed? Are "Normal Circumstances" present? Yes X No ____

Are Vegetation No , Soil No , or Hydrology No naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS—Attach a site map showing sampling point locations transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X No ____	**Is the Sampled Area within a Wetland? Yes ____ No X** (hydrology is relict)
Hydric Soil Present?	Yes ____ No X	
Wetland Hydrology Present?	Yes X No ____	

Remarks: † PEM1KFh = persistent, emergent, semiprmanently, artificially flooded, diked/impounded palustrine wetland. Not flooded

‡ See Hydrology Remarks.

VEGETATION—Use scientific names of plants.

	Absolute % Cover	Dominant Species?	Indicator Status
Tree Stratum (Plot size: app. 250 ft x 50 ft)			
1. *Trema orientalis*	10	Yes	FACU
3 *Leucaena leucocephala* (shrub)	<2	No	UPL
4.			
5.			
	<12 =Total Cover		
Sapling/Shrub Stratum (Plot size: app. 250 ft x 50 ft)			
1.			
2.			
3.			
	=Total Cover		
Herb Stratum (Plot size: app. 250 ft x 50 ft)			
1. *Urochloa mutica*	90	Yes	FACW
2. *Cyperus involucratus*	2	No	FACW
3. *Typha latifolia*	3	No	OBL
4. *Ludwigia octovalvis*	10	No	OBL
5. *Echinochloa crus-gali*	5	No	FACW
6.			
7.			
8.			
9.			
10.			
11.			
	110 =Total Cover		
Woody Vine Stratum (Plot size: app. 250 ft x 50 ft)			
1. None			
	0 =Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: ____ (A)

Total Number of Dominant Species Across All Strata: ____ **(B)**

Percent of Dominant Species That Are OBL, FACW, or FAC: ____ (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species ____	x1= ____
FACW species ____	x2= ____
FAC species ____	x3= ____
FACU species ____	x4= ____
UPL species ____	x5= ____
Column Totals: ____ (A)	____ (B)

Prevalence Index = B/A= ____

Hydrophytic Vegetation Indicators:

X 1 - Rapid Test for Hydrophytic Vegetation

____ 2 - Dominance Test is >50%

____ 3 - Prevalence Index is ≤3.0[1]

____ Problematic Hydrophytic Vegetation [1] (Explain in Remarks or in the delineation report)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes X No ____

Remarks:

SOIL **Sampling Point: P-3**

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0 – 2	2.5Y 3/1	99	7.5YR 5/8	1	C	PL	clay	high organics, prom redox
2 – 12	10YR 3/4	98	10YR 5/8	2	C	PL & M	sandy clay loam	prominent redox features
12 – 17	10YR 3/4	95	10YR 5/8	5	C	PL	sandy clay loam	more clay with depth prominent redox features

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains [2]Location: PL=Pore Lining, M=Matrix

Hydric Soil Indicators:

- ___ Histisols (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Muck Presence (A8)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Dark-Surface (S7)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ___ Stratified Layers (A5)
- ___ Sandy Mucky Mineral (S1)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type:________________________

Depth (inches):____________________________________

Hydric Soil Present? **Yes**________ **No** X

Remarks:

Kaloko clay, noncalcarous variant is on the 2012 list of hydric soils. Soil profile does not confirm mapped soil type.

HYDROLOGY

Wetland Hydrology Indicators: (Explain observations in Remarks, if needed.)

Primary Indicators (minimum of one required: check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Innundation Visible on Aerial Imagery (B7)
- ___ Water Stained Leaves (B9)
- ___ Aquatic Fauna (B13)
- ___ Tilapia Nests (B17)
- ___ Hydrogen Sulfide Odor (C1)
- X Oxidized Rhizospheres on Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tiled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Fiddler Crab Burrows (C10) (Guam, CNMI, and American Samoa)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- X Surface Soil Cracks (B6)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Salt Deposits (C5)
- ___ Stunted or Stressed Plants (D1)
- ___ Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- X FAC-Neutral Test (D5)

Field Observations:

Surface Water Present?	Yes_______	No X	Depth (inches): none
Water Table Present?	Yes_______	No X	Depth (inches):_______
Saturation Present? (includes capillary fringe)	Yes_______	No X	Depth (inches):_______

Wetland Hydrology Present? **Yes** X **No**______

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

As of Aug 2014, Punaluu Pump and Punaluu Stream rain gages were at 141% and 114% of year to date average (http://www.prh.noaa.gov/hnl/hydro/pages/oahu_ytd_08.gif)

Corbicula shells on ground – evidence of flooding.

Project/Site: Punaluʻu City: Punaluʻu Sampling Date: Sept 4, 2014 Time: 1355

Applicant/Owner: Kamehameha Schools State/Terr./Comm.: Hawaiʻi Island: Oʻahu Sampling Point: **P- 4**

Investigator(s): Susan Burr and Chad Linebaugh TMK/Parcel: 5-3-003:001

Landform (hillslope, coastal plain, etc.): depression Local relief (concave, convex, none): concave

Lat: 21° 34'29.18642"N Long: 157° 53'06.16955 "W Datum: WGS 84 Slope (%): 0

Soil Map Unit Name: Kaloko clay, noncalcareous variant NWI classification: PEM1KFh (also on NWI map)

Are climactic/hydrologic conditions on the site typical for this time of year: Yes ____ No X‡ (If no, explain in Remarks)

Are Vegetation No , Soil No , or Hydrology No significantly disturbed? Are "Normal Circumstances" present? Yes X No ____

Are Vegetation No , Soil No , or Hydrology No naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS—Attach a site map showing sampling point locations transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X No ____	
Hydric Soil Present?	Yes X No ____	**Is the Sampled Area**
Wetland Hydrology Present?	Yes X No ____	**within a Wetland? Yes X No ____**

Remarks: † PEM1KFh = persistent, emergent, semiprmanently, artificially flooded, diked/impounded palustrine wetland. Not flooded

‡ See Hydrology Remarks.

VEGETATION—Use scientific names of plants.

Tree Stratum (Plot size: app. 250 ft x 50 ft)	Absolute % Cover	Dominant Species?	Indicator Status
1. *Trema orientalis*	15	Yes	FACU
3			
4.			
5.			
	15 =Total Cover		
Sapling/Shrub Stratum (Plot size: app. 250 ft x 50 ft)			
1. *Trema orientalis*	5	Yes	FACU
2. *Leucaena leucocephala*	5	Yes	UPL
3. *Pluchea carolinensis*	5	Yes	FAC
	15 =Total Cover		
Herb Stratum (Plot size: app. 250 ft x 50 ft)			
1. *Paspalum conjugatum*	40	Yes	FAC
2. *Cyperus polystacheos*	10	No	FACW
3. *Typha latifolia*	15	No	OBL
4. *Ludwigia octovalvis*	15	No	OBL
5. *Urochloa mutica*	10	No	FACW
6. *Bidens alba*	5	No	UPL
7. *Kyllinga brevifolia*	5	No	FAC
8.			
9.			
10.			
11.			
	100 =Total Cover		
Woody Vine Stratum (Plot size: app. 250 ft x 50 ft)			
1. None			
	0 =Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 2 (A)

Total Number of Dominant Species Across All Strata: 5 **(B)**

Percent of Dominant Species That Are OBL, FACW, or FAC: 40 (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species	30	x1= 30
FACW species	20	x2= 40
FAC species	50	x3= 150
FACU species	20	x4= 80
UPL species	10	x5= 50
Column Totals:	130 (A)	350 (B)

Prevalence Index = B/A= 2.7

Hydrophytic Vegetation Indicators:

___ 1 - Rapid Test for Hydrophytic Vegetation

___ 2 - Dominance Test is >50%

X 3 - Prevalence Index is ≤3.0[1]

___ Problematic Hydrophytic Vegetation [1] (Explain in Remarks or in the delineation report)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes X No ____

Remarks:

SOIL

Sampling Point: P-4

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0 – 7	2.5YR 3/2	20	10YR 5/8	20	C	M	sandy loam	prominent redox features
	2.5YR 4/1	60			D	M		

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains
[2]Location: PL=Pore Lining, M=Matrix

Hydric Soil Indicators:

- ___ Histisols (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Muck Presence (A8)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Dark-Surface (S7)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- _X_ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ___ Stratified Layers (A5)
- ___ Sandy Mucky Mineral (S1)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: ______

Depth (inches): ______

Hydric Soil Present: **Yes** X **No** ___

Remarks:

Kaloko clay, noncalcarous variant is on the 2012 list of hydric soils. Soil profile does not confirm mapped soil type.

HYDROLOGY

Wetland Hydrology Indicators: (Explain observations in Remarks, if needed.)

Primary Indicators (minimum of one required: check all that apply)

- _X_ Surface Water (A1)
- _X_ High Water Table (A2)
- _X_ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Innundation Visible on Aerial Imagery (B7)
- ___ Water Stained Leaves (B9)
- ___ Aquatic Fauna (B13)
- ___ Tilapia Nests (B17)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres on Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tiled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Fiddler Crab Burrows (C10) (Guam, CNMI, and American Samoa)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Salt Deposits (C5)
- ___ Stunted or Stressed Plants (D1)
- _X_ Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- ___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes X No ___ Depth (inches): 2

Water Table Present? Yes X No ___ Depth (inches): at surface

Saturation Present? (includes capillary fringe) Yes X No ___ Depth (inches): at surface

Wetland Hydrology Present? **Yes** X **No** ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

As of Aug 2014, Punaluu Pump and Punaluu Stream rain gages were at 141% and 114% of year to date average (http://www.prh.noaa.gov/hnl/hydro/pages/oahu_ytd_08.gif)

Corbicula shells on ground – evidence of flooding.

WETLAND DETERMINATION DATA FORM—Hawaiʻi and Pacific Islands

Project/Site: Punaluʻu City: Punaluʻu Sampling Date: Sept 4, 2014 Time: 1408

Applicant/Owner: Kamehameha Schools State/Terr./Comm.: Hawaiʻi Island: Oʻahu Sampling Point: **P- 5**

Investigator(s): Susan Burr and Chad Linebaugh TMK/Parcel: 5-3-003:001

Landform (hillslope, coastal plain, etc.): depression Local relief (concave, convex, none): concave

Lat: 21° 34'29.45358"N Long: 157° 53'05.47495 "W Datum: WGS 84 Slope (%): 0

Soil Map Unit Name: Kaloko clay, noncalcareous variant NWI classification: PEM1KFh (also on NWI map)

Are climactic/hydrologic conditions on the site typical for this time of year: Yes ____ No X‡ (If no, explain in Remarks)

Are Vegetation No , Soil No , or Hydrology No significantly disturbed? Are "Normal Circumstances" present? Yes X No ____

Are Vegetation No , Soil No , or Hydrology No naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS—Attach a site map showing sampling point locations transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X No ____	
Hydric Soil Present?	Yes X* No ____	**Is the Sampled Area**
Wetland Hydrology Present?	Yes X No ____	**within a Wetland? Yes X No ____**

Remarks: † PEM1KFh = persistent, emergent, semiprmanently, artificially flooded, diked/impounded palustrine wetland. Flooded. ‡ See Hydrology Remarks.

VEGETATION—Use scientific names of plants.

Tree Stratum (Plot size: app. 250 ft x 50 ft)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
3			
4.			
5.			
	=Total Cover		
Sapling/Shrub Stratum (Plot size: app. 250 ft x 50 ft)			
1.			
2.			
3.			
	=Total Cover		
Herb Stratum (Plot size: app. 250 ft x 50 ft)			
1 *Neptunia oleracea*	75	Yes	*
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
	75 =Total Cover		
Woody Vine Stratum (Plot size: app. 250 ft x 50 ft)			
1. None			
	0 =Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: ____ (A)

Total Number of Dominant Species Across All Strata: ____ **(B)**

Percent of Dominant Species That Are OBL, FACW, or FAC: ____ (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species ____	x1= ____
FACW species ____	x2= ____
FAC species ____	x3= ____
FACU species ____	x4= ____
UPL species ____	x5= ____
Column Totals: ____ (A)	____ (B)

Prevalence Index = B/A= ____

Hydrophytic Vegetation Indicators:

X 1 - Rapid Test for Hydrophytic Vegetation

____ 2 - Dominance Test is >50%

____ 3 - Prevalence Index is ≤3.0[1]

____ Problematic Hydrophytic Vegetation [1] (Explain in Remarks or in the delineation report)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes X No ____

Remarks: * *Neptunia oleracea* is a cultivar, not naturalized in Hawaiʻi. It is known as "water mimosa" – should be OBL.

SOIL Sampling Point: P- 5

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains [2]Location: PL=Pore Lining, M=Matrix

Hydric Soil Indicators:

___ Histisols (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Muck Presence (A8)
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Dark-Surface (S7)
___ Loamy Gleyed Matrix (F2)
___ Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

___ Stratified Layers (A5)
___ Sandy Mucky Mineral (S1)
___ Red Parent Material (TF2)
___ Very Shallow Dark Surface (TF12)
___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type:________________________

Depth (inches):________________________

Hydric Soil Present: **Yes** X* **No** ______

Remarks:

Kaloko clay, noncalcarous variant is on the 2012 list of hydric soils.

* Flooded, could not obtain soil sample. Assumed to be hydric

HYDROLOGY

Wetland Hydrology Indicators: (Explain observations in Remarks, if needed.)

Primary Indicators (minimum of one required: check all that apply)

X Surface Water (A1)
X High Water Table (A2)
X Saturation (A3)
___ Water Marks (B1)
___ Sediment Deposits (B2)
___ Drift Deposits (B3)
___ Algal Mat or Crust (B4)
___ Iron Deposits (B5)
___ Innundation Visible on Aerial Imagery (B7)
___ Water Stained Leaves (B9)
___ Aquatic Fauna (B13)
___ Tilapia Nests (B17)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres on Living Roots (C3)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Tiled Soils (C6)
___ Thin Muck Surface (C7)
___ Fiddler Crab Burrows (C10) (Guam, CNMI, and American Samoa)
___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

___ Surface Soil Cracks (B6)
___ Sparsely Vegetated Concave Surface (B8)
___ Drainage Patterns (B10)
X Dry-Season Water Table (C2)
___ Salt Deposits (C5)
___ Stunted or Stressed Plants (D1)
X Geomorphic Position (D2)
___ Shallow Aquitard (D3)
X FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes X No ______ Depth (inches): 6

Water Table Present? Yes X No ______ Depth (inches): at surface

Saturation Present? (includes capillary fringe) Yes X No ______ Depth (inches): at surface

Wetland Hydrology Present? **Yes** X **No** ______

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

As of Aug 2014, Punaluu Pump and Punaluu Stream rain gages were at 141% and 114% of year to date average (http://www.prh.noaa.gov/hnl/hydro/pages/oahu_ytd_08.gif)

Water is entering pond from a pipe at the west end

WETLAND DETERMINATION DATA FORM—Hawai‘i and Pacific Islands

Project/Site: Punalu‘u City: Punalu‘u Sampling Date: Sept 4, 2014 Time: 1415

Applicant/Owner: Kamehameha Schools State/Terr./Comm.: Hawai‘i Island: O‘ahu Sampling Point: **P- 6**

Investigator(s): Susan Burr and Chad Linebaugh TMK/Parcel: 5-3-003:001

Landform (hillslope, coastal plain, etc.): depression Local relief (concave, convex, none): concave

Lat: 21° 34'30.45543"N Long: 157° 53'03.96598 "W Datum: WGS 84 Slope (%): 0

Soil Map Unit Name: Kaloko clay, noncalcareous variant NWI classification: PEM1KFh (also on NWI map)

Are climactic/hydrologic conditions on the site typical for this time of year: Yes ____ No X‡ (If no, explain in Remarks)

Are Vegetation No , Soil No , or Hydrology No significantly disturbed? Are "Normal Circumstances" present? Yes X No ____

Are Vegetation No , Soil No , or Hydrology No naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS—Attach a site map showing sampling point locations transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X No ____	
Hydric Soil Present?	Yes X* No ____	**Is the Sampled Area**
Wetland Hydrology Present?	Yes X No ____	**within a Wetland? Yes X No ____** (hydrology is relict)

Remarks: † PEM1KFh = persistent, emergent, semiprmanently, artificially flooded, diked/impounded palustrine wetland. Not flooded

‡ See Hydrology Remarks.

VEGETATION—Use scientific names of plants.

Tree Stratum (Plot size: app. 250 ft x 50 ft)	Absolute % Cover	Dominant Species?	Indicator Status
1. *Trema orientalis*	<5	Yes	FACU
3.			
4.			
5.			
	<5 =Total Cover		
Sapling/Shrub Stratum (Plot size: app. 250 ft x 50 ft)			
1.			
2.			
3.			
	=Total Cover		
Herb Stratum (Plot size: app. 250 ft x 50 ft)			
1 *Urochloa mutica*	100	Yes	FACW
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
	100 =Total Cover		
Woody Vine Stratum (Plot size: app. 250 ft x 50 ft)			
1. None			
	0 =Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 1 (A)

Total Number of Dominant Species Across All Strata: 2 **(B)**

Percent of Dominant Species That Are OBL, FACW, or FAC: 50 (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species		x1=
FACW species	100	x2= 200
FAC species	<5	x3= 7.5
FACU species		x4=
UPL species		x5=
Column Totals:	102.5 (A)	207.5 (B)

Prevalence Index = B/A= 2.0

Hydrophytic Vegetation Indicators:

X 1 - Rapid Test for Hydrophytic Vegetation

___ 2 - Dominance Test is >50%

X 3 - Prevalence Index is ≤3.0[1]

___ Problematic Hydrophytic Vegetation [1] (Explain in Remarks or in the delineation report)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes X No ____

Remarks:

SOIL

Sampling Point: P- 6

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type [1]	Loc [2]	Texture	Remarks
0 – 5	10YR 3/1	100	none				muck	
5 – 11	2.5YR 3/3	80	10YR 5/8	5	C	M &PL		prominent redox features
			2.5 YR 4/1	15	C	M		distinct redox features

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains [2]Location: PL=Pore Lining, M=Matrix

Hydric Soil Indicators:
- ___ Histisols (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Muck Presence (A8)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Dark-Surface (S7)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- _X_ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:
- ___ Stratified Layers (A5)
- ___ Sandy Mucky Mineral (S1)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type:____________

Depth (inches):____________

Hydric Soil Present: Yes _X_ No ___

Remarks:

Kaloko clay, noncalcarous variant is on the 2012 list of hydric soils. Does not confirm mapped soil type

HYDROLOGY

Wetland Hydrology Indicators: (Explain observations in Remarks, if needed.)

Primary Indicators (minimum of one required: check all that apply)
- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Innundation Visible on Aerial Imagery (B7)
- ___ Water Stained Leaves (B9)
- ___ Aquatic Fauna (B13)
- ___ Tilapia Nests (B17)
- ___ Hydrogen Sulfide Odor (C1)
- _X_ Oxidized Rhizospheres on Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tiled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Fiddler Crab Burrows (C10) (Guam, CNMI, and American Samoa)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)
- ___ Surface Soil Cracks (B6)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Salt Deposits (C5)
- ___ Stunted or Stressed Plants (D1)
- _X_ Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- ___ FAC-Neutral Test (D5)

Field Observations:

	Yes	No	Depth (inches)
Surface Water Present?		X	none
Water Table Present?		X	>11
Saturation Present? (includes capillary fringe)		X	>11

Wetland Hydrology Present? Yes _X_ No ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

As of Aug 2014, Punaluu Pump and Punaluu Stream rain gages were at 141% and 114% of year to date average (http://www.prh.noaa.gov/hnl/hydro/pages/oahu_ytd_08.gif)

Appendix C

Biological Assessment Punalu‘u Stream, O‘ahu, Hawai‘i with Recommendations for Stream Enhancement

BIOLOGICAL ASSESSMENT
PUNALU‘U STREAM, O‘AHU, HAWAI‘I

WITH RECOMMENDATIONS FOR STREAM ENHANCEMENT

Prepared for
The Kamehameha Schools
Land Assets Division, Endowment Group
567 South King Street, Suite 200
Honolulu, HI 96813

Prepared by
Robert A. Kinzie III, Ph.D., John Ford, M.S.,
Tiffany Thair, B.A., and Ryan Taira, B.A.

SWCA Environmental Consultants
201 Merchant Street, Suite 2310
Honolulu, HI 96813

Revised January 2009

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 Background to the Present Study

Appropriate stewardship of its lands and resources is a principal objective of The Endowment Group at Kamehameha Schools (KS). Within the Endowment Group, the Land Assets Division (LAD) has the specific responsibility for stewardship of agricultural and conservation lands, and implementation of eco-cultural education programs for KS. Land and water stewardship (mālama ʻaina and mālama wai) reflect a commitment to Hawaiian values, and recognition of the kinship between man and the environment. Stewardship efforts encompass reforestation, monitoring, invasive species control, fire suppression, site surveys, ecosystem stabilization, and scientific research that may result in greater management efficiencies. KS also recognizes that concurrent stewardship, education, and research will help sustain its land and water resources in perpetuity.

KS recognizes that a stream and its watershed are inseparable, and that mālama wai requires an integrated mauka-makai water management strategy. Several key issues have been identified by the LAD in its integrated Water Plan, including an assessment of all freshwater ecosystems, instream and out-of-stream flow requirements, conservation and renewal strategies, and establishment of appropriate eco-cultural education programs. Finding effective answers to these issues in a timely manner is of paramount importance. This is especially true in light of the long-term downward trend in the base flows of Hawaiian streams noted by Oki (2004) over the past century.

2.0 Scope of the Present Study

Water diverted from Punaluʻu Stream, Oʻahu, has served agricultural uses in Punaluʻu Valley since pre-contact times (Handy and Handy 1991). Today, agriculture in the valley has changed from taro and/or rice to multiple crops and aquaculture products grown on several farms. As one of the largest land owners and water users in Punaluʻu Valley, Kamehameha Schools has a vested interest in a stable and clear determination of present and future surface water allocation in the valley. The setting of an interim instream flow standard (IIFS) for Punaluʻu Stream by the Commission on Water Resources Management (Commission) would clarify water use claims, facilitate long-term planning for agricultural development, and guarantee stability for the future of the valley while protecting the stream ecosystem.

In October 2007, the Land Assets Division of the Kamehameha Schools Endowment Group tasked SWCA Environmental Consultants (SWCA) to develop information necessary to support a petition to amend the IIFS for Punaluʻu Stream. Specifically, SWCA has:

- Assembled and analyzed existing information on geology and hydrology, stream biology, and water uses in Punaluʻu Valley;
- Evaluated how the proposed water system improvements may be used to enhance flow and passage for native migratory stream life;
- Developed recommendations for stream ecosystem improvements

This study was based in large part upon the results of recent work conducted by other investigators, and was supplemented by stream reconnaissance surveys conducted to clarify our understanding of the stream ecosystem. SWCA has also assisted with the development of a petition for designation of an IIFS for Punaluʻu Stream to be submitted to the Water Commission.

3.0 Background to Instream Flow Protection

Cultural and natural resources are one and the same to the Hawaiian people. Waiʻola, living waters, are recognized as the source of life and have a strong spiritual connotation (Pukui 1983). In pre-western contact Hawaiʻi, prior to the reign of Kamehameha, inalienable titles to water rights did not exist (Handy and Handy 1991). High chiefs (*aliʻi*) held all lands, waters, fisheries, and other natural resources extending from the mountain tops to the depths of the ocean in trust (Maly and Maly 2003). The *ahupuaʻa*, or principal political subdivisions of lands, helped insure that planters had access to a share of subsistence resources, including ability to harvest ʻoʻopu, ʻopae, and hīhīwai from streams. The right to use of these resources was given to the native tenants at the prerogative of the *aliʻi* and their representatives or *konohiki* (Maly and Maly 2003).

The breakdown of the traditional Hawaiian method of sharing of flowing water, beginning with western influences upon Kamehameha I through modern case law, has left a controversial legacy (Miike 2004).

In 1987, the State Water Code, Chapter 174C, Hawaii Revised Statutes (HRS) changed the way instream and out of stream uses of water are regulated in Hawaiʻi. This Code constitutionally established the State Commission on Water Resource Management (Commission), which is an entity within the State of Hawaii's Department of Land and Natural Resources that functions as trustee of water resources. Among its responsibilities, the Commission has the power to regulate and protect instream uses of water. Chapter 174C-71 of the Water Code states:

"*The commission shall establish and administer a statewide instream use protection program. In carrying out this part, the commission shall cooperate with the United States government or any of its agencies, other state agencies, and the county governments and any of their agencies.*"

An important component of this role is the establishment of instream flow standards (IFS). The State of Hawaiʻi Water Code states:

"*Each instream flow standard shall describe the flows necessary to protect the public interest in the particular stream. Flows shall be expressed in terms of variable flows of water necessary to protect adequately fishery, wildlife, recreational, aesthetic, scenic, or other beneficial instream uses in the stream in light of existing and potential water developments including the economic impact of restriction of such use*;"
[Chapter 174C-71(1)(C)].

In making these decisions, the Commission must consider the following beneficial instream uses:

- Maintenance of fish and wildlife habitats
- Outdoor recreational activities
- Maintenance of ecosystems
- Aesthetic values
- Navigation
- Instream hydropower generation
- Maintenance of water quality
- Conveyance of irrigation and domestic water supplies to downstream points
- Protection of traditional and customary Hawaiian rights

Pending the establishment of permanent instream flow standards, an interim instream flow standard (IIFS) may also be set by the Commission. An interim instream flow standard is a temporary instream flow standard of immediate applicability, adopted by the commission without the necessity of a public hearing, and terminating upon the establishment of an amended or permanent instream flow standard. Interim instream flow standards are initiated when any person of proper standing petitions the Commission to adopt an interim standard in order to protect the public interest. In setting IIFS, the Commission considers the maintenance of fish and wildlife habitats as one of the beneficial instream uses set out by the Water Code. Generally, in Hawaiian streams where the native macrofauna are amphidromous, this criterion centers on the impact of water diversions, channelization, and other alterations to natural stream flow that affect the connectivity of the constituent populations in each stream.

Ford (2006a) recommended that any proactive approach to stream enhancement in Hawaiian watersheds should consider flow restoration to periodically provide for critically important migratory pathways to and from the sea. If flow restoration is to be considered, he suggests that it be focused upon gaining reaches that connect channel sections having natural or high habitat values downstream of significant bottlenecks for individual species of interest. Scientifically based biological monitoring studies should be carefully planned and initiated prior to flow releases to evaluate the efficacy of our recommendations. This adaptive management approach will allow adjustments to be made as deemed appropriate to the mutual benefit of the resources, Kamehameha Schools, the public, and CWRM. Finally, stream restoration efforts must also encompass programs to control invasive species, and may include recommendations for minor structural modification of intake structures to enhance passage by amphidromous species.

The specific goals and objectives of future comprehensive stream studies will ultimately determine the most appropriate methods. The final approach should be one that considers the entire watershed as well as the stream itself, and incorporates relevant elements and techniques used in protocols employed by contemporary aquatic scientists in Hawaiʻi. In addition, execution of future field studies should involve KS students to the extent possible.

4.0 Surface Waters as Habitat for Native Species

In a previous report for Kamehameha Schools, Ford (2006b) gave an extensive discussion of the biology and ecology of Hawaiian streams and an overview of human impacts on stream ecosystems. A brief summary of his main points are relevant here.

All native biota in Hawaiʻi originally came from sources outside the archipelago (Ziegler 2002). Immigrant stream organisms from many taxa arrived from regions throughout the Pacific region. For ease of discussion, the larger native stream animals are sometimes called macrofauna. In Hawaiʻi, this group consists of gobioid fishes (ʻoʻopu), neritid snails (hīhīwai and hapawai), and decapod crustaceans (ʻopae). The remaining smaller, but no less important animals are generally insects; however, lymnaeid snails, worms, sponges and smaller crustaceans are numerous. This somewhat artificial division based on size also separates the amphidromous macrofaunal species from the remaining animals which live their entire life in or around the streams (Ford and Kinzie 1982, Kinzie 1997, McDowall 2003). Notably, the only freshwater animals listed as endangered or as candidates for listing are in this second group.

4.1 Definitions and Biogeography of Amphidromy

Myers (1949) used the term *amphidromous* to describe fishes that undergo regular, obligatory migration between freshwaters and the sea ʻat some stage in their life cycle other than the breeding period'. McDowall (1988) described two different forms of amphidromy. All the Hawaiian amphidromous species exhibit ʻfreshwater amphidromy' where spawning takes place in freshwater, and the newly hatched larvae are swept into the sea by stream currents. While in the marine environment, the larvae undergo development as zooplankton before returning to freshwater to grow to maturity. An important ecological characteristic of the amphidromous fauna is the ability (in varying degrees among species) to move upstream, surmounting riffles and small falls, and for some species, even very high waterfalls (Ford and Kinzie 1982, Radtke and Kinzie 1996).

The native amphidromous fishes of Hawaiian streams consist of only five gobiid species: *Awaous guamensis* (ʻoʻopu nākea), *Sicyopterus stimpsoni* (ʻoʻopu nōpili), *Lentipes concolor* (ʻoʻopu alamoʻo), *Stenogobius hawaiiensis* (ʻoʻopu naniha); and the eleotrid *Eleotris sandwicensis* (ʻoʻopu akupa). Native amphidromous invertebrates include two gastropods, *Neritina granosa* (hīhīwai) and the estuarine *Neritina vespertina* (hapawai); and the decapods, *Atyoida bisulcata* (ʻopae kalaʻole) and *Macrobrachium grandimanus* (ʻopae ʻoehaʻa).

4.2 Non-Amphidromous Fauna

In addition to the amphidromous macrofauna, some other native marine species are important in Hawaiian stream ecology. Fishes in the terminal and lower reaches of Hawaiian streams also include an endemic predatory flagtail *Kuhlia xenura* (ʻāholehole). There is some confusion on the taxonomy of āholehole. Originally, a single species was described: *Kuhlia sandwicensis*. Subsequently, a second species *K. xenura* was described (Randall and Randall 2001, Benson 2002). The latter is endemic and is the species most likely to be found in freshwater. *K. sandwicensis* is not endemic and tends to be restricted to marine habitats. ʻĀholehole are known to attack nests of goby eggs (Ha and Kinzie 1996) and may also consume returning post-larval gobies. Many other itinerant marine species may undergo juvenile development in streams; however, since non-amphidromous species do not have the ability to climb terminal waterfalls, these species may only occur in streams with low gradient terminal reaches or estuaries.

Additionally, alien species including the introduced amphidromous *Macrobrachium lar* are impacting native Hawai'i systems including fishes, amphibians, and crustaceans (Yamamoto and Tagawa 2000), yet there are few published studies available that quantify these impacts.

The non-amphidromous native stream fauna has, until fairly recently, received less attention. However, the native insects, snails, and other invertebrates are important for their diversity, endemism, and their contribution to the freshwater ecosystem dynamics. Scientists are continually describing new species of endemic aquatic insects as their field studies take them farther into the headwaters of Hawaiian streams (e.g. Englund et al. 2003). As with the macrofauna, there are many alien freshwater insects and other invertebrates. The impact of these organisms on native systems is not well understood. Decisions regarding re-watering streams must take into account not only the direct benefits to native species, but should also consider the potential for the spread of alien stream species and their parasites (Font 1997).

4.3 Evaluation of Hawaiian Stream Fauna as Indicators of Stream Quality

In the recent past, aquatic biologists in Hawai'i considered the presence of all the native species described above as an indicator of outstanding environmental quality. Conversely, the total absence of these species in streams between sea level and 457 m (1,500 ft) elevation was considered a possible indicator of environmental degradation (Hawai'i National Park Studies Unit 1990). Kinzie and Ford (1982) and Kinzie (1988) suggested that community structure in a given Hawaiian stream may change frequently due to random processes affecting reproduction, recruitment of post-larvae, migration, predation and competition, and survival. Therefore, the absence of a given species at any reach and time can not be taken as a definitive indicator of poor stream quality (see also McRae 2007).

Various metrics or indices have been devised to try to quantify the 'quality' or 'status' of streams. Kido (2002) supported the Hawai'i Stream Bioassessment Protocol (HSBP) to quantitatively assess stream quality. The HSBP relies on the presence or absence of benthic invertebrates as indicator of stream quality, and was originally developed for use in continental streams. Its application in Hawai'i is highly controversial (Devick, personal communication). Wolff (2005) subsequently tested refinements to this approach based upon a careful assessment of benthic invertebrate assemblages in Hawai'i. Biologists of the Hawai'i Division of Aquatic Resources advocate the use of the PABITRA (Pacific Area Biodiversity Transect) sampling protocol (Fitzsimons et al. 2005). There is no single generally accepted method for evaluating the status of Hawaiian streams.

5.0 Human Impacts

Since the arrival of humans in the archipelago some 1600 years ago there have been alterations to the islands' landscapes, streams, and watersheds (Kirch 1982, 2000, Burney et al. 2001, Athens et al. 2002). Prior to the arrival of Captain Cook, the people of Hawai'i had developed a sophisticated and extensive wetland agricultural system to support the growing of kalo, the major starch in their diet (Handy and Handy 1991, Franco 1995). These activities had impacts on the natural systems they replaced (Zimmerman 1963, Kirsch 1982, Wagner et al. 1985, Stone 1985, Cuddihy and Stone 1990, Athens et al. 2002, and Ziegler 2002). Additionally, Hawaiians directly influenced the stream fauna by fishing and collection of returning post-larvae, known as hinana (Titcomb 1972); however, this impact may have been small compared to the alterations in the landscapes (Athens et al. 2002).

By the time comprehensive descriptions of the Hawaiian landscape began appearing in western literature in the late 1700s, feral ungulates and non-native plants had already begun to dramatically change the nature of Hawaiian watershed structure and function. The kapu placed upon killing introduced cattle permitted the unchecked growth of large herds, which along with introduced sheep beginning in 1793, decimated native lowland forests. This was accompanied by the introduction of and invasion by non-native plants that forever changed the nature of Hawaiian watersheds. These cumulative effects of human activities led to the permanent and irreversible modification of Hawaiian watersheds and their streams. The effects include, but are not limited to the following, in rough chronological order:

- Changes to watershed vegetation, soils, and water budgets by introduced species
- Destruction of watershed vegetation and soil erosion caused by feral ungulates
- Surface water diversions, groundwater and well development
- Soil erosion from sugar cane and pineapple cultivation
- Discharge of bagasse at stream mouths between the late 1800's and 1972
- Aquatic alien plant and animal introductions
- Introduced diseases and parasites of aquatic animals
- Urbanization and industrialization with subsequent impacts to water budgets and water quality
- Widespread stream channel modifications for flood control
- Modern consumptive practices (e.g. fishing with illegal electroshocking and traps)

Of these, diversion and ground water development, channel modification and consumptive use have been best documented.

5.1 Water Development

The history of water resource development in Hawaiʻi was summarized by Wilcox (1996). She documented the tremendous engineering feats involved in bringing water, often from long distances over rough terrain, to centers of large scale agriculture. The plantation system this water development supported laid the groundwork for the economic development of the Hawaiian Islands beginning in the late 1800's.

While the history and current state of irrigation systems is well known, much less is known about how diversions impact Hawaiian stream ecosystems. In one of the few published studies that directly examined the effects of stream dewaterment in Hawaiʻi, Kinzie et al. (2006) found that stream diversion reduced available habitat for benthic invertebrates in reaches below a hydropower dam on the Wainiha River, Kauaʻi. Benthic primary and secondary production were lowest at sampling sites below the diversion dam with the lowest flows. Complex and sometimes subtle biotic and abiotic effects associated with diversions were also discovered that are yet difficult to explain. Invertebrate drift was strongly influenced by the dam suggesting entrainment of drift into the diversion ditch (Kinzie et al. 2006).

5.2 Channelization

Timbol and Maciolek (1978) catalogued stream diversion, channelization, and related morphological alterations to stream channels. By the time their report was published most streams in the State had had some form of modification. Kido (1997) noted that the "rapidly changing terrestrial landscape in Hawaiian watersheds coupled with the escalating rates of alien species introductions are altering natural functioning of these [stream] ecosystems." In any particular stream, however, it has been difficult to determine which of the detrimental impacts (e.g. diversion, channelization, water pollution, continued fishing pressure, or invasive species), or combination thereof, are having the greatest negative impact on populations of native amphidromous species. On every stream, there is probably a different set of pressures; however, all of these are likely to have a synergistic impact on amphidromous species statewide.

5.3 Consumptive Use

By the mid-1950's, fishing for ʻoʻopu nākea was mainly for sport or home consumption (Ego 1956). Most fishing pressure for ʻopae is focused on upper elevation ditches and flumes where the ʻopae are most abundant and easy to catch. ʻOpae are usually collected with ʻopae nets that can be purchased from local fishing and sundry stores. While ʻopae populations are much reduced in urban streams, the causes of these losses are unknown and assumed to mirror the population decline in other amphidromous species. The shrimp are still abundant in higher elevations in streams on islands other than Oʻahu, especially in more remote areas. Today, only low numbers of hīhīwai and ʻoʻopu may be found in some Oʻahu streams.

In the 1950's, the Hawaiʻi State Fish and Game Division (now Division of Aquatic Resources, or DAR) outlawed the practice of collecting goby fry or hinana in response to declining stocks. Illegal gathering apparently continued for some time despite enforcement efforts. To the best of our knowledge, goby fry runs of the magnitude historically reported (Titcomb 1972) have not been seen in Hawai'i for decades. Furthermore, traps that were designed to catch adult 'o'opu nākea as they migrated downstream to spawn during freshets were also outlawed; however, such traps can occasionally be found in remote areas today.

5.4 Long Term Trends in Streamflow

Oki (2004) demonstrated a pattern of declining base flows in streams throughout the Hawaiian Islands since 1913, and suggested that this may indicate a reduction in groundwater storage and subsequent reduction in groundwater discharge to streams. The causes of this state-wide trend were not completely clear, but large scale climatic factors probably are suggested as having an important role.

5.5 Summary of Human Impacts on Hawaiian Streams

The authors believe that there are no 'pre-Captain Cook' streams (sensu Miike 2004) in Hawai'i today, and there can never be such streams again due to the complex synergistic effects of watershed alteration by a millennium of human alteration of the environment throughout the archipelago. There are, however, streams with minimal levels of alteration that continue to harbor healthy populations of native amphidromous species. These are commonly referred to today as being 'pristine', 'unaltered', or 'natural' (Hawai'i National Park Studies Unit 1990).

No specific evidence is available to suggest that any of the amphidromous species is presently at risk of extinction. However, the synergistic effects of human alterations have led to a decline in the populations of native freshwater species statewide. Surprisingly, no studies focused upon the long-term population trends for Hawaiian amphidromous species have yet been conducted, and there is nothing in the scientific literature on this topic. Even less is known about how the habitat requirements for the non-amphidromous fauna are impacted by the alterations discussed above, despite the fact that several of these are considered to be candidate endangered species. A single lymnaeid species restricted to central Kaua'i, *Erinna newcombi*, is listed as an endangered species by the US Fish and Wildlife Service.

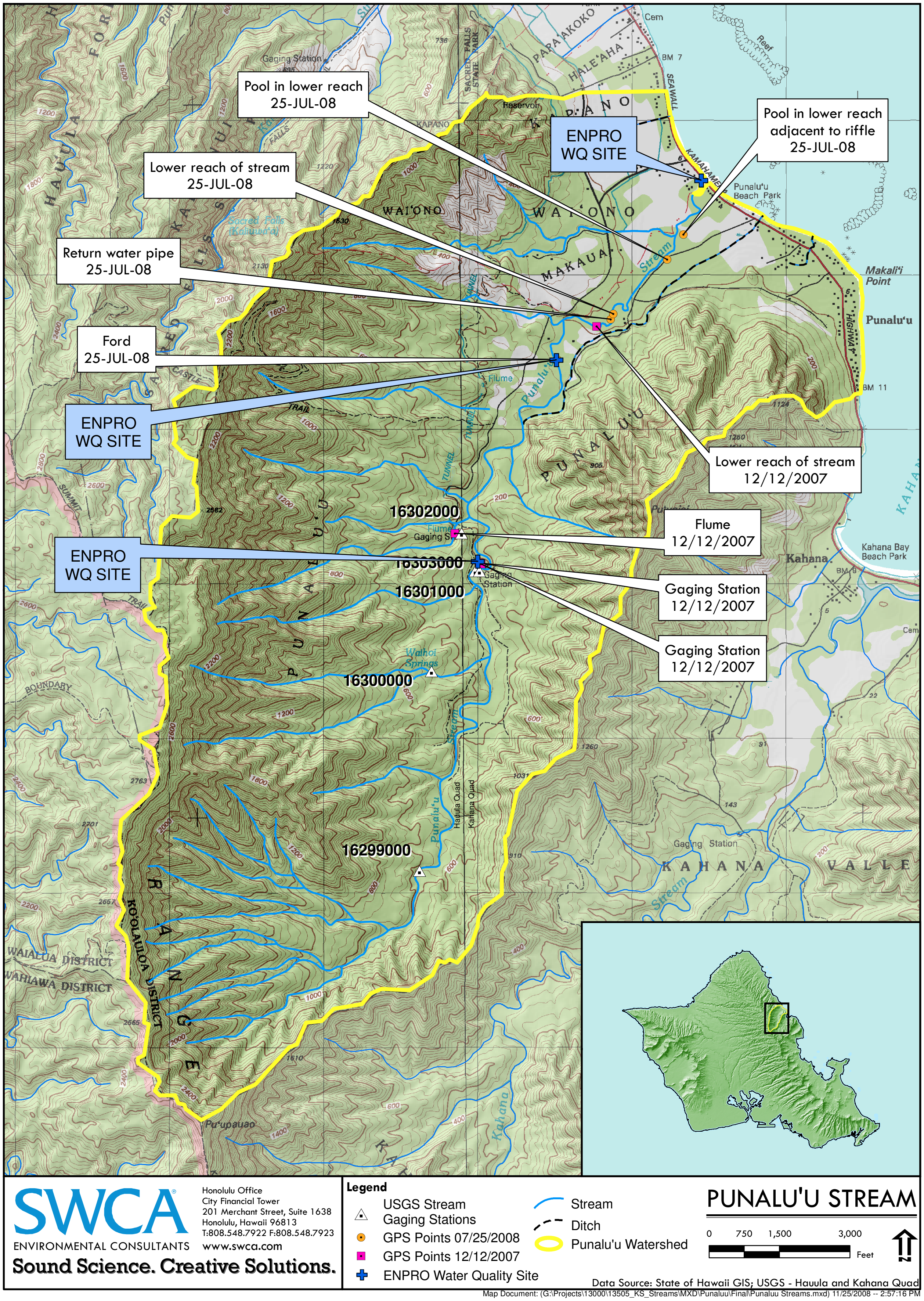
6.0 Punalu'u Valley Setting

6.1 Climate, Geology, and Hydrology

The 1,735 ha (4,287 ac) Punalu'u Valley is located on O'ahu's windward coast in the Ko'olauloa District, and lies between Kaluanui Valley (to the North) and Kahana Valley (to the South) (Figure 1). The most recent geological and hydrological study of this valley and its waters is by Oki et al. (2006). The Ko'olau volcano consists of thinly bedded basaltic lava flows with only minor ash deposits. Numerous dike complexes radiate out from the original vent along rift zones (Stearns 1966). The density of these thin, vertical, high density basalt intrusions can be as high as 1,000 per mile of horizontal distance (Takasaki and Mink 1985).

As will be discussed below, dike-rich systems have important hydrological effects due to their low permeability relative to the bedded shield forming basalts. The windward slope of the Ko'olau Range is characterized by dramatic pali (cliffs) whose fluted, almost vertical slopes form the backdrop to the more gently sloping coastal plains. These steep pali are thought to be the result of massive landslides followed by erosion of the remaining faces (Moore et al. 1989, 1994).

The Nu'uanu landslide that occurred between 2.1 and 1.78 million years ago was the event that removed the eastern part of the Ko'olau volcano that gives the windward side of O'ahu its characteristic landscapes (Clague et al. 2002, Herrero-Bervera et al. 2002). Subsequent erosion, particularly in the more northerly Ko'olauloa districts produced large valleys such as Punalu'u. Erosion coupled with changing sea level has resulted in deep sedimentary deposits on the valley floor below about 198 m (650 ft) above sea level (Oki et al. 2006).


Pool in lower reach
25-JUL-08
Pool in lower reach
adjacent to riffle
25-JUL-08
ENPRO
WQ SITE
Lower reach of stream
25-JUL-08
Return water pipe
25-JUL-08
Ford
25-JUL-08
ENPRO
WQ SITE
Lower reach of stream
12/12/2007
16302000
Flume
12/12/2007
ENPRO
WQ SITE
16303000
16301000
Gaging Station
12/12/2007
Gaging Station
12/12/2007
16300000
16299000
Punalu'u
Makali'i Point
Kahana Bay Beach Park
Kahana
KAHANA VALLEY
PUNALU'U
KO'OLAULOA DISTRICT
WAIALUA DISTRICT
WAHIAWA DISTRICT
Honolulu Office
City Financial Tower
201 Merchant Street, Suite 1638
Honolulu, Hawaii 96813
T:808.548.7922 F:808.548.7923
www.swca.com
ENVIRONMENTAL CONSULTANTS
Sound Science. Creative Solutions.
Legend
USGS Stream Gaging Stations
GPS Points 07/25/2008
GPS Points 12/12/2007
ENPRO Water Quality Site
Stream
Ditch
Punalu'u Watershed
PUNALU'U STREAM
0 750 1,500 3,000
Feet
N
Data Source: State of Hawaii GIS; USGS - Hauula and Kahana Quad
Map Document: (G:\Projects\13000\13505_KS_Streams\MXD\Punaluu\Final\Punaluu Streams.mxd) 11/25/2008 -- 2:57:16 PM

Because O'ahu is located in the trade wind region, the north-west sides of the islands generate precipitation from orographic rainfall (Giambelluca and Schroeder 1998). The highest mean annual rainfall (~260 inches per year) on O'ahu lies just to the lee of the crest of the Ko'olau range behind Kahana and Punalu'u valleys. Because of the orientation of the valley, most of the tributaries are on the west and north-west side of the watershed. Mean annual rainfall decreases towards the sea and at the shore it is about 70 inches per year (Giambelluca and Schroeder 1998). They indicate that mean monthly rainfall shows peaks in April, August and early September and lows in February, June and late September giving a tri-modal pattern (Giambelluca and Schroeder 1998, Oki 2004). Data from the USGS rain gage at 73 m (240 ft) in Punalu'u only runs from 2003 to 2007. This rather short record (Figure 2) could support the possibility of a tri-modal pattern in rainfall; however, the stream flow (see below) does not show this pattern.

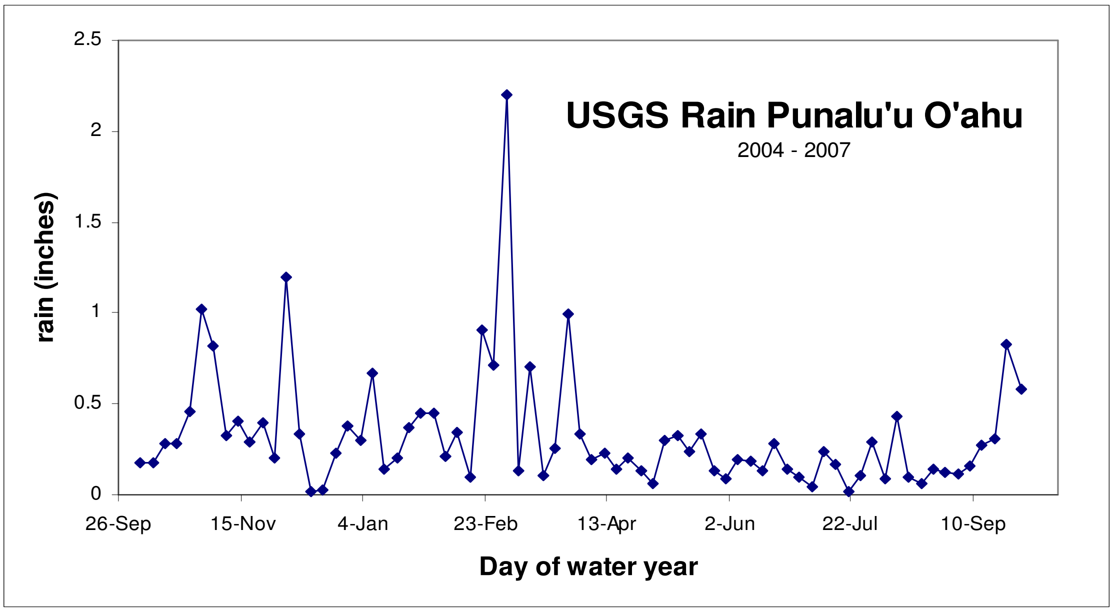


Figure 2. Rainfall at the USGS rain gage in Punalu'u Valley at 73 m (240 ft). Data from the three year period of record and averaged for five day intervals through one annual cycle.

6.1.1 Geology

The floor of Punalu'u Valley is composed of sedimentary deposits which are thickest at the coast and taper towards the back of the valley. Near the coast these deposits can be as much as 60 m (200 ft) in thickness (Oki et al. 2006). Deeper layers of these deposits are weathered basalts, while the more recent upper layers are mixtures of marine sediments (carbonate) and alluvium. These sedimentary deposits are important for hydrology because they are much less permeable than the underlying basalts. The sedimentary deposits can serve as caps on the aquifers held in the basalts preventing or retarding the flow of ground water to the sea.

Stearns and Vaksvic (1935) note that the Ko'olau basalts store water, primarily in dike limited zones and that this water appears as numerous springs at the foot of the pali from Kahuku to Waimanalo. One suggestion was that these springs occur where the dike impounded water, often with a considerable hydrological head contacts the older alluvium in the valley floors and appears at the surface. Waihoi Spring on the west wall of Punalu'u Valley may be an exception to this general rule as it appears at an elevation of 180 m (590 ft) from breccia. At the time of the Stearns and Vaksvic report (1935) that source was considered as a potential hydroelectric power source. The Waihoi tributary was gaged from 1915 – 1917 (USGS gage 16300000), recording a flow range between 4 cfs (2.6 mgd) and 7 cfs (4.5 cfs) (Oki et al. 2006).

6.1.2 Surface Water

Flow in a stream is the result of inputs (or losses) from ground water plus direct inputs from rainfall, overland and interflow, bank storage, and water returned from agricultural practices. Natural losses of water in stream channels in Hawai‘i are often a result of the permeable nature of the volcanic rocks. Streams or stream reaches can be classified as gaining (there is net input to the stream from groundwater sources) or losing (there is a net loss from the stream to ground water). However, this is not a fixed state since as the water table rises and falls in response to recharge or extraction by plant transpiration, wells and tunnels, a reach can change from gaining to losing and back. Perennial streams are characterized by continuous flow through time due to the input of ground water. The flow rate of a stream fed only by ground water sources is termed base flow. This rate is also only statistically constant as instantaneous base (groundwater fed) flow changes through time.

Punalu‘u Stream is a third order, continuous perennial stream (sensu Polhemus et al. 1992) that arises at the crest of the Ko‘olau ridge. In the early 20th century, USGS also maintained two gaging stations on Punalu’u Stream at 164 m (539 ft) (station 16299000) and 76 m (250 ft) (station 16301000). Oki et al. (2006) report that median flow for water years 1916 – 1917 at these gages was 6.5 cfs (4.2 mgd) and 25 cfs (16.2 mgd), respectively. Currently, there are two active stream flow gages in the valley one on the stream above the ditch diversion at 64 m (210 ft) (station 16303000) and the other on Punalu‘u Ditch at elevation 60 m (200 ft), about 274 m (900 ft) from the intake (station 16302000). The sum of these two flows represents what the total undiverted flow in the stream would be. USGS provides a combined daily stream flow that sums these two flows (referred to as station 16303003). The available record runs from 1952 to 2006 and the median flow over this period was 19 cfs (12.3 mgd). Flow for the combined gages is shown in Figure 3. Between 1955 and 2004, the value for mean discharge for the combined stream and ditch flow was 24.9 cfs (16.1 mgd) with minimum and maximum flows based on mean daily discharge of 8.0 cfs (5.2 mgd) and 1,020 cfs (659 mgd), respectively. Over the same time period, about 0.5 percent of the days of record had daily mean flow in the stream of zero at Station 16303000 (Oki et al. 2006). The period of record in Punalu‘u Valley was between February 18 and April 18, 2006, with five sustained freshets of 120 cfs (78 mgd) – 300 cfs (194 mgd).

Seasonality of the flow indicates a dry season from late May to early October and a wet season from October to mid May (Figure 4). Oki et al. (2006) report that April had the highest mean monthly discharge with 29.6 cfs (19.1 mgd), while September had the lowest with 20.2 cfs (13 mgd). Because irrigation needs are greater in summer months than in the rainy season there is an inverse relationship between median monthly flows in the stream and the ditch (Figure 5). From June to September more water flows to the ditch than remains in the stream based on median monthly flows.

The flow exceedance curve shows the percent time a flow greater or equal to a flow is exceeded (Figure 6). For example, in Figure 6, the vertical line representing 50 percent line crosses the curve at a point that is just under 20 cfs corresponding to the median flow or Q_{50}, of 19 cfs (12 mgd). From these data the 90 percent exceedance (Q_{90}) is 13 cfs (8.4 mgd), while the 70 percent exceedance (Q_{70}) is 16 cfs (10.3 mgd). Note that this graph is based on the combined flow of the ditch and Punalu‘u Stream. While it indicates the potential water supply for the valley, it does not provide information about flow in the stream channel.

Figure 7 shows a similar curve, but for data only from the gage that records mean daily flow in the stream channel (station 16303000). For Punalu'u Stream alone, which has a drainage area of 7.2 km^2 (2.78 mi^2), median flow is 11 cfs (7.1 mgd) while Q_{95} and Q_{70} are 0.96 cfs (0.62 mgd) and 7.1 cfs (4.6 mgd), respectively. For comparison, Kahana Stream to the south of Punalu‘u that has a drainage basin area of 9.69 km^2 (3.74 mi^2) has a median discharge of 23 cfs (4.9 mgd), while Kaluanui to the north which has a drainage area of 2.85 km^2 (1.1 mi^2) has a median discharge of 1.4 cfs (0.90 mgd) (Oki et al. 2006).

Oki et al. (2006) present flow information for Punalu‘u Stream and ditch combined, as well as the stream and ditch flows separately. The ditch gage (station 16302000) shows low values from

1971 to 1988. Monthly mean flows in the ditch show a gradual rise to a maximum of a little more than 10 cfs (6.5 mgd) in August and a low of about 5 cfs (3.2 mgd) in December and January (Oki et al. 2006).

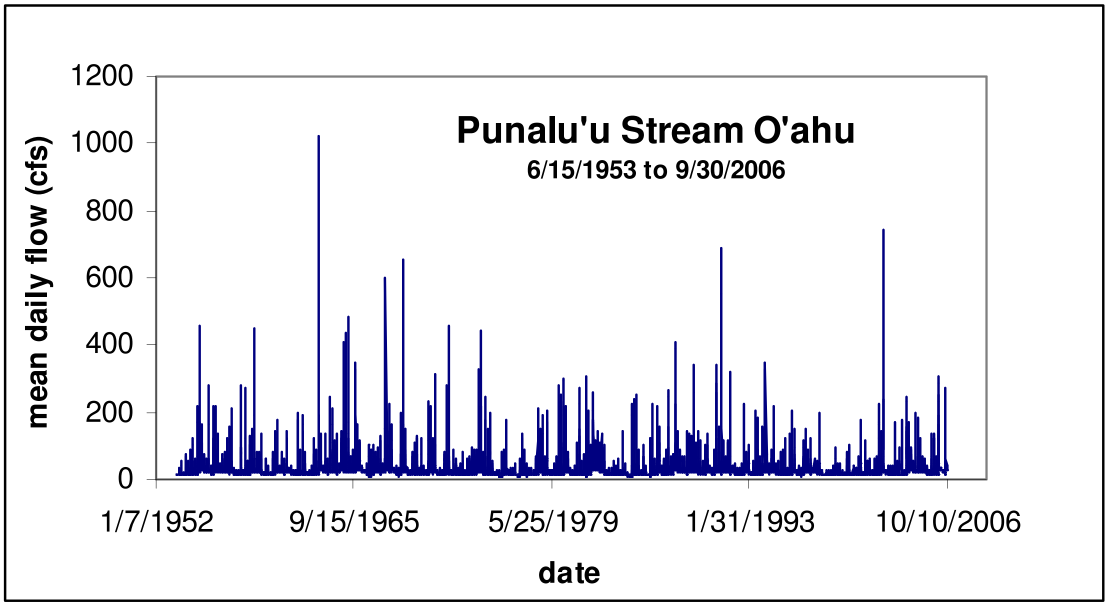


Figure 3. Combined daily mean flow in Punalu'u Stream and Punalu'u Ditch.

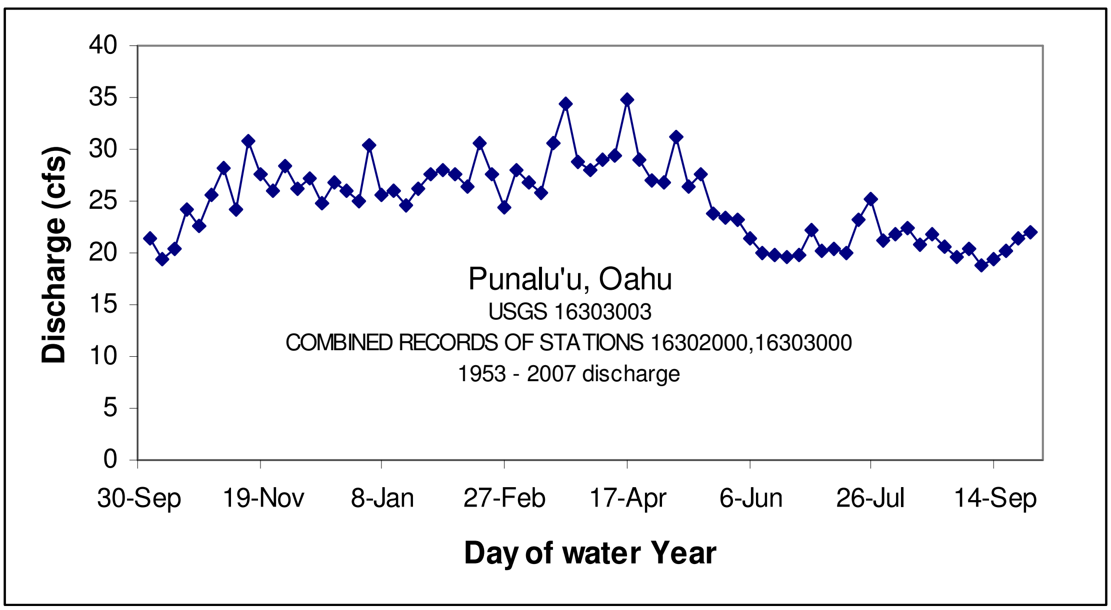


Figure 4. Seasonal flow for Punalu'u Stream. Points represent mean daily flows for 5-day increments for the entire period of record.

It is important to note that the arrangement of the sites where water height is gaged are not as the description of the sites might indicate. Gage 16302000 (the ditch gage) measures water in the ditch, but gage 6303000 measures water height above the diversion dam. Apparently, this value is somehow 'adjusted' to represent what flow would be occurring below the dam.

Oki et al. (2006) also derive estimates of base flow. Based on calculation, their study found that mean base flow (as defined using the computerized base-flow separation model of Wahl and Wahl 1995) for the combined flows from 1954 to 2004 was 18.2 cfs (11.8 mgd), suggesting that base flow in Punalu'u Stream was about 73 percent of the total flow. This was attributed to groundwater discharge, while the remaining 27 percent was attributed to direct runoff.

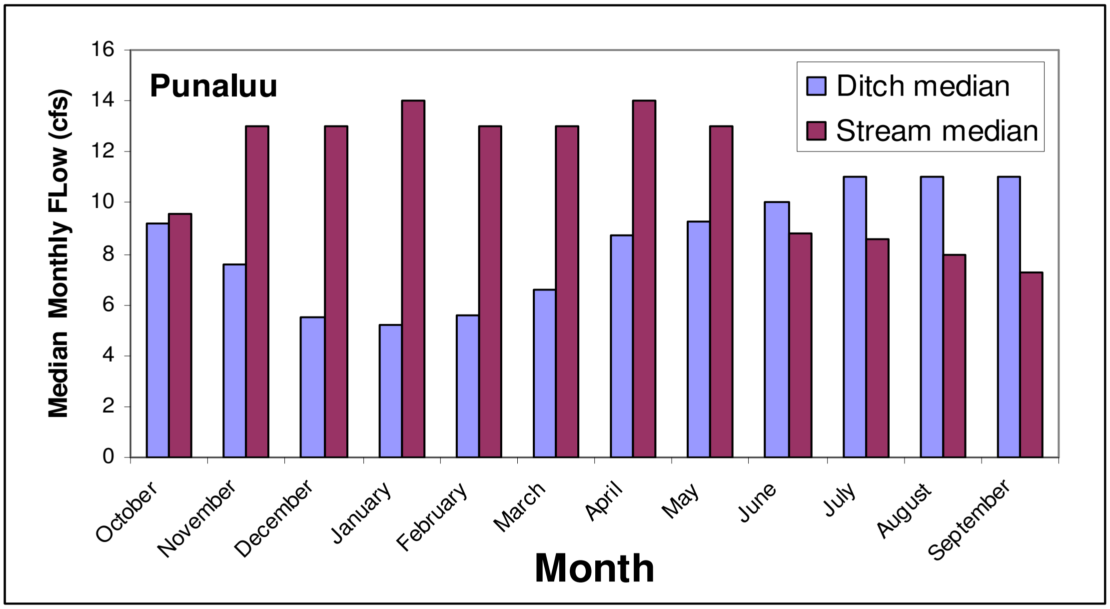


Figure 5. Monthly median flows in Punalu'u Stream and the Punalu'u Ditch based on mean daily flow records.

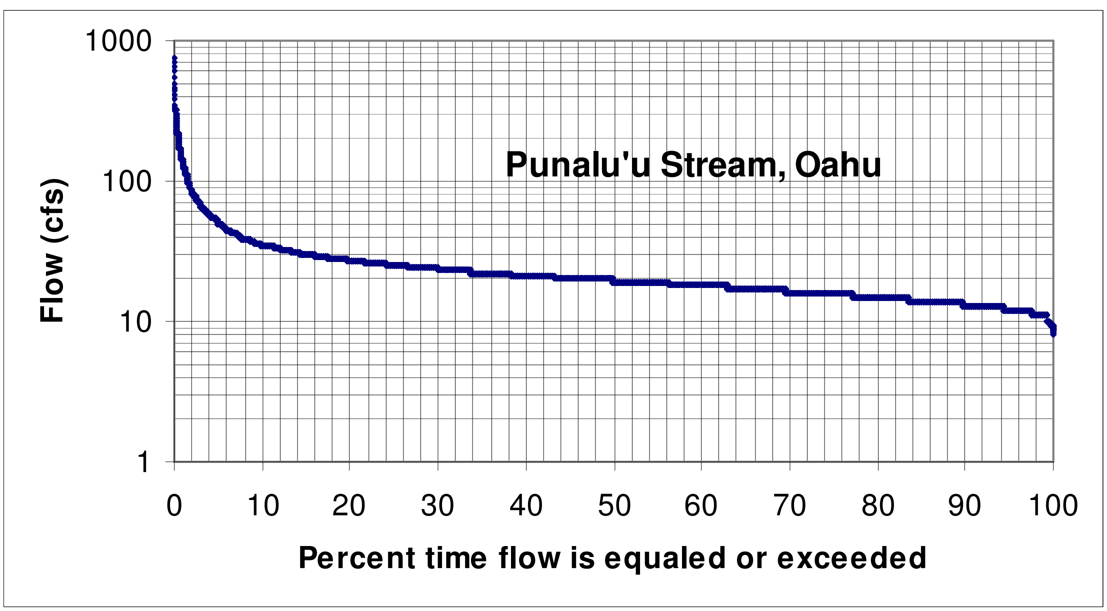


Figure 6. Flow exceedance curve for combined Punalu'u Stream and Punalu'u Ditch flows.

Flooding has sometimes been a problem affecting Punalu'u Valley (R. M. Towill Corp. 1979, Group 70 2006). The FIRM Flood insurance Rate Map produced by the National Flood Insurance Program (NFIP) of FEMA for lower Punaluu Valley illustrates flood prone areas extending upstream roughly 800m (0.5 miles) from the shoreline to the upper limit of the NFIP study which corresponds to the areas mapped by Ushijima and Ewart (1973). The map alone suggests that an area of greater than 40ha (nearly 100 acres) adjacent to the estuary is at risk of flooding during a 100yr storm event.

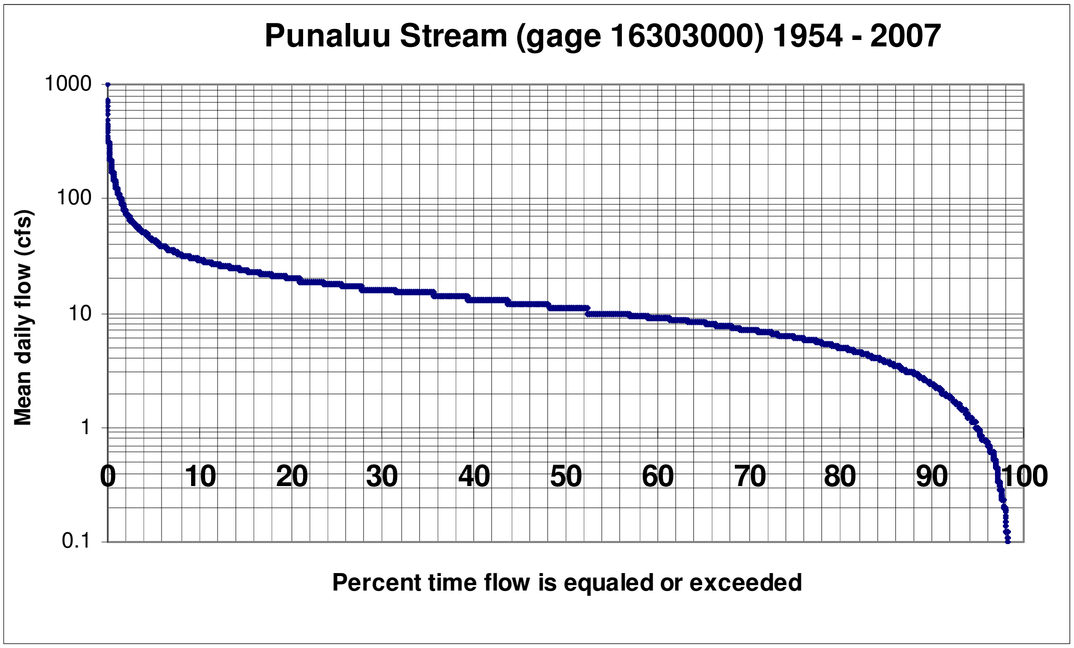


Figure 7. Flow exceedance curve for USGS Station 16303000, Punalu'u Stream.

Stream flow records can be used to estimate the probability of a flood occurring (P) or the recurrence interval (T) of floods of a given magnitude; however, caution must be used when evaluating these estimates. In general, the shorter the period of record, the greater the error involved. For Punalu'u Stream, with 54 years of data, there would be an approximately 25 percent error in estimating the 100 year flood (the flood which on average would occur every 100 years). To reduce the error to 10 percent, 115 years of record would be required (Gordon et al. 1992). Secondly, the record for Punalu'u Stream is actually the sum of ditch water and water in the stream channel. While the largest floods probably overwhelm the capacity of the ditch, its presence will still introduce some error.

Also, the data used in these analyses are mean daily flows, not peak flows. This will tend to reduce the apparent magnitude of flood events making the results underestimates of actual potential peak flows. Most importantly, it must be recognized that recurrence interval estimates are probabilities not predictions. Even if the data were prefect and the period of record was very long, the results of the analysis are statistical in nature. Thus, the occurrence of a 50 year flood in no way precludes a flood of equal magnitude occurring the following year. The analysis only states that over a very long time interval a flood of a given size might be expected to occur in a given time interval.

With these caveats in mind, it is still of some value to use the existing data for Punalu'u Stream to investigate the chances of a flood occurring. Figure 8 presents the probability of exceedance for floods of a given magnitude using the Weibull plot (Dalrymple 1960). With this analysis, a year with a maximum flood flow as great as 200 cfs (129.3 mgd) could be expected in about 6 out of 10 years, while only 3 percent of all years would be expected to have a peak annual flood of 800 cfs (517 mgd). Note that this graph represents data from the stream only, not the combined total flow.

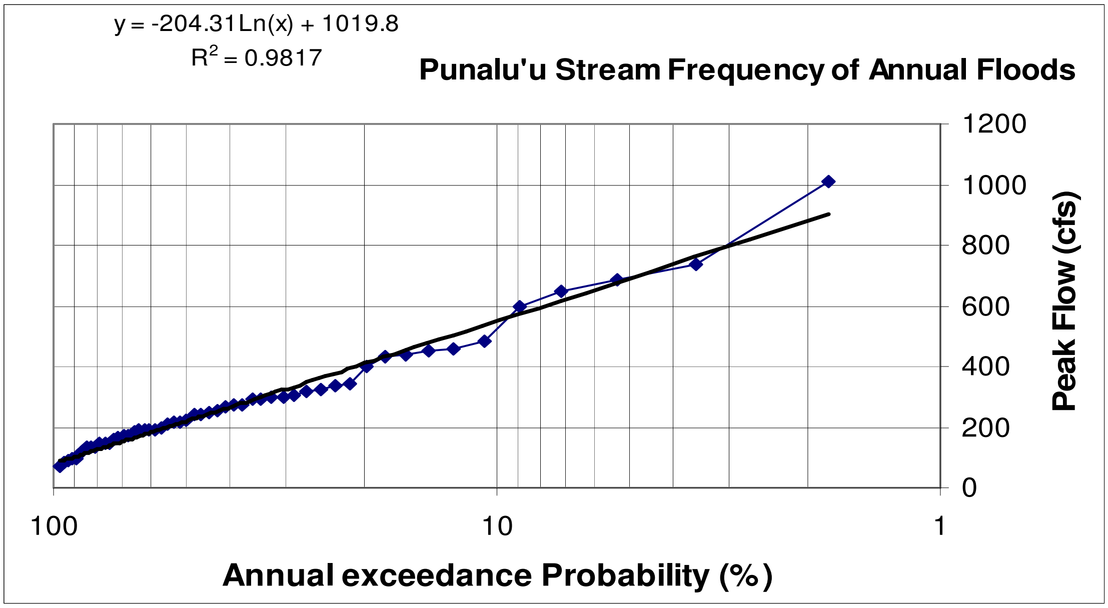


Figure 8. Annual exceedance flood probability for Punalu'u Stream (station 16303000). The straight line is a fitted logarithmic estimate.

A more direct way of examining the same data is to plot the average flood frequency (Figure 9). In such a plot, the mean recurrence interval is plotted against the magnitude of the flood. For example, in Punalu'u Stream a flood peak of about 540 cfs (349 mgd) could be expected on average every 10 years. Oki (2004) studied and analyzed long term trends in many Hawaiian streams, including Punalu'u Stream. He found that trends in annual total and base flow in Punalu'u Stream had decreased significantly over the 49 year period of record.

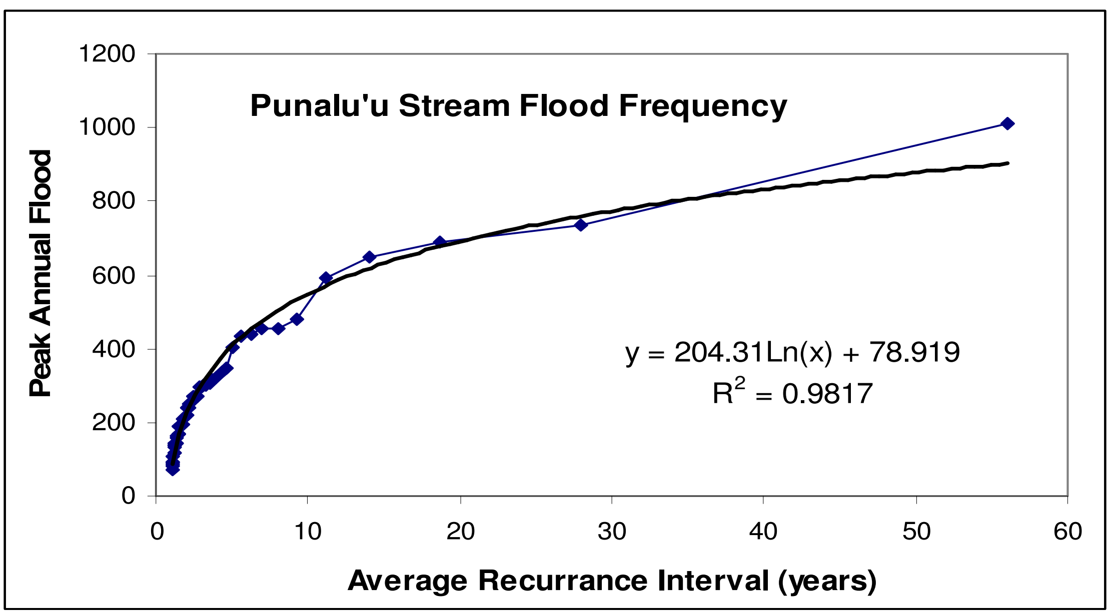


Figure 9. Flood frequency analysis for Punalu'u Stream. The fitted curve is a logarithmic estimate.

Figure 10 provides an oversimplification of the extensive analysis Oki carried out. This slight downward trend was consistent with findings at most streams in the State. Oki (2004) concluded for streams State-wide that there appeared to be both decadal and inter-annual variability. No clear cause for the downward trend or the variability was found, but Oki (2004) suggested that one possibility for the long term decreases might be downward trends in groundwater storage. The shorter variability could be due to ENSO (El Niño/Southern Oscillation) or PDO (Pacific Decadal Oscillation) regional climate influences.

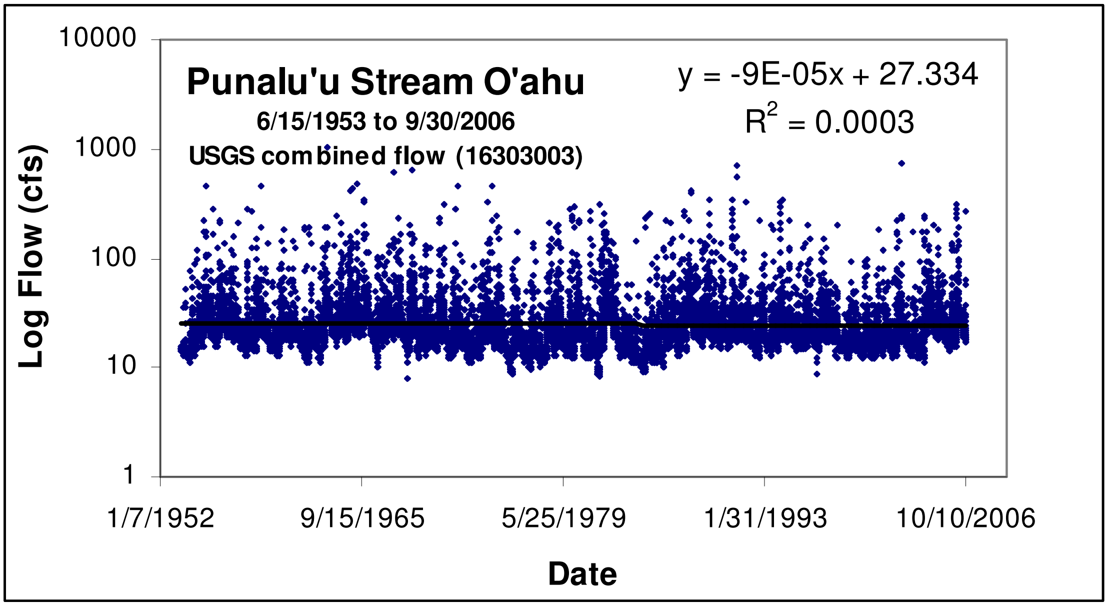


Figure 10. Daily mean flow for Punalu'u Stream plus ditch flow.

6.2 Water and Land Use in Punalu'u Valley

6.2.1 Surface Water Development and Agriculture

Historically, Punalu'u Valley was extensively terraced for taro cultivation which extended to the shore (Handy and Handy 1972). Maly and Maly (2005a) prepared an extensive cultural and historical review of accounts of Punalu'u Valley for Kamehameha Schools which details land ownership including documents establishing land tenure. Maly and Maly (2006b) provide oral histories on land and water use in the valley and its vicinity extending back to the 1820's. As in many other areas in the State of Hawai'i, the wetland taro agriculture was initially replaced, to a greater or lesser extent, by rice another wetland crop. In turn, rice was eventually replaced by sugar, although taro culture has always been, and remains, important in parts of the valley.

Each of these three agricultural practices has its own impacts on the landscape and, more pertinent here, its own needs for water. The more 'industrialized' water development for sugar-based agriculture in the valley began in 1906 when James B. Campbell's Ko'olau Agricultural Company developed a sugar plantation using both fee-simple land and acreage leased from Bishop Estate. Subsequently, the Kahuku Plantation Company, which was started in 1890 by James Castel and Alexander Young, expanded to Punalu'u in 1906 with a lease from Bishop Estate (Wilcox 1996). The Kahuku Plantation Company was finally closed by the owners Alexander and Baldwin in 1971. Beginning in 1907, water for the sugar plantations in Punalu'u, Kaluanui and Kahana was developed into a system termed the Punalu'u Ditch system (Maly and Maly 2005). It consisted of a diversion dam on Punalu'u Stream at an elevation of about 64 m (210 ft). This water passes through a series of open ditches and tunnels along the north side of the valley (ITC 2008). R.M. Towill Corporation (2006) provided a detailed assessment of current agricultural water uses in the valley (Figure 11).

In the past, water was delivered as far as Kaluanui Valley to the north, but today, at the end of the system, any remaining water is returned to a tributary of Punalu'u Stream (Oki 2006), though currently there is no water being returned to the tributary. A second, smaller ditch system led southward to Kahana Valley (Wilcox 1996), but is no longer in existence. There are places where water can be added to the present-day system from three tributaries as well as surface water draining into the open ditches (Oki et al. 2006). Additionally, the system has several gates for release of water as well as several pipes that have been added over time (R.M. Towill 2006), some of which are now blocked or otherwise unused. Today, there are two major pipe systems that take water from the ditch. One of the systems belongs to Kamehameha Schools and consists of three pipes that take water from the Punalu'u Ditch as it runs across KS land.

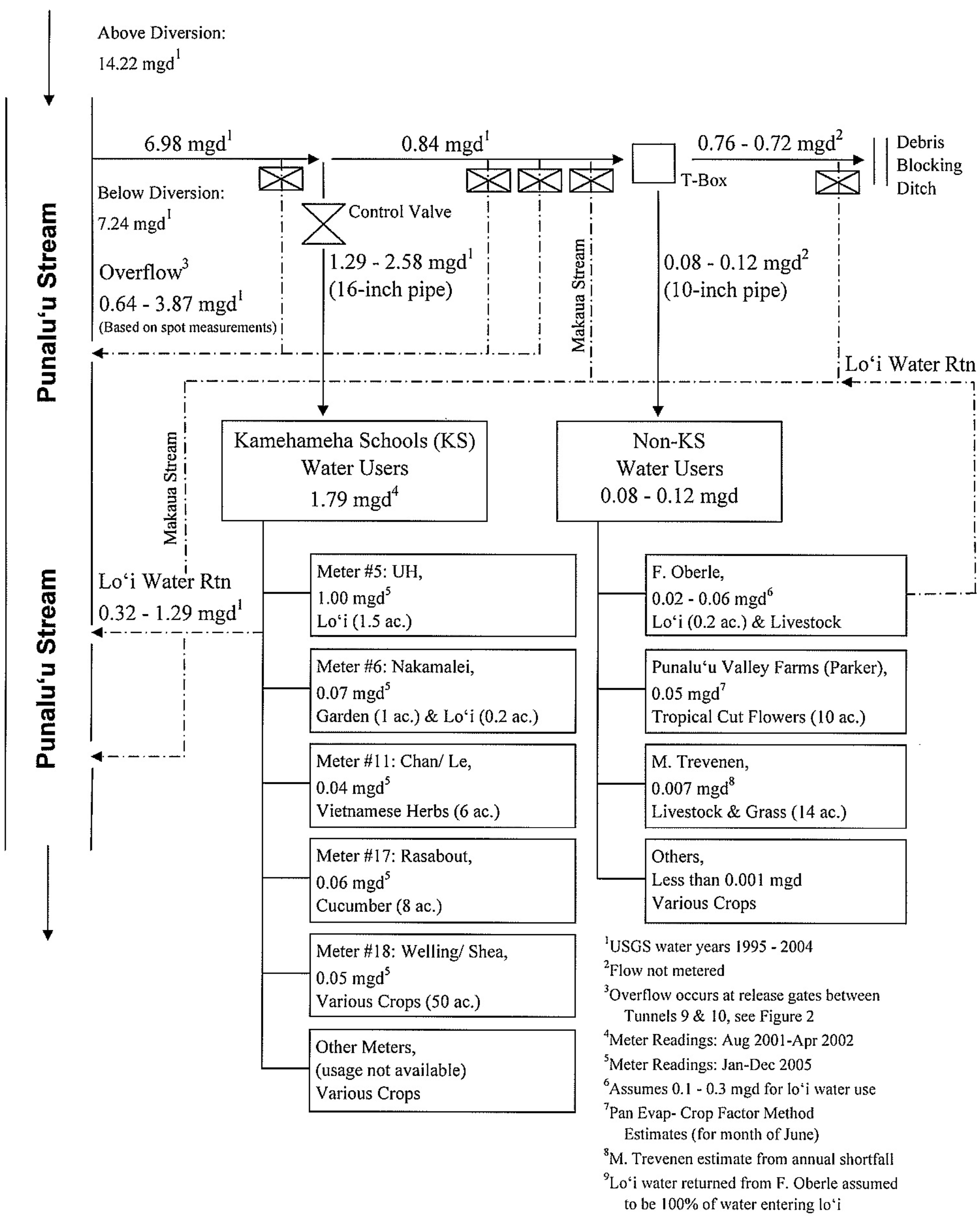


Figure 11. Schematic plan of existing agricultural water diversions on Punaluu Stream (from R.M. Towill Corporation, 2006).

The Kamehameha Schools pipes are a 6” (15 cm) pipe that takes water from between tunnels #5 and #6, a 10” (25 cm) pipeline that takes water from just after tunnel #9 and the major pipe system that takes water to a 16” (41 cm) pipe and distributes it throughout the lower part of the valley. The other, smaller, system that takes water from the terminus of the Punaluʻu Ditch system beyond the Kamehameha Schools property boundary is used by farmers on non-Kamehameha Schools lands. As of 2006, only the Kamehameha Schools pipe system was metered (R. M. Towill 2006). Kamehameha Schools has commissioned several studies of current and projected water use in the valley (R. M. Towill 1979, 2006, CH2MHill 1991) as well as an estimate of costs needed to repair the ditch system and rationalize water distribution in the valley (Wai Engineering 2005). Water is returned from the system (or loʻi that receive water from the system) in two places on KS land as well as one taro farmer not on KS land (Towill 2006).

6.2.2 Ground Water Resources

The two groundwater sources in Punaluʻu Valley are the dike impounded water that, for the most part lies toward the back of the valley, and the freshwater lens which underlies the valley floor. The high elevation dike water primarily feeds the headwaters of tributaries of Punaluʻu Stream (Stearns and Vaksvik 1932, Oki et al. 2006). Nearer the coast, the dominant groundwater source is the basal freshwater lens in the volcanic rocks and sediments that make up the floor of the seaward part of the valley (Oki et al. 2006). Freshwater lenses essentially float on top of the underlying seawater aquifer. There is a mixed zone of intermediate salinity in the transition zone between the upper freshwater lens and the underlying salt water. The usefulness of the freshwater lens for agriculture and especially domestic use can be compromised if transition zone water is drawn up too near the point where water is taken from the lens by excessive pumping (Lau and Mink 2006).

Mink and Yuen (1991) describe the Makaliʻi basal aquifer as lying beneath Punaluʻu Valley. They state that it is only about 2.5 km^2 (1 mi^2) in area, but is dynamic in that it gets substantial discharge from the dike impounded aquifer mauka, and from precipitation and infiltration in the lower elevations (Mink and Yuen 1991). The bulk of the basal aquifer is in the underlying permeable Koʻolau basalt, but the less permeable coastal plane sediments serve as a ‘leaky’ caprock so that the basal aquifer rose to a head of about 3 m (10 ft) in 1991 (Mink and Yuen 1991).

In another report of the same date CH2MHill (1991) showed two distinct aquifers underlying the valley with the Koʻolauloa aquifer to the north and the Kahana aquifer to the south. The aquifer system boundary shown by CH2MHill (1991) runs, for the most part, to the north of Punaluʻu Stream.

Historically, there were several wells in the valley that developed ground water in the basal aquifer by drilling through the sedimentary deposits into the underlying basalt (Oki et al. 2006). Today, there are three main production well fields in the northern, coastal part of the valley tapping this aquifer. These wells provide water for domestic use in the area, and are maintained by the Honolulu Board of Water Supply. Table 1 provides pumping information on the three fields. There are also private wells in the area with reported withdrawals less than 0.5 Mgd (Oki et al. 2006). In addition, Kamehameha Schools has several wells that are not currently in use.

Table 1. Main Production Wells in Punaluʻu Valley, Oʻahu.

Well field	State well #	Date drilled	Withdrawal (Mgd)
Punaluʻu I	3553-02	1958	0.2 – 0.6
Punaluʻu II	3553- 03 to -08 and 3554-03	1965 – 1967	2.0 – 8.0
Punaluʻu III	3453-06 -07	1974	1 – 1.5

Source: *Date from Oki et al. (2006)*

Water levels depend on recharge from rainfall, withdrawals, and barometric pressure. Near the coast, tidal changes also influence water levels. Salinity in the basal aquifer increases with depth as the transition zone is approached and toward the coast (where the lens is thinner) and pumping (as the water level is drawn down). Oki et al. (2006) provide data on water levels and salinity in the basal aquifer derived from pumping logs. There is evidence for increasing chloride in several production wells since the 1990's (Oki et al. 2006). If surface waters and groundwater are connected, withdrawals of ground water could affect stream flow. Oki et al. (2006) suggest such an effect could occur at lower elevations (~ 7.6 m or 25 feet above sea level), but there is no evidence this is currently the case. However, CH2MHill (1991) state that in lands owned by Kamehameha Schools in the southern half of Punalu'u Valley '….the withdrawal of groundwater from wells and tunnels can be expected to cause a corresponding reduction in stream flow."

6.2.3 Water Quality

USGS conducted an intensive survey of water quality in surface and groundwater on O'ahu as part of the nation-wide NAWQA program (Brasher and Anthony 2000). Levels of contaminants including organic compounds, nutrients and metals were determined for many O'ahu streams and aquifers including Punalu'u. Except for a few wells, drinking water standards were not exceeded for organic compounds or nutrients. Most problem areas were either urban or in central O'ahu, where large scale plantation agriculture, especially pineapple, dominated (Anthony et al. 2004). Land use was an important predictor not only of general water quality, but specific contaminants were correlated with specific land use patterns. Hunt (2004) surveyed ground water in central O'ahu, but not the windward side of the Ko'olau range; however, Oki and Brasher (2003) included all O'ahu in a study of effects of environmental factors on water quality. In another report from the NAQWA program, Brasher et al. (2004) related land use to stream fauna.

Nitrogen and phosphorous borne to the sea in stream flow are important components of coastal ecosystems (Hoover 2002). Excessive amounts of both nutrients, often contributed by agricultural, industrial, and residential activities, can be detrimental. Hawai'i Department of Health (HDOH) conducts water quality monitoring throughout the state. Under the Clean Water Act, HDOH was required to identify all impaired waters in the state. Their final report (HDOH 2004) noted that Punalu'u Stream did not exceed limits for nitrate, total nitrogen, total phosphorus, total suspended solids or turbidity for the years 1997 to 2003. However, the report noted data for Punalu'u were incomplete and a final decision on whether to list that stream was not possible. As a result, Punalu'u Stream was designated a Category 2 stream, meaning "some designated uses are met, but insufficient data exist to evaluate all uses."

The Clean Water Branch (CWB) monitors marine waters for *Enterococcus* and *Clostridium*, two indicators of fecal contamination. The CWB has a shore monitoring site for beach water quality at the Punalu'u Beach Park just south of where Punalu'u Stream crosses the beach. As part of the NAWQA program, USGS studies several streams on O'ahu. Brasher et al. (2004) reported water quality from Punalu'u stream combining their above- and below-diversion sites. For most nutrients (nitrogen and phosphorus forms), concentrations were low or below detection. Metals (Mg, Mn, Fe) were lower than in more urban streams.

ENPRO (2008) conducted laboratory analysis of water samples drawn on May 19, 2008 from three sampling locations on Punalu'u Stream. These three sites are illustrated in Figure 1. Discharge above the intake at the time of sampling was just over 12 cfs (7.8 mgd). Just over 2 cfs (1.3 mgd) was passing below the dam on this occasion. Stream flow had been decreasing gradually for a period of two days prior to sampling.

The ENPRO report noted elevated values of mercury, chlorine, and aluminum in stream waters at the middle and lower reach sample sites. ENPRO (2008) concluded that the elevated aluminum and mercury values were below all three State of Hawaii Department of Health numeric regulatory standards for 'dry season' (HAR 11-54-05.2); and chlorine was below the acute standard but slightly above the chronic numeric standard. Turbidity and chlorophyll-a values at station two were elevated above DOH standards.

6.3 Estuary and Nearshore Environment

6.3.1 Estuary

The lower reaches of Punaluʻu Stream have a relatively flat longitudinal gradient that reduces flow velocity and creates a depositional environment characteristic of geologically older stream valleys. Most of the residential and much of the farming in Punaluʻu Valley lies adjacent to the estuary and terminal reaches of the stream. The valley has been subjected to flooding on numerous occasions in the past. The flood stage in each event is influenced by the amount of vegetative debris blocking culverts and bridges, as well as the configuration of the stream channel and mouth. During the summer months or when stream flow is low for an extended period, a berm of sand naturally builds across the stream mouth (Handy and Handy 1972). When this occurs, stream flow can back up forming an almost static pool upstream of the bridge with minimal flow to the sea. When stream flow is high the sand blockage is broken and the estuary is open to the sea. Handy and Handy (1991) witnessed just such a changing of seasons in late November 29, 1954 when a deluge of rain led to "…the lagoons and Kahana Bay were brown with mud from the streams." They go on to describe the importance of these events to seasonal fisheries:

> "*The freshets was out the sand banks blocking the stream mouths from the sea, making 'backwaters' (muliwai) where the mullet, which have just migrated to the windward side of the island, enter the shallow waters were stream meets sea and spawn. Soon the sand banks will again block the streams, and in the warm shallow waters of the now dammed muliwai the mullet eggs hatch. Here the fingerlings (pua ama) will swarm in great numbers until heavy rains again open the stream mouths, allowing them to swim into the lagoon where they feed and grow until the time comes in early summer for them to swim back around the eastern end of the island to their summer home in Pearl Harbor." Handy and Handy (1991).*

This seasonal pattern of migration by striped mullet (*Mugil cephalus*) on Oʻahu is also discussed, and additional details were provided, by Titcomb (1972). Others (e.g. Hoover 2008) perpetuate the story of mullet spawning in *muliwai*; however, McDowall (1988) and Randall (2005) correct the record by noting that striped mullet are catadromous and spawn in marine waters. Their young frequently invade estuaries and stream mouths; however, there appears to be no evidence that this migration into freshwater is obligatory as it is for *āholehole* (*Kuhlia* sp) and *oʻopu* (McDowall 1988, Keith 2003). Prior to the 1980's, many Punaluʻu residents apparently collected ʻopae kalaʻole, hīhīwai, ʻoʻopu, āholehole, and ʻama ʻama from the stream and estuary for subsistence (Maly and Maly 2005b).

There is very little information available describing the estuarine environment in Punaluʻu Stream. AECOS (2002) conducted a reconnaissance survey of aquatic biota and riparian vegetation in the areas adjacent to the south Punaluʻu Stream highway bridge. Salinity at depths ranging of 0.30m (1 ft) to 0.70m (2.3 ft) seaward of the bridge (0.1-3.6ppt) was measured at a time when the influence of freshwater streamflow dominated the characteristics of the shallow stream delta (AECOS 2002). Surface waters just five meters upstream from the highway bridge were found to be fresh (specific conductance = 182µS). The stream above the bridge forms a deep pool which appears to persist year round. Thus, the highway bridge can be considered to be the boundary between the estuary and the mouth of the stream.

6.3.2 Nearshore Environment

Along the windward coast of Oʻahu from Kaʻoio Point to Mokuauia there is a reef structure about 800 m (0.5 mi) offshore (Figure 12). This reef is fairly continuous and provides some degree of protection to the shoreline areas (Anon 1954, Balder 1992). A cross section at Hauʻula indicates a sandy-bottomed lagoon structure with a maximum depth of 20' extending 1200' off shore where the shallow reef reaches the surface (Anon 1954). SHOALS Lidar imagery available from the University of Hawaii (http://www.soest.hawaii.edu/coasts/data/oahu/shoals.html) provides visual details of this nearshore reef bathymetry.

AECOS (1981) reports use of this back reef area at Punalu'u Beach Park for limu gathering, torch fishing, tako (octopus) fishing, spear and pole fishing, as well as trap and gill net fishing. The latter two activities are now restricted by the Department of Land and Natural Resources, Division of Aquatic Resources (DAR). The substratum offshore of the Punalu'u Stream mouth consist of cobbles and small boulders, sandy bottoms with limestone outcrops and sand (AECOS 1981). Punalu'u Channel is shown in AECOS (1981) as a sand-bottomed offshore extension of the stream. This channel is extends more than 500m (1,640ft) offshore. There is a similar sand channel offshore of the much larger Kailua Beach (Harney et al. 2000).

Handy and Handy (1991) discuss the importance the historic mullet and *akule* (*Selar crumenopthalmus*) fisheries at Punaluʻu; and Maly and Maly (2005b) relate stories from elders regarding nearshore fishing at Punaluʻu in past decades. As simple regression on the reported commercial fish catch from annual DAR fisheries statistics (DAR 2006-1997) covering the waters from Laie to Kahana Bay from 1997 through 2006 shows a gradual decline in pounds of fish landed. There is insufficient information available to suggest a cause for the decline or to identify what portion of this catch comes from waters off Punaluʻu.

Figure 12. Oblique photo of Punaluu Beach, reef, and channel.
Source: http://www.soest.hawaii.edu/coasts/data/oahu/oblique_windward.xml

6.4 Biological Resources of Punaluʻu Stream

6.4.1 Previous Surveys

The Division of Aquatic Resources (DAR) maintains a database which documents all records of stream fauna (http://hawaii.gov/dlnr/dar/streams/stream_data.htm). They recently released a Hawaiian Watershed Atlas for the island of Oʻahu, as well as the 4 other main islands (http://www.hawaiiwatershedatlas.com/). The Atlas indicates that some 11 studies of Punaluʻu Stream have taken place from 1937 to 2003; however, all are not included.

Based on these surveys, the Hawaiian Watershed Atlas identifies the stream as having native insect and macrofauna diversity, an abundance of native species, and candidate endangered species (DAR 2008). Species recorded in Punaluʻu Stream by DAR are listed in Appendix A; however, the atlas does not indicate when or precisely where along the stream the species were observed.

The DAR Hawaiian Watershed Atlas also provides watershed and biological stream ratings for Punaluʻu compared to all other watersheds in the Atlas (Table 2). The ratings in each criterion range from 0 to 10, with 10 being the highest. Note: the ratings do not consider diversion, channelization, or impaired water quality. As part of the NAQWA program, Brasher et al. (2004) surveyed invertebrate community structure in nine Oʻahu streams including Punaluʻu. They sampled both below and above the diversion at an elevation of about 65 m (212 ft). Both sites were characterized as 'forested,' but stream flow below the diversion was "less than half of the flow above" (Brasher et al. 2004). At both sites, more than 85 percent of the invertebrates were insects and of these, more than 75 percent were alien caddisflies (Trichoptera). Invertebrate species diversity was somewhat higher at the downstream site. In an appendix to this paper, Brasher et al. (2004) reported the presence of the endemic shrimp *Atyoida bisulcata* as well as the alien atyid *Neocaridina denticulata sinensis* and the alien prawn *Macrobrachium lar*. The total number of individual (abundance) invertebrates sampled by Brasher et al. (2004) above the diversion in Punaluʻu exceeded that of any other Oʻahu stream in their study.

USGS conducted a thorough study of Punaluʻu Stream between 2004 and 2005 (Oki et al. 2006) to evaluate the effects of surface water diversion on streamflow and habitat for native Hawaiian stream life. This study encompassed 12 sampling sites, six above and six below the diversion. The Physical Habitat Simulation Model (PHABSIM) was also employed by USGS to estimate the availability of weighted usable habitat (WUA) in each of four study reaches (at altitudes of 140, 100, 40, and 10 ft) for ʻoʻopu nākea (*Awaous guamensis*) and hīhīwai (*Neritina granosa*).

Table 2. DAR Hawaiian Watershed Atlas Watershed Rating for Punaluʻu Stream.

Criteria	Description	Rating
Watershed Ratings		
Land Cover	Compares forested lands vs. developed lands, where forested lands are given a higher score.	8
Shallow Waters	Based on the amount of estuarine and shallow marine areas associated with the watershed and stream.	1
Stewardship	Ranks the amount of land and biodiversity protection within the watershed.	2
Size	Based on the watershed area and total stream length, with larger watershed and streams scoring higher.	4
Wetness	Based on average annual rainfall, with greater rainfall totals scoring higher.	6
Reach Diversity	Based on the types and amounts of different stream reaches available in the watershed.	4
Total Wetland	Combination of the above ratings.	6
Biological Ratings		
Native Species	Based on the number of native species in the watershed.	10
Introduced Genera	Based on the number of introduces genera observed in the watershed.	5
All Species' Score	Compares number of native species to introduced species according to the Hawaii Stream Assessment.	6
Total Biological	Combination of the above ratings.	6
Overall	Combination of the total wetland and biological ratings	6

Oki et al. (2006) found that the indigenous goby ʻoʻopu nākea (*Awaous guamensis*) was fairly common both below and above the diversion. Fish of several size classes were seen, indicating that recruitment is occurring. Eight of the 10 characteristic native stream animals have been recorded from Punaluʻu Stream from the Hawaii Stream Assessment (HSA), DAR surveys, Brasher et al. (2004), and by Oki et al. (2006). The estuarine gobioids, ʻoʻopu ʻakupa (*Eleotris sandwicensis*) and ʻoʻopu naniha (*Stenogobius hawaiiensis*), as well as the itinerant āholehole (Kuhlia xenura), were observed at elevations of 15 m (50 ft) or lower. ʻOʻopu nōpili (*Sicyopterus stimpsoni*) has not been recorded from the stream in any recent study.

There is only a single published record of *L. concolor* in Punaluʻu Stream (Higashi and Yamamoto 1993), and none were found by SWCA biologists. Oki et al. (2006) noted that the abundance of ʻoʻopu nākea may be increasing following an apparent population decline in the late 1990's. However, without quantitative field data based on comparable methodologies, no firm conclusions about abundances of any of the stream fauna can be made. In addition to the native stream fishes, the USGS report noted the endemic ʻopae (*Atyoida bisulcata*) and the endemic snail hīhīwai (*Neritina granosa*) were observed at 12 m (40 ft). Larvae of four native amphidromous species (*Eleotris sandwicensis*, *Awaous guamensis*, *Stenogobius hawaiiensis*, and *Macrobrachium grandimanus*) were collected by Luton et al. (2005) at the highway bridge in 1999 and 2000. AECOS, Inc. (2002) performed aquatic and botanical surveys at the mouth of Punaluʻu Stream for use in the assessment of potential impacts associated with highway bridge replacement.

6.4.2 SWCA Observations

SWCA scientists made four visits to the study area from December 12, 2007 to July 25, 2008. The stream above and immediately below the diversion structure, the lower reach, and the mouth of the stream were specifically targeted for observation. There were two general objectives of the field work:

1. Inspection of the dam and diversion system to determine if there were ways that negative impacts to amphidromous fauna could be minimized;

2. Evaluation of the quality of the stream channel, especially at lower elevations, to asses the suitability for movement of amphidromous species, particularly to and from the sea.

The goal of the study was to provide Kamehameha Schools with information that could be used in preparation of a petition to the Water Commission to set an Interim Instream Flow Standard (IIFS) for Punaluʻu Stream.

SWCA staff observed stream fauna approximately 100m (328ft) above and below the diversion dam by snorkel and pedestrian surveys. Digital photographs were taken of structures and channel features where appropriate and habitat maps were created in the lowest reach. In addition to evaluating the current condition of the intake and impoundment, the authors qualitatively evaluated how and where structural modifications might be made in such a way as to increase connectivity and facilitate movement of stream animals. The effectiveness of the diversion structure was noted, i.e. was there significant seepage under the diversion dams or leakage through the system. The structure of the dam itself, as a barrier to migration, was also evaluated. SWCA scientists also collaborated closely with Planning Solutions, Inc. and ITC Engineering, Inc. in the development of the structural design of the new diversion dam and intake for the benefit of native stream life.

6.4.3 SWCA Field Studies

6.4.3.1 Habitat Mapping

Habitat mapping is a quantitative determination of the proportions of the stream providing specific habitat requirements for various instream organisms. Habitat mapping is typically the first step in preparing for an instream modeling study such as PHABSIM. The purpose is to quantitatively determine what proportion of a selected reach can be assigned to each of the habitat types. This information is essential in selecting cross-sections for the detailed data gathering phase. Knowing the proportion of each habitat type insures that cross-sections are selected so as to be representative of the entire reach. However, for example in our survey, habitat mapping is also a valuable quantification of the nature of a stream reach, useful in its own right. While many finely divided habitat types can be defined the SWCA survey of lower Punaluʻu Stream used the following:

Pools - Stream reaches where there is little evidence of downstream flow. Pools tend to be deeper than other habitat types.

Runs – Stream reaches where the downstream flow is obvious, but the surface of the water is mostly unbroken. Flow is typically smooth and unidirectional. Sometimes this type is divided into shallow and deep.

Glides – Stream reaches, similar to runs, but where the water surface is especially smooth.

Riffles – Stream reaches where the water surface is broken and there is usually a strong vertical component to the flow. Riffles are typically shallow and substratum elements (boulders, cobbles snags etc.) often protrude through the water surface. Sometimes this type is divided into shallow and deep.

Pocket water – Stream reaches with complex flow patterns occurring in the same cross section so that part of a cross section might be a riffle with clear downstream flow while adjacent to it there might be ponded water, or even water with an upstream component due to eddies.

Cascades – Stream reaches where the water changes elevation rapidly, but is mostly in contact with the bottom. Flow is turbulent and white water is typical.

Falls – Falls are steeper than cascades and at least some of the descending water drops freely with no contact with the bottom.

SWCA biologists conducted the habitat mapping exercise on July 25, 2008. Stream flow at the USGS Gage 16303000 at the time of these surveys was between 2.9 cfs (1.9 mgd) and 2.6 cfs (1.7 mgd) (provisional data). There had been rain during the previous days, but little rain in the past 24 hours. The study reach extended from the ford (GPS 593) to just above the Kamehameha Schools property line (GPS 597) for a total of 1.123 km (0.698 mi).

Runs, riffles and pools are the dominant habitat type in this reach (Figure 13). Pools within this reach were typically large. The mean length and estimated width of all pools in the study reach were 21.7 and 9.3 m (71.2 and 30.5 ft), respectively. Mean estimated depth of all pools in the reach was 0.87 m (2.9 ft). Common of low gradient stream, such as the reach surveyed in lower Punalu'u, valley cascades and falls were not observed; however, such habitat types are common in Punalu'u at higher elevations where the gradient is steeper.

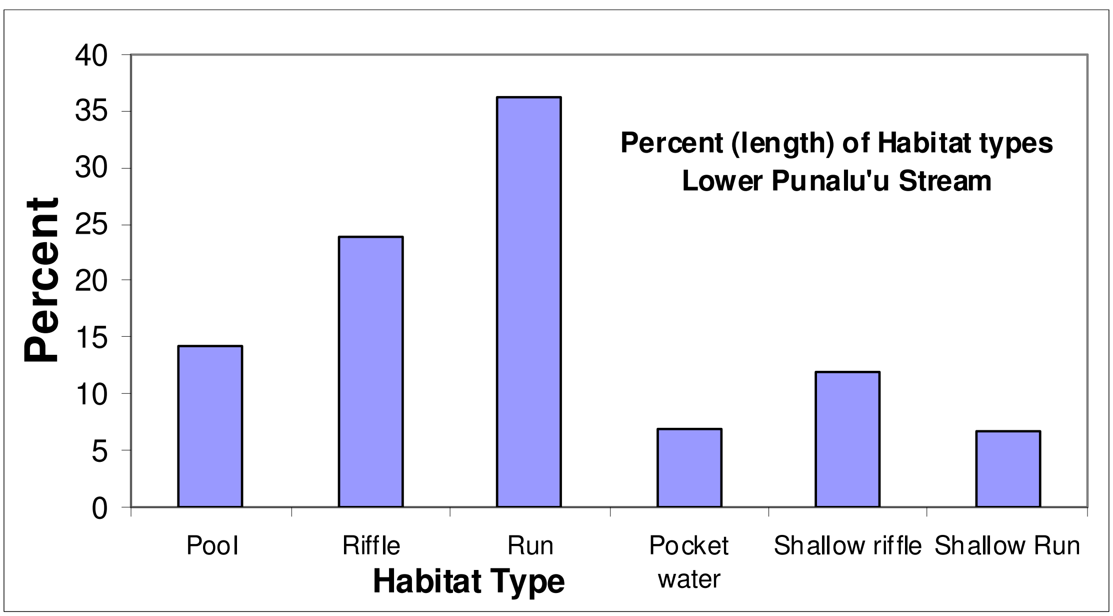


Figure 13. Percent of habitat types in lower Punalu'u Stream.

The dominance of slow moving deep water habitats has implications for the suitability of the stream for native animals as well as invasive alien species. The figures below shows a shallow pool (Figure 14) compared to a deep pool (Figure 15) in the lower reach of Punaluʻu Stream.

The amount of silt observed within the stream bed may reduce habitat quality for native species. There were few places in the study reach where the cobble and boulder substratum was not covered by a thick layer of flocculent material (Figure 16). Continuous, high-gradient streams draining forested watersheds are generally free of benthic fine sediment accumulation in their upper and middle reaches.

The relatively low gradient of the study reach at Punaluʻu lies within an area of sediment accumulation. However, lower reaches of streams of similar gradient draining forested watersheds on other islands lack excessive benthic sediment accumulation. Further research is necessary to identify the source of sediments, rate of accretion, and effectiveness of periodic freshets or controlled releases in purging fine sediments from the stream bed.

Figure 14. Shallow pool in the lower reach of Punaluʻu Stream.

6.4.3.2 Results of Biological Surveys

The existing diversion dam consists of a concrete and rock structure approximately 11.5 m (38 ft) wide (Figure 17). The top of the dam is more or less level in an upstream-downstream direction. The left side of the dam is slightly lower (probably due to damage to the structure) such that at low flows most water passes over that side of the dam. A shallow pool of water is impounded by the dam, and varies in depth with streamflow. The diversion is on the right side of the stream just upstream of the dam. It takes off from the stream at almost 90^{o} to the general flow. There is a grate to reduce movement of debris into the diversion system (Figure 18). The downstream face of the dam slopes downward at about 45^{o} to a concrete sill. This sill is about 2.5 m (8 ft) wide (Figure 19). The downstream face of the sill terminates in a 1.5 m (5 ft) vertical drop with a face consisting of boulders irregularly cemented into the structure. In some places this vertical face is undercut resulting in free falling water, while in others the boulders protrude into the flow providing wetted surfaces for upstream movement of amphidromous species.

The substratum downstream of the dam consisted of large boulders and cobble. The habitat types were pools and riffles passing through the boulders.

Figure 15. Deep pool in the lower reach of Punaluʻu Stream.

Figure 16. Silt covering stream cobbles in lower Punaluʻu Stream.

During the SWCA visits to this area, the entire bottom was covered with fairly thick sediments. These were easily suspended, turning the stream turbid. In locations with slower flow, mats of filamentous algae were abundant. By far, the dominant animals downstream of the dam were green swordtails (*Xiphophorus helleri*). These Poeciliids are live bearers and thus are able to reach large numbers in reaches where they occur. Surprisingly, the usually abundant alien prawn *Macrobrachium lar* was not common below the dam, although some were seen.

The only native species observed in this reach was the indigenous goby ʻoʻopu nākea (*Awaous guamensis*). A few individuals were seen, all quite large with the largest reaching 17.8 to 20.3 cm (7 to 8 inches). While no living hīhīwai (*Neritina vespertina*) were seen below the dam, one freshly dead shell was collected. In general, the habitat below the dam superficially appears suitable for native species in terms of the habitat types, the abundance of boulders, and flow (even at near base flow conditions).

Figure 17. The Punaluʻu diversion dam showing the sloping downstream face.

However, the extensive sediment cover renders much of this area less than ideal for native stream animals. The pool upstream of the dam could serve as a settling basin under low flow conditions, and there is no agriculture upstream of this site. Whether disturbance by pigs in the upper watershed or other activities can be to blame would require further work. This is a problem that must be addressed in any considerations of stream restoration. The nature of pig damage in Koʻolau watersheds and recommendations for their management and control were summarized by Sumiye (2002).

A pool impounded by the dam extends upstream in low flow conditions (Figure 20). The bottom of the pool is mostly fine silt and filamentous algae. *Macrobrachium lar* were seen commonly in this pool by surface observers, but less frequently by snorkelers. This might be attributed to the turbid conditions caused by swimmers re-suspending the sediment. Swordtails were also exceedingly dense upstream of the dam with large populations occurring not only in the pool above the dam, but in riffles immediately upstream of the pool. Electroshocking may be a more reliable means of estimating fish populations in turbid waters.

As noted in the discussion of the DAR data, Punaluʻu Stream, like most Oʻahu streams, is dominated by alien species. The USGS report (Oki et al. 2004) document many of the same native species as DAR noted. Additionally, they recorded some potential problem species. This includes the crayfish *Procambarus clarkii* and some possible piscivorous fish species. The crayfish can damage stream banks by its burrowing activity potentially increasing sedimentation. Of the non-native fishes, carnivory is documented in two; the banded jewel cichlid, *Hemichromis elongatus* and the Chinese catfish, *Clarius fuscus.* They further noted that *H. elongatus* appears to be extending its distribution in Punaluʻu Stream toward higher elevations based on the highest elevation of 22 m (71 ft) for *H. fasciatus* in the DAR database. *Hemichromis elongatus* and *H. fasciatus* are morphologically quite similar.

It is not clear if the *H. fasciatus* reported in the DAR data base from Punaluʻu Stream is distinct from the *H. elongatus* reported by USGS. SWCA biologists also observed many *Hemichromis* in pools along the lower reaches of the stream.

Figure 18. The opening into the diversion system showing the grate.

Figure 19. Showing the drop below the face of the dam.

The USGS study also reported that three of the eight *Hemichromis elongatus* were infected with the parasitic intestinal nematode *Camallanus cotti* (Oki et al. 2006). This parasite has been reported from native stream fishes (Font 1997) and so it must be considered to be a concern for native fish populations in Punalu‘u Stream. The USGS report did not mention the external parasitic leeches (e.g. *Myzobdella lugubris*) that have been reported from freshwater fishes in Hawai‘i (Font 1997). This leech was observed in the neighboring Kaluanui Stream on ‘o‘opu nōpili (Kinzie per. obs.).

SWCA scientists found no native fishes above the dam, but USGS personnel reported ‘o‘opu nākea as well as ‘opae kala‘ole (*Atyoida bisulcata*) in reaches upstream of the dam. An interesting observation made on the July 25, 2008 visit was a large aggregation of dead hīhīwai. Most of the specimens were clean shells, usually with the operculum still attached, but one still had tissue remaining. All appeared to have an ‘upstream shell morph’ (Ford 1979). A single living hīhīwai was found among the empty shells.

Figure 20. Large pool upstream of the dam.

While ‘midden’ of hīhīwai shells are common along stream sides (Ford 1979), these animals, probably caught by rats or birds, typically have the shell damaged. The shells in Punalu‘u stream were all intact and in the water not on the stream bank. It is difficult to envision a natural scenario that might result in this large aggregation of dead shells. One possibility is that someone is transporting snails from other streams to Punalu‘u in an attempt to re-establish populations. This is known to be occurring in other ‘Oahu streams with the source of the snails being Moloka‘i streams. If this is the case in Punalu‘u, the fact that almost all snails were found dead suggests that this may be a futile and costly activity.

At roughly the same elevation as the dam, there are several tributaries mostly along the western side of the valley. SWCA personnel surveyed these small streams (Figure 21). Because they were too small for snorkeling, only net sampling was done. The endemic ‘opae kala‘ole was common in the larger of the two tributaries checked. This small stream ran, for some distance through an old concrete box culvert or ditch remnant. In general, the substratum of these tributaries appeared to be free of fine sediment accumulation. Due to turbid conditions in the lower reaches, SWCA biologists did not conduct snorkeling surveys where the habitat mapping took place. However, observations in shallow water allow some points to be made. First of all, almost the entire lower reach is heavily silted. There are few if any reaches where clean rock surfaces are available. Secondly, as noted by USGS and DAR surveys, this low gradient reach is dominated by alien species. Of particular concern are the banded jewel cichlid (*Hemichromis elongates*), a carnivore that preys on fish, shrimp and insects, and the convict cichlid (*Archocentrus nigrofasciatum*), an aggressive omnivore. In the large pools, high densities of these fish almost certainly prevent migration or development of populations of native species. The convict cichlid was abundant at higher elevations near the ford in reaches characterized by riffles. As noted earlier, DAR suggested *H. elongates* may be extending its distribution upstream. If these carnivorous fishes are indeed moving upstream, it will likely be to the detriment of native species. In addition, tilapia is common in the lower reaches and estuary. Large accumulations of tilapia skeletons were located at a farm between the road and the stream (Figure 22). Whether these fish were caught in prawn traps and discarded, collected for use in fertilizing the crops, or trapped in a drying pool left by receding flood waters, is not known.

Figure 21. Small perennial tributary just above the 4X4 road.

Figure 22. "Midden" of tilapia remains.

Lach and Cowie (1999) studied the spread of non-native apple snails (*Pomacea canaliculata*) on O‘ahu and reported them as being absent from Punalu‘u Stream. However, we found abundant eggs masses of this species throughout the lower reaches of the stream above the estuary (Figure 23). While they are not known to directly harm native stream species, their presence is of concern to taro growers since floods could transport these pests into active lo‘i.

Figure 23. Eggs of apple snails on vegetation along the stream bank.

The riparian vegetation along the lower reaches was almost entirely alien. In many sections of the study reach, the channel was almost blocked by streamside vegetation. Riparian vegetation was largely dominated by California grass (*Brachiara mutica*), honohono grass (*Commelina diffusa*), cane grass (*Pennisetum purpureum*), hau (*Hibiscus tiliaceus*), gunpowder tree (*Trema orientalis*), octopus tree (*Schefflera actinophylla*), and java plum (*Syzygium cumini*). Where the stream banks are close to the road there is some dumping of vegetation into the channel (Figure 24). While probably not a major concern in this reach given the more acute problems, this dumping should be discouraged since it traps sediments and can interrupt flow.

In addition to their survey of stream fauna, USGS (Oki et al. 2004) carried out a study of the possible effect of the water diversion on the availability of habitat for freshwater animals. They began this effort by estimating what stream flow would be at elevations below the diversion if no diversion was occurring, with low-flow partial-record (LFPR) stations. Basically, this technique uses several one-time flow measurements at selected ungaged sites when stream flow is low. These measurements are correlated with gaged flows occurring at the same time. The two gaged sites used were the stream downstream of the intake (16303000) and the combined stream and ditch flow (16303003). The ungaged sites were at elevations of 3, 12, 30.5, and 43 m (10, 40, 100 and 140 ft). They present flow duration curves and tables for these four stations with the existing diverted, flow and estimated undiverted flow.

7.0 Relationships Between Flow and Potential Habitat

A similar comparison just at the diversion can be made by comparing the flow remaining in the stream as gaged by station 16303000 and the total flow (remaining in the stream plus ditch flow station 16303003). Table 3 shows the Q_{50} (median) values for these five elevations. Note that the difference between the diverted flow and what is estimated to be the undiverted flow decreases with decreasing elevation and is 50 percent at the 12 m (40 ft) station.

The gradual decline in the difference between the two values (from 60 to 12 m, or 200 to 40 ft) is probably due to gains in stream flow from groundwater and tributary inputs plus some return from agricultural uses and ditch return flows. The marked drop in the difference between the two values at 3 m (10 ft) is mostly due to return flow from agricultural users.

Figure 24. Palm fronds discarded into lower Punaluʻu Stream.

The USGS study also evaluated the relationship between stream flow and the availability of habitat for the aquatic fauna. The method used was the Physical Habitat Simulation Model (PHABSIM). Annear et al. (2004) characterize PHABSIM as an incremental method. Stalnaker et al. (1995) defined incremental techniques as "site-specific analyses that examine multiple decision variables and enable different flow management alternatives to be explored."

Table 3. Oki et al (2006) Estimated Median flow (Q_{50}) under current diverted conditions, and estimated Q_{50} for undiverted flow at four selected elevations.

Elevation (ft)	Diverted Q_{50} (cfs)	Estimated undiverted Q_{50} (cfs)
10	18	22
40	10	21
100	8.8	20
140	7.7	19
200	7	18

PHABSIM is a set of linked computer models that relate hydraulic habitat features and discharge to individual species and life-history stages of aquatic organisms of interest. It provides inputs to the Instream Flow Incremental Methodology (IFIM) analysis (Bovee et al. 1998). Basically the model uses data from cross-stream transects in representative reaches that describe depth, substratum composition and velocity conditions across the stream. These data are collected at the same sites on days with different flows. The data are then analyzed together in a hydrological simulation to model the depth, substratum and velocity across the stream over a range of discharge conditions and can, if correctly done, be extrapolated to flows outside those actually measured.

The second feature of PHABSIM is a set of curves that define the habitat use in terms of depth and substratum type (other habitat parameters can also be included) over a range of flows. Each species or life-history stage has its own suitability index (i.e. relative habitat suitability versus flow). These are derived from direct observations, preferably in the study area. The habitat suitability curves used by Oki et al. (2006) are derived from Maui streams (Figures C4 to C8 in Gingrich and Wolff (2005)). The habitat suitability indices were be combined with the hydraulic simulations to predict the change in useable habitat for each species or life-history stage, over a range of flows.

The output from PHABSIM is a set of graphs that depict an index: weighted usable area (WUA) for each species or life-stage vs. discharge. The method used in this study is given in Waddle (2001). Annear et al. (2004) discuss the method listing its strengths and assumptions.

Because Punalu‘u is currently diverted, Oki et al (2006) adjusted the PHABSIM outputs to provide WUA area as a percentage of what the WUA would be at median natural discharge (Q_{50} of the estimated undiverted flow at each study elevation). With this adjustment, WUA at a flow equal to what the undiverted flow would by definition equal 100 percent.

For the lower elevations (3, 12, 30.5 m or 10, 40, and 100 ft), Oki et al. (2006) provided WUA curves for ‘o‘opu nākea and hīhīwai. For the reach at 60 m (200 ft), WUA curves for adult and juvenile ‘o‘opu nōpili and ‘opae kala‘ole are presented. In general, the slopes of the curves (increase in WUA with increase in discharge) are steepest at low flows. All their WUA curves start at 0 cfs and increase sharply, beginning to level off at discharges of 5 cfs (3.2 mgd) to 10 cfs (6.5 mgd) at the 3 and 12 m (10 and 40 ft) sites.

The curve for the 30.5 m (100 ft) site increases more gradually and does not reach a maximum value. However, all the WUA curves had to be extrapolated from the lowest flow used in the hydraulic simulation. Oki et al. (2006) did this using a combination of cross section elevation surveys, measured stage discharge relations and adjusted estimated velocities.

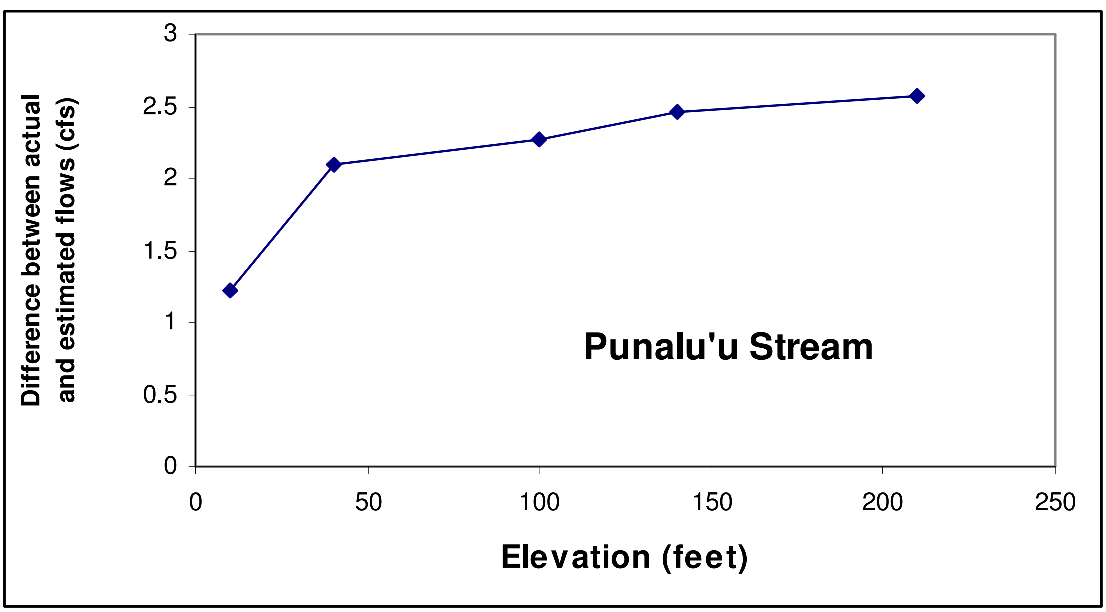


Figure 25. The difference between current diverted flow and the estimated flow in Punalu‘u Stream at five elevations.
Source: Oki et al. (2006).

This method was also employed by Gingerich and Wolff (2005) in East Maui streams. However, without external validation of this extrapolation technique for low velocities, it is unclear how well the low flow lines reflect WUA. Therefore, the most sensitive (steepest slope) parts of the WUA curves are not clearly defined. For the 3 and 12 m (10 and 40 ft) sites, the Q_{50} (under diverted conditions) lies in the region of the WUA vs. discharge curves that are below the lowest measured flow (i.e. in the extrapolated part of the curve). The curve for the 12 m (40 ft) site shows WUA for ʻoʻopu nākea and hīhīwai as being greater under diverted conditions than ʻnatural' flow conditions. This unexpected phenomenon is explained by Oki et al. (2006):

> "If the shape of the relation between WUA and discharge is accurate, reducing streamflow by diverting water from Punaluu Stream may result in a predicated increase in WUA, relative to natural-habitat conditions at a stream altitude of 40 ft, although total habitat will decrease with decreasing streamflow."

For the 30.5 and 60 m (100 and 200 ft) sites the existing Q_{50} lies above the lowest flow Oki et al. (2006) used to construct their curves. At these elevations, WUA at the diverted Q_{50} is 60 to 70 percent of that predicted for the estimated natural median flow. Oki et al. (2006) then produced ʻhabitat-duration curves'. These are similar to flow duration curves in that WUA (or in this case WUA as a percentage of WUA at median undiverted discharge) is plotted against the percentage of time the indicated WUA value is equaled or exceeded.

In this presentation, a WUA_{50} would indicate that half the time the percentage of actual WUA was equal or greater than it would be if the flow were not diverted and that half the time it would be less. It is important to note that they only developed these curves for flows less than or equal to the Q_{50}. In other words, these habitat-duration curves do not take into account flows greater than the median flow.

Oki et al. (2006) use this approach for hīhīwai and ʻoʻopu nākea at 3, 12, and 30.5 m (10, 40 and 100 ft). In their graphs (Figure 26), the highest (blue) and lowest (red) lines represent natural flow conditions and current diverted conditions, respectively (except ʻoʻopu nākea at 12 m, or 40 ft). The two intermediate lines represent hypothetical constant diversions of 5cfs (2.3 mgd) and 10 cfs (6.5 mgd). The median diversion (i.e. Q_{50} ditch flow) is 8.3 cfs over the period of record. Unlike flow in streams, the average ditch flow (8.5 cfs) is quite similar to the median flow. Thus, the actual case lies between these two simulations, but closer to the higher volume as shown by the ʻrecent diverted conditions' trend (1995 – 2004 when mean discharge was 10.8 cfs, or 7 mgd) in some, but not all the graphs. In general as the level of diversion increases from none (blue line) to current levels (red line) the WUA_{50} or any exceedance value declines; the WUA is increasingly a smaller percentage of the undiverted WUA. This implies that under diverted conditions there is less WUA available than in undiverted conditions and the degree of loss is correlated with the amount of water diverted.

A second concern with these curves is raised by the similarity in shape for curves for different species. The habitat duration curves are identical in shape for all five species/life-stages, with only slight offsets on the Y axis. Given the very different ecological roles and habitat requirements for the fishes, the snail and the shrimp, as well as the differences among the habitat suitability curves, this seems counter-intuitive (Payne, personal communication).

The last step in the Oki et al. (2006) analysis of relationships between stream flow and habitat availability is a set of curves showing estimated change in WUA for over a range of constant diversion rates from 0 cfs (undiverted) to about 11 cfs (7.1 mgd) (ʻrecent diverted conditions'), and a similar set of graphs showing the average number of days per year that habitat is less than 50 or 75 percent of the habitat at median natural discharge. These relationships were developed for ʻoʻopu nākea and hīhīwai only. The curves show: 1) an increasing loss of available habitat with increasing diversion rate, and 2) a corresponding increase in number of days per year that available habitat is less than a given percentage of the median available at natural discharge.

Oki et al. (2006) suggest that increasing flow in the channel would increase the available habitat for selected native stream species. The additional habitat for two species - hīhīwai and ʻoʻopu nākea - that would be provided by increased flow is not marked at lower elevations (their 10 and

40 ft sites), except for the 'constant 10 cfs' (6.5 mgd) scenario. At their 100 ft site, the differences are more pronounced. However, as noted above, the 10 to 25 percent projected increase in weighted usable area might not provide more usable habitat if siltation and predation are the prevalent ecological factors limiting native species.

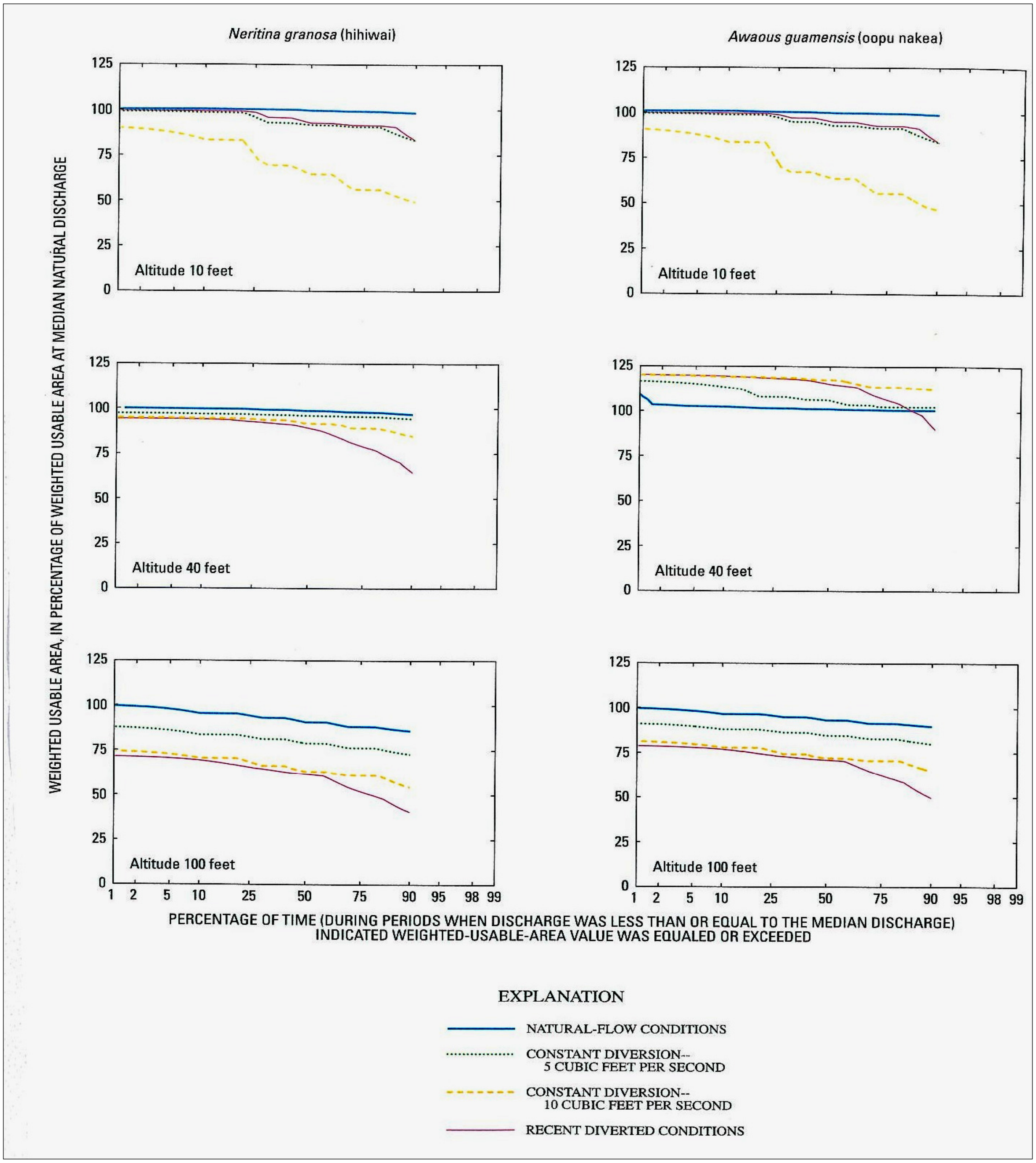


Figure 26. Plots of WUA as a percentage of undiverted WUA vs. percentage of time the indicated WUA is exceeded. ***Source: Oki et al. (2006).***

All the relationships set out in Oki et al. (2006) ultimately stem from the output of the PHABSIM analysis. This in turn depends on the accuracy of the habitat suitability relationships and the validity of the cross-sectional transects used to develop the hydrologic model. Oki et al. (2006)

noted that one of the main limitations in their study is the lack of habitat-suitability criteria specific to Punaluʻu Stream. They also noted that direct measurement of WUA over a wider range of flows would have eliminated their need to extrapolate the curves, especially to lower flows – the ones most likely to be of concern when questions of IIFS arise. For these reasons, the relationships reported between instream flow and available habitat should be verified.
Even if the relationships had been less problematic, they point out that the PHABSIM approach provides no information on the effects of diversion on species densities, reproduction, and recruitment of food availability for any of the species studies. While the PHABSIM modeling exercise does provide some predictions about increased habitat with increased flow, under the existing conditions, the dense populations of carnivorous alien fishes and the heavily silted benthic habitat are also detriments to use of the stream by native species than low flow per se. Factors such as predation, competition and siltation are not addressed in PHABSIM simulations.

8.0 Improving Punaluʻu Stream

8.1 Enhanced Stream Flow

The Punaluʻu ditch was constructed in the 1920s for sugarcane irrigation. Maly and Maly (2005b) reported that some residents felt that stream flow was substantially greater many decades ago even after the stream had been diverted for irrigation. The ditch continues to divert water from Punaluʻu Stream for uses such as cultivation of taro and vegetable crops, ornamental plants, livestock, and aquaculture operations.

The Punaluʻu ditch system consists of open ditches connected by 12 tunnels and one flume; it extends approximately two miles from the intake at an elevation of about 210 feet above mean sea level (msl) to its terminus in Kaluanui Stream Valley at +50 feet msl (Appendix B). When stream flow is very low, all of the water is diverted into the ditch system. As stream flow exceeds the amount being diverted into the ditch intake, water overtops the dam as shown in Figure 13. KS is proposing to reconstruct the diversion for several reasons:

- Accurate estimates of stream flow at the existing intake can only be determined by simultaneously measuring flow in both the ditch and the stream and using the ditch flow information to adjust the stream gauge data. The need to measure at two locations doubles the cost maintaining accurate flow measurements on Punaluʻu Stream. The proposed reconstruction will also relocate the gage to simplify flow measurement.

- The existing configuration causes the ditch system to capture most or all of the stream flow during very low flow conditions. While this design maximizes delivery of water for out-of-stream uses, it adversely affects habitat used by native aquatic fauna.

- The existing screen is prone to clogging with floating debris such as leaves. Because of this, the intake must be manually cleaned frequently to maintain ditch flows, and the cost of this adversely affects the economics of the irrigation system.

- Adjusting the amount of water that enters the ditch system can only be done manually. This adds to the cost of operation and leads to a greater volume of water being diverted than is needed with automatic controls.

Between the multiple survey results available from DAR, NAWQA studies, and the recent USGS studies in Punaluʻu Stream as well as the SWCA surveys, we believe there is sufficient biological information available to develop recommendations for improving the stream ecosystem. Amending the IIFS in concert with the design of the new diversion structure created by ITC (2008) will benefit aquatic life by: 1) allowing a base flow to remain in the stream below the dam during low flow periods; 2) returning all flow to the stream below the dam in the early hours of the evening to facilitate downstream drift of larvae; and, 3) providing constant upstream passage to allow post-larvae and juveniles to venture upstream safely past the intake.

The new diversion structure will consist of 19-foot wide section on the right bank of the stream (i.e., the side on which the USGS stream gauge is located) with a top elevation of +213.87' msl;

a 1.5-foot wide section against the left bank will also be at this elevation (Figure 26). Because the capacity of the new pipe to be installed is less than the original ditch, less water will be diverted at the dam and more water will flow downstream during base flow conditions. In fact, even at low flow, the pipe will only convey 50 percent of that the ditch takes. Water will flow over the remainder of the weir when streamflow exceeds the capacity of the lower part of the weir. During periods of lower flow, all of the water in the stream will pass through these two parts of the channel to allow upstream migration of post-larval native gobies and shrimp. The apex of the weir for the 'fish ladders' will be +213.47' msl (Nance 2009). The proposed intake structure will be a stainless steel screen with 1/8-inch wide bars spaced with 1/16-inch openings sloping downward at a 2 percent grade in the direction of stream flow. This design is relatively self cleaning as debris build-up is flushed off the sloping screen by stream flow.

Nance (2009) estimated that over a typical discharge rate of 15.5 cfs (10 mgd) to 23.2 cfs (15 mgd), about 20 percent of the flow would continue downstream below the dam (Figure 28). The proposed inlet box for the new pipe will establish the head for the new structure; and the dam would not overflow until surface water elevation of the pool reaches 212.67 ft.

A change in the timing of releases might have a significant impact, particularly on the downstream movement of newly hatched larvae (Lindstrom 1998). Since most downstream drift of goby larvae takes place in the 2 to 3 hours following sunset, flow over the dam at this time is the most important. The new system is designed with an automated shut-off valve that will completely close the intake for 3 hours each day beginning 30 minutes after sunset. This will permit the unrestricted downstream migration of larval gobies and shrimp (Lindstrom 1998 and McRae 2007), and facilitate upstream migration and habitat for adult fishes, crustaceans, and mollusks below the dam. This will be achieved by a solar powered valve located downstream of the intake that will be programmed with an astronomical clock to adjust its operation daily. Other improvements to the structure include adding grouted rubble "ramps" downstream of the existing structure adjacent to the stream banks to aid the upstream migration of post-larvae past the structure.

The system is designed such that in a "worst case" (i.e. extremely low flow) situation, no more than 80 percent of the water will be diverted; approximately 20 percent will always continue to flow downstream through the two low flow channels in the structure (Nance 2009). For example, for a Q_{90} low flow of approximately 12 cfs (7.8 mgd) (Oki et al. 2006, Figure 21), 9.6 cfs (6.2 mgd) would be diverted and 2.4 cfs (1.6 mgd) would flow downstream during the daylight hours. All 12 cfs (7.8 mgd) would flow downstream for three hours after sunset each day. As streamflow increases above its base flow amount, a decreasing percentage of the flow will be diverted so that by the time it reaches the median flow rate, only 5 percent of the water will be diverted and 95 percent will remain in the stream. Because the dam is overtopped most of the time under existing conditions and additional flow is provided by undiverted tributaries, SWCA believes that enhanced flows allowed by new intake structure will significantly improve both upstream and downstream migration of native amphidromous species.

The reconstructed diversion structure that is proposed has roughly the same size, density, footprint, and function of the existing one. It will not adversely affect the physical environment of the stream. Instead, it will improve habitat for aquatic species by (i) increasing the flow in Punaluʻu stream over present conditions during critical low-flow periods; (ii) providing surfaces and passages that facilitate the upstream and downstream movement of aquatic species; and (iii) allowing all flow to remain in the stream during hours when aquatic species are most active. It will also enhance the ditch system's ability to serve downstream water users by reducing the potential for debris to block the intake, a functional improvement that is likely to extend its useful service life. Finally, the new diversion will simplify the USGS' stream data collection process by allowing it to abandon the extra gauge that it must now maintain on the ditch.

These improvements have been endorsed by the Department of Land and Natural Resources Division of Aquatic Resources (DAR Letter dated June 27, 2008). The IIFM recommendations are consistent with Ford (2006 and 2007) and with the intent of HRS Chapter 174C. The ongoing tunnel/ditch improvement being done by Kamehameha Schools will reduce water loss from the ditch system. This will allow more efficient use of the water, reducing to some extent the amount that needs to be diverted while providing farmers on both leased lands and private lands a more dependable water source.

8.2 Fisheries

Investigation of fisheries within Punalu'u Valley was not addressed in the scope of work for this study. However, a review of historic information (Handy and Handy 1972, Maly and Maly 2005b) reveals that at least prior to 1980, the stream, estuary, and nearshore waters provided a source of subsistence and recreational fishing for valley residents. Throughout O'ahu, once plentiful 'o'opu, 'opae, and hīhīwai do not appear to be as abundant as reported several decades ago (Titcomb 1972; Brasher et al 2004). The natural pattern of seasonal of rainfall, freshets, and the opening and closing of stream mouths with sand and rock berms as described by Handy and Handy (1972) persists today. However, the numbers of āholehole, 'ama 'ama, and 'o'opu once witnessed in Punalu'u Stream and estuary have declined markedly.

The causes of these declines are not a result of factors within Punalu'u Valley or stream alone. It is the result of multiple factors affecting populations of these species throughout the Hawaiian Archipelago, including water pollution, habitat loss, fishing pressure, invasive species and disease, reduction in stream flow, and stream channelization (Maciolek 1975, Timbol and Maciolek 1978, Norton et al 1978, Maciolek 1984, Devick 1991, Brasher and Anthony 2000, Anthony et al 2004).

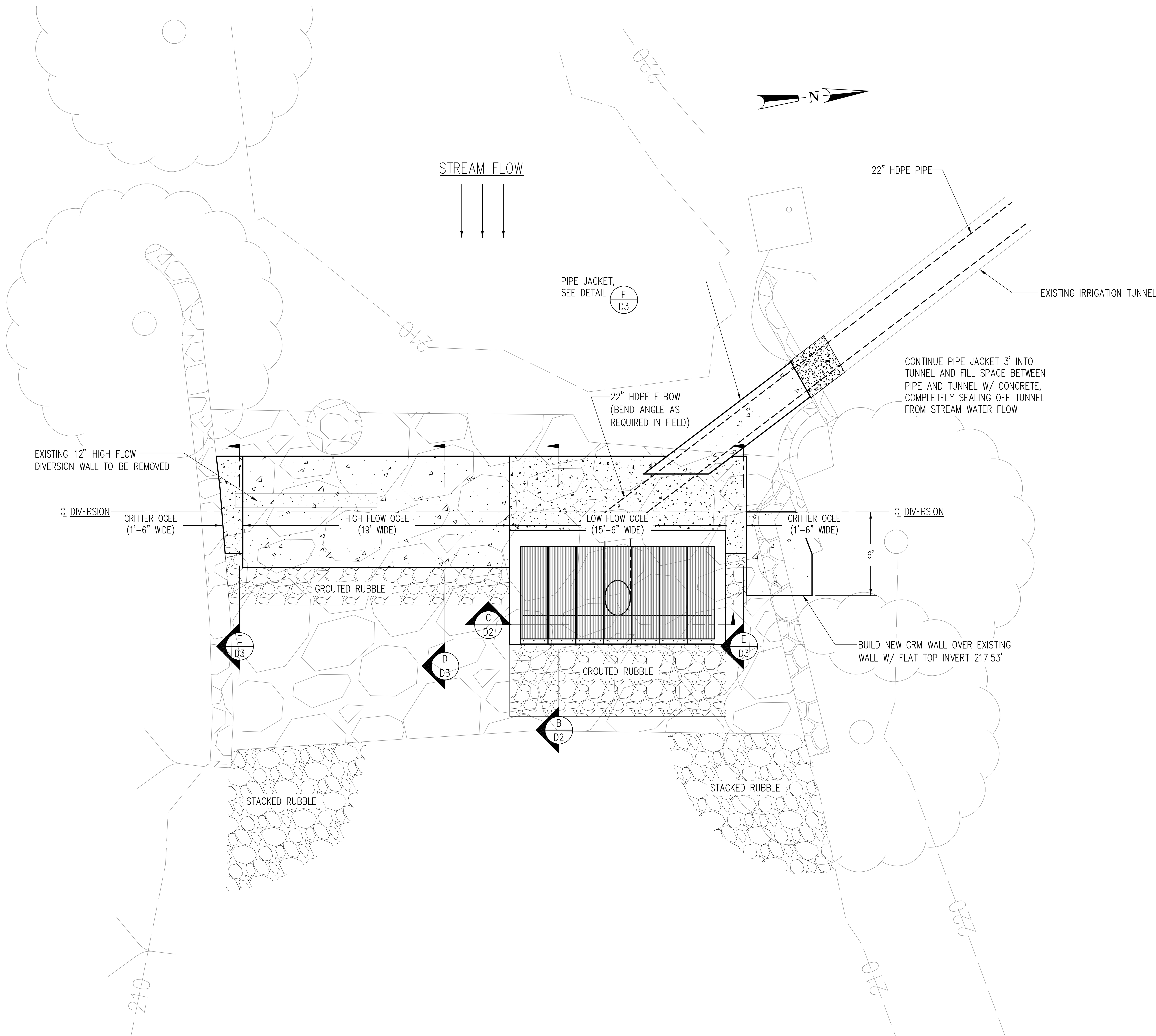
It has been difficult to determine which of these and other detrimental impacts are having the greatest negative impact on populations of fisheries. In fact it is unlikely that even for a single stream system one factor alone will be responsible for any decline in abundance of native species. Further, on every stream, there is probably a different set of pressures, all of which are likely to have a synergistic impact on amphidromous species statewide. These changes not only act in different ways for different species at different times, but more importantly they may all act in concert both locally (e.g. elevated temperatures, reduced water quality in a reach) and regionally (e.g. reduced production of larvae statewide).

Thus, the potential success of any steps taken in hopes of ultimately restoring a fishery within Punalu'u Stream, estuary, and nearshore waters cannot be predicted. Even the return of flow to the stream through the enactment of amended interim instream flow standards (IIFS) should not lead to false expectations for a dramatic return of native aquatic life to the stream, especially in the short term. Returning water to a stream has measurable costs to off-stream users and if these costs are to be justified, some demonstrable instream benefits must be documented following flow restoration.

8.3 Alien Species

Like many O'ahu streams, Punalu'u is dominated by alien species. While some of these, such as the apple snail, are probably not directly impacting native stream species, the high densities of cichlids and poeciliids can cause several problems. Apple snails are known to be a pest to taro farmers. Apple snails were not reported from Punalu'u Stream by DAR (2008); however, SWCA biologists observed numerous egg cases in submerged grass stems along the lower stream reaches (Figure 21). It has been demonstrated that alien freshwater fishes carry parasites that are now known to infect native fishes (Font and Tate 1994).

No inventory of fish parasites has been conducted in Punalu'u Stream for either alien or native species. This should be conducted as soon as practical. Of perhaps more direct concern is the presence of dense populations of predaceous cichlids and omnivorous poeciliids. With no estimates of actual densities or diet, it is impossible to evaluate this threat. SWCA recommends that research into the densities and distribution as well as the diets of invasive cichlids and poeciliid (guppies and swordtails) be undertaken within Punalu'u Stream. These studies should have the goal of developing methods to reduce their numbers.



DIVERSION IMPROVEMENT DETAIL, PLAN VIEW (A / D1)

SCALE: 1" = 4'-0"

GENERAL NOTES

1. WATER
   - A. STREAM FLOW MUST CONTINUE DOWNSTREAM PAST CONSTRUCTION SITE AT ALL TIMES. UNDER NO CIRCUMSTANCES MAY STREAM FLOW BE INTERRUPTED BY THE CONTRACTOR.
   - B. DIVERSION STREAM FLOW MUST CONTINUE THROUGH EXISTING IRRIGATION TUNNEL AND DITCH SYSTEM DURING CONSTRUCTION. CONTRACTOR MAY SCHEDULE WITH OWNER'S REPRESENTATIVE INTERRUPTION IN FLOW TO THE EXISTING IRRIGATION TUNNEL AND DITCH SYSTEM AT OWNER'S DISCRECTION.
   - C. CONTRACTOR SHALL PROVIDE MEASURES TO MINIMIZE IMPACT ON THE STREAM'S AQUATIC ANIMALS, HABITAT AND BEHAVIORS DEEMED NECESSARY BY THE OWNER'S REPRESENTATIVE.
2. CONSTRUCTION
   - A. CONTRACTOR SHALL VERIFY SITE CONDITIONS AS EXISTING CONDITIONS MAY DIFFER FROM THESE PLANS.
   - B. UNLESS OTHERWISE NOTED, ALL EXPOSED CONCRETE EDGES SHALL BE CHAMFERED ¾" X ¾".
   - C. CONTRACTOR SHALL VERIFY ELEVATIONS BEFORE FABRICATING REINFORCING.
3. CONCRETE
   - A. STRENGTH: WALLS, SLABS & FOUNDATIONS 2500 PSI @ 28 DAYS.
   - B. EXISTING SURFACE OF DIVERSION SHALL BE COMPLETELY CLEANED OF ANY LOOSE OR DAMAGED MATERIAL INCLUDING MOSS AND ALGAE.
   - C. AN APPROVED BONDING AGENT (PRIMER) SHALL BE USED ON THE CLEANED SURFACE OF THE EXISTING DIVERSION PRIOR TO CONCRETE POUR.
   - D. NEW SURFACE OF CONCRETE OGEE SHALL BE ROUGHENED. CONTRACTOR SHALL PROVIDE A SAMPLE TO THE OWNER'S REPRESENTATIVE OR OTHER OFFICIALS FOR APPROVAL.

9. REINFORCING
   - A. ALL REINFORCING SHALL BE ASTM A615 GRADE 60, EPOXY COATED.
   - B. MINIMUM COVER:
     - CAST AGAINST AND PERMANENTLY EXPOSED TO EARTH: 3"
     - ALL OTHERS UNLESS OTHERWISE NOTED: 2"

REVISION	DATE	BRIEF	MADE BY	APPROVED

ITC Water Management, Inc.
P.O. BOX 458 / 66079 KAMEHAMEHA HWY., HALEIWA, HI, 96712

PREPARED FOR: KAMEHAMEHA SCHOOLS

PROJECT: PUNALU'U DIVERSION & DITCH SYSTEM IMPROVEMENTS
PUNALU'U, OAHU, HAWAII

IMPROVEMENT DETAILS

DESIGNED BY GDP DRAWN BY GDP CHECKED BY

THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION AND CONSTRUCTION OF THIS PROJECT WILL BE UNDER MY OBSERVATION

SIGNATURE DATE

0 1 2
LINE IS 2 INCHES AT FULL SIZE
(If NOT 2-inches : Scale Accordingly)

DWG. NO. D1
SHEET OF .

FILE	POCKET	FOLDER	NO.

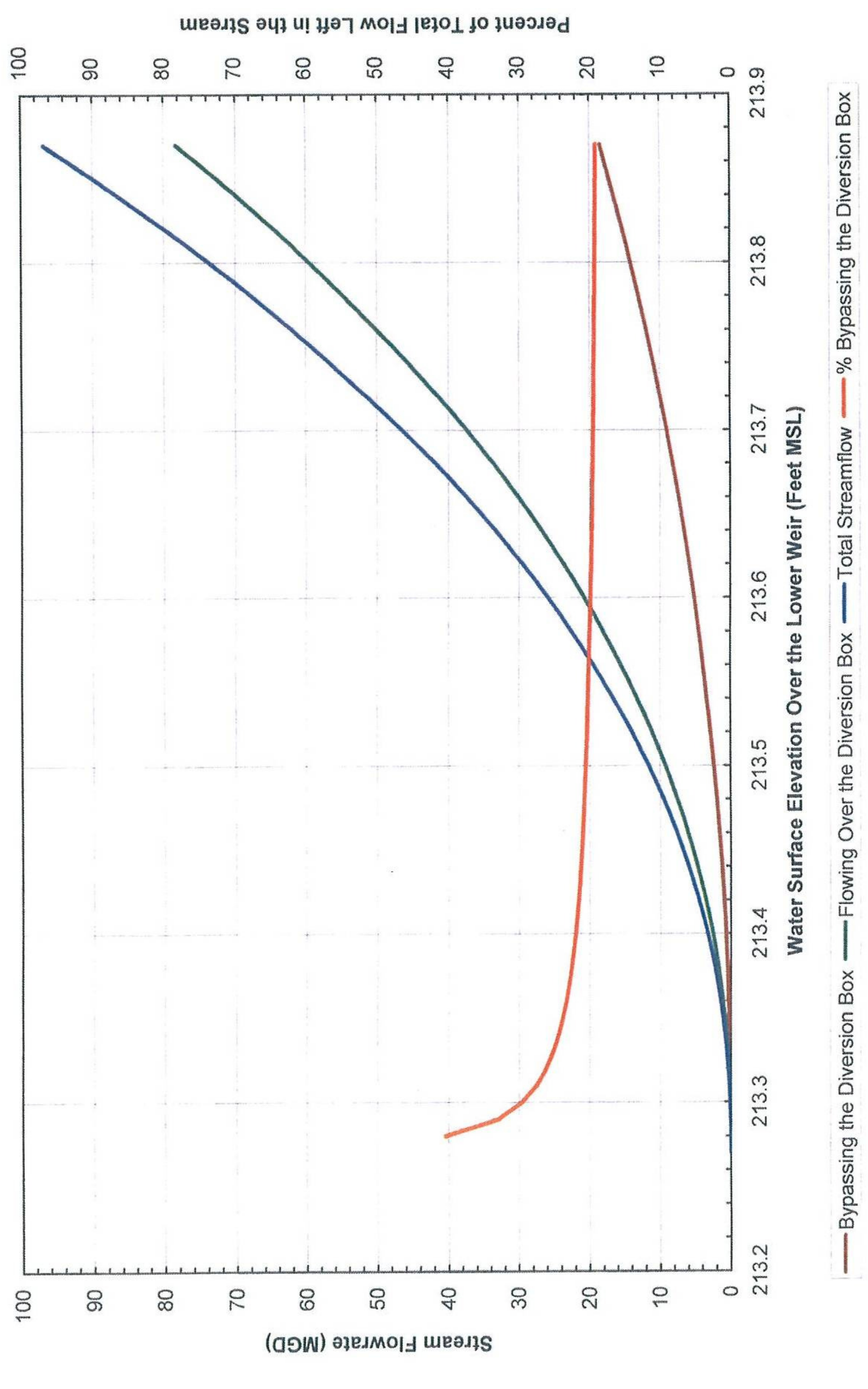


Figure 28. Distribution of Flow Over the New Punalu'u Weir (Source: Nance 2009, Figure 3).

8.4 Sedimentation

Soil erosion caused by unpaved roads, cut banks, and eroded slopes and subsequent disturbance of stream habitat and biological processes is a common problem worldwide (summarized in Ziegler, et al. 2006). Brasher et al. (2004) found silt was present at only 30 percent of their instream habitat measurement locations above the diversion on Punaluʻu Stream, compared to 94 percent of the locations sampled downstream of the diversion.

Our qualitative assessment of siltation in the upper stream reaches led us believe that there are significant accumulations of silt in the reaches immediately above the diversion as well as below. Fine sediment accumulation is a major concern. While Brasher et al. (2004) identified the Punaluʻu watershed as being 100 percent forested, agricultural activities, access roads, and unchecked feral pig foraging might be contributing sediments to lower reaches of the stream. SWCA did not conduct any work specifically related to feral pigs so the extent of their range and the intensity of their activity were not assessed. However, Maly and Maly (2005b) interviewed residents of the valley who claimed that there are many pigs in the upper valley.

Another possible source of sediments might by alien crayfish (*Procambarus clarkii*) that create burrows in muddy stream banks. This should be a research priority for management planning. If the recommendation for increased discharges during evening hours is accepted, it will be important to determine if this regular increase in discharge improves the sedimentation situation. This can be accomplished by a before-and-after study of benthic sediments at various locations along the stream. How conditions change after high flow events should also be studied.

We recommend that a comprehensive review of road grading and farm drainage in the lower reaches, as well as feral ungulate activity in the upper portion of the watershed be evaluated. Best management practices including buffers of native vegetation, erosion control blankets, silt fences, and improved drainage should be applied where appropriate.

8.5 Estuary and Nearshore Environment

Much of the lower reaches where the stream and estuary pass through the agricultural areas is very heavily shaded. Additionally, grasses and other herbaceous vegetation encroach on the stream margins reducing the area available for native stream species. Some attention should be given to the possibility of reducing the canopy of thirsty non-native shade trees (e.g. java plum, eucalyptus, ironwood, and others). This might increase instream primary and secondary production and streamflow to the benefit of native ʻoʻopu (Keith 2003). Dumping of vegetative debris and waste anywhere in the stream should be halted to prevent blockage of flood waters and increases to biochemical oxygen demand in deep pools.

8.6 Biological Monitoring Recommendations and Adaptive Management

It is important therefore to ensure that long-term hydrologic and biological monitoring studies be conducted to document the response of the aquatic community to flow enhancement and related mitigation measures (SWCA 2004, 2006, 2007).

A precedent for monitoring in support of an adaptive management approach has been made by the Commission on Water Resources Management (CWRM) through their assignment of amended interim instream flow standards (IIFS) for five East Maui streams (summarized in CWRM 2008). Despite this advance, no long-term biological monitoring studies have yet been initiated on any stream in the state. However, augmenting stream flow, addressing the problems that cause habitat siltation, and related mitigation measures discussed in this report are positive steps that may offer some improvement in the overall health of Punaluʻu Stream, estuary, and bay. Only monitoring of instream conditions after changes in flow regime will inform managers whether the flow alterations are effective. This is the core of adaptive management.

SWCA recommends that scientifically-based biological monitoring studies be conducted to evaluate the efficacy of the recommendations as implemented in Punaluʻu Stream. Monitoring populations of native Hawaiian stream animals should be an iterative process where existing data and expert opinions can be employed to refine population models and remedial flow releases. The studies can then be used to define which demographic parameters should be monitored, and allow for testing, validation, and, if necessary, modification of model assumptions to provide the most sensitive and realistic measure of population health.

Studying the impact of new flow release schedules and the physical improvements to the diversion structure on stream fauna will allow for an adaptive management approach to improve our management of native aquatic resources, not only in Punaluʽu Stream, but statewide. Adjustments to the IIFS can be made as deemed appropriate to the mutual benefit of the resources, Kamehameha Schools, and the public. It is very important that sufficient lead time be given to initiate studies ***prior to*** the release of supplemental flows in order to establish a baseline from which changes in the patterns of abundance and distribution of aquatic species can be evaluated.

SWCA (2006) provided an overview of research methods, sampling techniques, and study protocols applied in Hawaiian streams. The KS stream study protocol applied in Punaluʽu should recognize the entire watershed as well as the stream itself, be particularly sensitive to traditional and customary Hawaiian practices and the existing land and water uses, and incorporate relevant elements and techniques used in several protocols, including those currently being applied in KS streams on Oʽahu and Hawaiʽi Islands. The protocol should recognize limitations of budget and time, be of value for land and water resource management decision support, address both instream and off-stream water uses, and involve KS students to the maximum extent possible throughout design and execution of the field studies. At a minimum, the monitoring studies should address:

- Long-term population trend assessments for amphidromous species
- The rate and sequence of population recovery following flow restoration
- Dispersal and impacts of alien species in KS streams

Additional studies addressing the following questions would also be valuable:

- Validation of the PHABSIM habitat availability model developed by USGS (Oki et al. 2006)
- The role of ditches on larvae and as migratory pathways between watersheds and as sinks of reproductive input
- The effects of the new flow regime on benthic sedimentation
- Use of taro lo'i by native amphidromous species

Additionally, population and diet assessments of the carnivorous cichlids would be useful, as well as a determination of parasite loads in native and alien species. Discussions with DAR staff about possible methods for reducing the populations of these fishes, or at least prevent the apparent upstream range spread should be initiated. Furthermore, land managers should implement estimates of feral ungulate density in the upper watershed to ascertain if this might be the source of the high sediment loads in Punaluʽu Stream.

8.7 Summary of Recommendations

- 100 percent of natural flow will be released over the new dam for three hours every day, 365 days/year, beginning one half-hour after sunset. Release will be automatically controlled by a solar-powered valve calibrated with an astronomical clock at the downstream end of the new pipe.

- Roughly nine percent additional low flow will be available continuously, flowing through the two low flow channels in the new impoundment structure, designed to facilitate upstream migration of post-larval and juvenile amphidromous species.

- Because the head will be controlled by the level of the new intake box instead of the impoundment itself, it is difficult to compare pre- and post-construction flows. Therefore, a post-construction flow exceedance curve should be developed to compare actual flow regime against predicted flows.

- Long-term biological monitoring will be conducted above, at, and below the new impoundment to evaluate the efficacy of the proposed improvements and amended IIFS in allowing downstream larval drift and upstream post-larval and juvenile migration. Research protocols for the monitoring study should be reviewed and approved by KS and the resource agencies. Continuous monitoring is recommended for a minimum period of five years.

- A comprehensive review of road grading and farm drainage, as well as feral ungulate activity in the upper portion of the watershed should be conducted. Best management practices including vegetative buffers, erosion control blankets, silt fences, and improved road grading and drainage should be applied where appropriate.

- A before-and-after construction assessment of sedimentation in the stream should be conducted to quantify the problem and identify sources of excessive siltation.

- USGS should be encouraged to attempt *in situ* validation of its habitat suitability models for native amphidromous species.

- Attention should be given to the possibility of reducing the canopy of thirsty non-native shade trees over the lower reaches to some extent. This might increase instream primary and secondary production and streamflow to the benefit of native o'opu (Keith 2003).

- Dumping of vegetative debris and waste into the stream should be halted.

9.0 Literature Cited

AECOS, Inc. 1979. Oahu Coral Reef Inventory. Part B. Sectional Map Descriptions. Prepared for US Army Corps of Engineers, Pacific Ocean Division. AECOS No. ECI-149: 552 pp.

AECOS, Inc. 2002. Reconnaissance survey of aquatic biota and riparian vegetation for Kamehameha Highway bridge replacement at Punalu'u, Windward Oahu. Prepared for Sea Engineering, Inc. AECOS No. 1011, 8 pp.

Annear, T.I, C.H. Beecher, A. Locke, and 12 other authors. 2004. Instream flows for stewardship, revised edition. Instream Flow Council, Cheyenne WY.

ANON 1954. Hawaii's Shoreline. No publication information given produced for the Urban Planning Assistance Program (sect 710 of the Housing Act id 1954).

Anthony, S.S. C.D. Hunt, Jr., A.M.D. Brasher, L.D. Miller, and M.S. Tomlinson. 2004, Water quality on the island of Oahu, Hawaii, 1999-2001: U.S. Geological Survey Circular 1239, 31 p.

Athens, J.S. H.D. Tuggle, J.V. Ward and D. J. Welch. 2002. Avifaunal extinctions, vegetation change and Polynesian impacts in Prehistoric Hawai'i. Archaeol. Oceania 37: 57-78.

Balder, A. P. 1992. Marine Atlas of the Hawaiian Islands. Univ. Hawaii Press.

Benson, L.K. 2002. Aspects of the behavioral ecology, life history, genetics, and morphology of the Hawaiian kuhliid fishes. PhD. Dissertation Louisiana State University.

Bovee, K.D., B.L. Lamb, J.M. Bartholow, C.B. Stalnaker, J. Taylor, and J. Henriksen. 1998. Stream habitat analysis using the instream flow incremental methodology. U.S. Geological Survey, Biological Resources Division Information and Technology Report USGS/BRD-1998-0004. viii + 131 pp.

Brasher, A.M. and Anthony, S.S., 2000, Occurrence of Organochlorine Pesticides in Stream Bed Sediment and Fish From Selected Streams on the Island of O'ahu, Hawai'i, 1998: U.S. Geological Survey, Fact Sheet 140-00, 6 p.

Brasher, A.M.D., R.H Wolff and C.D. Luton. 2004. Associations among land-use, habitat characteristics, and invertebrate community structure in nine streams on the island of O'ahu, Hawai'i: U.S. Geological Survey Water-Resources Investigations Report 03-4256, 47p.
Burney, D.A., H.F. James, L Pigott- Burney, S.L. Olson, W. Kikuchi, W.L. Wagner, M. Burney, D. McCloskey, D. Kikuchi, F.V. Grady, R. Gage II, and R. Nishek. 2001. Fossil evidence for a diverse biota from Kaua'i. Ecol. Monog. 71: 615-641.

CWRM 2008. Report to the Twenty-fifth Legislature 2009 Regular Session on Identification of Rivers and Streams Worthy of Protection. Prepared by the Commission on Water Resources Management, DLNR. http://hawaii.gov/dlnr/cwrm/reportstolegislature/CW2009_IDofRivers.pdf

Cuddihy, L.W. and C.P. Stone. 1990. Alteration of native Hawaiian vegetation-effects of humans, their activities and introductions. Cooperative National Park Resources Studies Unit University of Hawai'i at Manoa, Honolulu, HI, 138 pages.

D.A. Clague, J.G. Moore, and A.S. Davis (2002) Volcanic breccia and hyaloclastite in blocks from the Nu'uanu and Wailau landslides, Hawai'i, In: *Hawaiian Volcanoes: Deep Underwater Perspectives*, E. Takahashi, P.W. Lipman, M.O. Garcia, J. Naka, and S. Aramaki (eds), *Geophysical Monograph 128*, American Geophysical Union, 279-296.

Dalrymple, T. 1960. Flood frequency analysis. IN: Manual of Hydrology: Part 3 Flood-Flow Techniques. USGS Water-Supply Paper 1543A

Devick, W.S. 1991. Patterns of introduction of aquatic organisms to Hawaiian freshwater habitats. In: W.S. Devick (Editor), *New Directions in Research, Management, and Conservation of Hawaiian Freshwater Stream Ecosystems*. Department of Land and Natural Resources, Honolulu, 318pp.

Devick, W.S. Personal communication. State of Hawai'i Department of Land and Natural Resources, Division of Aquatic Resources.

Division of Aquatic Resources (DAR), Hawai'i Department of Land and Natural Resources. Freshwater Database. Available at: http://www.state.hi.us/dlnr/dar/streams/stream_data.htm.

Division of Aquatic Resources (DAR), Hawai'i Department of Land and Natural Resources. 2008. Hawaiian Watershed Atlas. Available at: http://www.hawaiiwatershedatlas.com/.

Ego, K. 1956. Life history of freshwater gobies. Project Number 4-4-R, freshwater game fish management research, Department of Land and Natural Resources, Honolulu, HI, USA 23pp.

Englund, R.A., K. Arakaki, D.J. Preston, N.L. Evenhuis, and M.K.K. McShane. 2003. Systematic inventory of rare and alien aquatic species in selected O'ahu, Maui, and Hawai'i island streams. Contribution No. 03-017 to the Hawai'i Biological Survey.

ENPRO™ Environmental. 2008. Water Quality Assessment of Punaluu Stream. ENPRO Project # 804-00091-OTH. Prepared for Kamehameha Schools.

Fitzsimons, J.M., J.E. Parham, L. K. Benson, M. G. McRae, and R.T. Nishimoto. 2005. Biological Assessment of Kahana Stream, Island of O'ahu, Hawai'i: An Application of PABITRA Survey Methods. Pacific Science 59 (2): 273–281.

Font, W. F. 1997. Distribution of helminth parasites of native and introduced stream fishes in Hawai'i. Bishop Museum Occasional Papers 49: 56-62.

Font, W.F and D.C. Tate. 1994. Helminth parasites of native Hawaiian freshwater fishes: an example of extreme ecological isolation. J Parasitol 80:682-688.

Ford, J.I. 2006a. Ecological connectivity and instream flow standards for Hawaiian streams. Paper presented at the 21st Pacific Science Congress, Okinawa, Japan.

Ford, J. I. 2006b. A summary of Kamehameha Schools Stream Resources. 54pp.

Ford, J.I. and R.A. Kinzie III. 1982. Life crawls upstream. Natural History 91(12): 51-66.

Ford, J.I. 1979. Biology of a Hawaiian fluvial gastropod *Neritina granosa* Sowerby (Prosobranchia: Neritidae). M.S. Thesis in Zoology, University of Hawai'i, Honolulu. 94pp

Franco, R.W. 1995. Water: Its meaning and management in pre-contact Hawaii. Water Resources Research Center Project Report PR-96-02, University of Hawaii at Manoa, Honolulu. 76pp.

Gingerich, S.B. and R.H. Wolff. 2005. Effects of Surface–Water Diversion on Habitat Availability for Native Macrofauna, Northeast Maui, Hawai'i. Honolulu, HI, U.S. Geological Survey, Scientific Investigations Report 2005-5213. 93 pp.

Gordon, N.D., T.A. McMahon, and B.L. Finlayson. 1992. Stream Hydrology. John Wiley & Sons New York. 526 pp.

Group 70. 2006. Ko'olau Loa Watershed Management Plan, Public Review Draft. Prepared for Honolulu Board of Water Supply.

Ha, P.Y. and R.A. Kinzie III. 1996. Reproductive biology of *Awaous guamensis*, an amphidromous Hawaiian goby. Environmental Biology of Fishes 45: 383-396.

Handy, E.S.C and E.G. Handy. 1991. Native Planters in Old Hawai'i: Their Life, Lore, and Environment. Bernice P. Bishop Museum Bulletin 233. Bishop Museum Press, Honolulu. 675 pp.

Harney, J.N., Grossman, E.E., Richmond, B.M., and Fletcher, C.H. (2000) Age and composition of carbonate shore face sediments, Kailua Bay, Oahu, Hawaii: Coral Reefs, v. 19, pg. 141-154.

Hawai'i Cooperative National Park Studies Unit. 1990. Hawai'i Stream Assessment: A Preliminary Appraisal of Hawai'i Stream Resources. Report R84. Prepared for the Commission of Water Resources Management. Honolulu, Hawai'i. 294 pp.

Higashi, G. R., and M. N. Yamamoto. 1993. Rediscovery of "extinct" *Lentipes concolor* on the island of O'ahu, Hawai'i. Pacific Science 47:115-117.

Hoover, D.J. 2002. Fluvial nitrogen and phosphorus in Hawaii: storm runoff, land use, and impacts on coastal waters. Ph.D. dissertation in Oceanography, University of Hawaii at Manoa, Honolulu. 437pp.

Hunt Jr., C. D. 2004. Ground-water quality and its relation t land use on Poahu, Hawai'i, 2000-2001. U.S. Geological Survey Water-Resources Investigations Report 03-4305.

ITC 2008. Comparison of Conveyance Capacities of the Diversion from Punalu'u Stream. Engineering Report provided to Kamehameha Schools.

Keith, P. 2003. Biology and ecology of amphidromous Gobiidae of the Indo-Pacific and the Caribbean regions. Journal of Fish Biology 63: 831-847

Kido, M.H. 1997. Food webs and feeding dynamics of coexisting native Hawaiian stream gobies. Micronesica 30(1): 71-82.

Kido, M.H. 2002. The Hawai'i Stream Bioassessment Protocol: Version 3.01, University of Hawai'i: Hawai'i Stream Research Center.

Kinzie III, R. A. 1997. Evolution and life history patterns in freshwater gobies. Micronesica 30: 27-40.

Kinzie III, R.A. 1988. Habitat utilization by Hawaiian stream fishes with reference to community structure in oceanic island streams. Environmental Biology of Fishes 22:179-192.

Kinzie III, R.A. and J.I. Ford. 1982. Population biology in small Hawaiian streams. Water Resources Research Center Cooperative Report No. 147, Hawaiʻi Cooperative Fishery Research Unit, No. A-080-HI. 60 pp.

Kinzie III, R.A., C. Chong, J. Devrell, D. Lindstrom, and R. Wolff. 2006. Effects of water removal on a Hawaiian stream ecosystem. Pacific Science 60 (1): 1-47.

Kirch, P.V. 1982. The impact of the prehistoric Polynesians on the Hawaiian ecosystem. Pacific Science 36: 1-14.

Kirch, P.V. 2000. On the Road of the Winds: An archaeological History of the Pacific Islands Before European Contact. Univ. Calif. Press, Berkeley.

Lach, L. and R.H. Cowie. 1999. The spread of the introduced freshwater apple snail *Pomacea canaliculata* (Lamarck) (Gastropoda: Ampullariidae) on Oʻahu, Hawaiʻi. Bishop Museum Occ. Pap. 58:66-71.

Lau, L.S. and J.F. Mink. 2006. Hydrology of the Hawaiian Islands. University of Hawaiʻi Press, Honolulu. 274 pp.

Lindstrom, D.B. 1998. Complete watershed reproductive patterns for amphidromous Hawaiian gobioids. University of Hawaiʻi, Department of Zoology Doctoral Thesis, Publication No. 3, pp.62-103

Maciolek, J.A. 1975. West Maui Streams: an example of socio-economic impact on a natural resource. Unpublished manuscript of the Hawaii Cooperative Fishery Resource Unit, University of Hawaii at Manoa, Honolulu, HI.

Maciolek, J.A. 1984. Exotic fishes in Hawaii and other islands of Oceania. In: W.R. Courtnay Jr. and J.R. Stauffer Jr. (Editors), *Distribution, Biology, and Management of Exotic Fishes*. Johns Hopkins University Press, Baltimore, MD, pp. 131-161.

Maly, K. and O. Maly. 2003. "Hana ka lima, ʻai ka waha": A collection of historical accounts and oral history interviews with kamaʻaina residents and fisher-people of lands in the Hanalei-Na Pali region of the Island of Kauaʻi. Contract report prepared for The Nature Conservancy of Hawai'i and the Pacific Tropical Botanical Gardens (Limahuli Gardens), 585 pp.

Maly, K. and O. Maly. 2005a. A collection of traditions, historical accounts and kamaʻaina recollections of Punaluʻu and vicinity, Koʻolauloa, Island of Oʻahu. Report prepared for Kamehameha Schools. KPA No. OaPuna91 (b) 072905. 299 pp.

Maly, K. and O. Maly. 2005b. A collection of kamaʻaina recollections in oral history interviews of Punaluʻu and vicinity, Koʻolauloa, Island of Oʻahu. A report prepared for Kamehameha Schools. KPA No. oaPuna91-Appendix A (113005).

McDowall, R.M. 1988. Diadromy in Fishes. Timber Press, Portland, Oregon, 308 pp.

McDowall, R.M. 2003. Hawaiian biogeography and the islands freshwater fish fauna. Journal of Biogeography 30: 703-710.

McRae, M.G. 2007. The potential for source-sink population dynamics in Hawaiʻi's amphidromous fishes. Bishop Museum Bulletin in Cultural and Environmental Studies 3: 87-98.

Miike, L.H. 2004. Water and The Law in Hawai'i. University of Hawaiʻi Press, Honolulu. 264 pp.

Moore, J.G., Clague, D.A., Holcomb, R.T., Lipman, P.W., Normark, W.R., and Torresan, M.E., 1989. Prodigious submarine landslides on the Hawaiian Ridge. *J. Geophys. Res.,* 94:17,465-17,484

Moore, J.G., Normark, W.R., and Holcomb, R.T., 1994. Giant Hawaiian landslides. *Annu. Rev. Earth Planet. Sci.,* 22:119-144.

Myers, G.S. 1949. Usage of anadromous, catadromous and allied terms in migratory fishes. Copeia 1949: 89-97.

Nance, T. 2009. Unpublished memorandum to Harold Edwards, ITC Engineering. Analysis of potential Punaluu stream diversion as a function of the stream's flow rate. 7pp.

Norton, D.E., A.S. Timbol, and J.D. Parrish. 1978. Stream Channel Modification in Hawaii. Part B: Effect of channelization on the distribution and abundance of fauna in selected streams. FWS/OBS-78/17. USFWS National Stream Alteration Team, Columbia, Missouri, 47pp.

Oki, D.S. 2004. Trends in streamflow characteristics at long-term gaging stations, Hawai'i. US Geological Survey Scientific Investigation Report 2004-5080.

Oki, D.S. and A.M.D. Brasher. 2003. Environmental setting and the effects of natural and human-related factors on water quality and aquatic biota, O'ahu, Hawai'i: U.S. Geological Survey Water-Resources Investigations Report 03-4156, 98 p.

Planning Solutions, Inc. 2007. Stream Channel Alteration Permit Application Support Document for Punalu'u Stream Diversion Reconstruction. Engineering report prepared for Kamehameha Schools.

Polhemus, D.A., J.A. Maciolek, and J.I. Ford. 1992. An ecosystem classification of inland waters for the tropical Pacific islands. Micronesica 25: 155-173

R.M. Towill Corporation 2006. Punalu'u Agricultural Water System Assessment, Punalu'u, O'ahu, Hawai'i. Contract report prepared for the Board of Water Supply, City and County of Honolulu.

Radtke, R. L. And R. A. Kinzie III. 1996. Evidence of a marine larval stage in endemic Hawaiian stream gobies from isolated high-elevation localities. Trans. Am. Fish. Soc. 125: 613-621.

Randall, J. E. and H. A. Randall. 2001 Review of the fishes of the genus *Kuhlia* (Perciformes: Kuhliidae) of the Central Pacific. Pacific Science. 55: 227-256.

Stalnaker, C.B., B.L. Lamb, J. Henriksen, K. Bovee, and J. Bartholow. 1995. The Instream Flow Incremental Methodology, a primer for IFIM. National Biological Service, U.S. Department of the Interior. Biological Report 29, March 1995. 45pp.

Stearns, H.T. and K.N. Vaksvik. 1932. Geology and groundwater resources of the Island of Oahu, Hawaii. U.S. Geological Survey Water-Supply

Sterns, H.T. 1966. Geology of the State of Hawai'i. Pacific Books. Palo Alto Calif.

Stone, C.P. 1985. Alien animals in Hawaii's native ecosystems: toward controlling the adverse effects of introduced vertebrates. Pp. 251-297 in C.P. Stone and J.M. Scott (eds.): Hawaii's Terrestrial Ecosystems Preservation and Management. Cooperative National Park Resources Studies Unit, University of Hawai'i, Honolulu.

Sumiye, J. 2002. Ko'olau Mountains Watershed Partnership Management Plan. Contract report prepared for the Ko'olau Mountains Watershed Partnership. 75pp + Appendices

Timbol, A.S. and J.A. Maciolek. 1978. Stream channel modification in Hawai'i: Part A. Statewide inventory of streams. Habitat factors and associated biota. FWS/OBS-78/16, USFWS National Stream Alteration Team, Columbia, Missouri, 157pp.

Titcomb, M. 1972. Native Use of Fish in Hawai'i. University of Hawai'i Press, Honolulu.

USGS 2001. PHABSIM for Windows – user’s manual and exercises: Open File Report 01-340. 288 pp

Ushijima, T.M. and C.J. Ewart. 1973. Floods in the Punaluu-Hauula area, Oahu, Hawaii. USGS Hydrologic Atlas 473.

Waddle, T.J., ed. 2001. PHABSIM for Windows: User's Manual and Exercises. Fort Collins, CO. U.S. Geological Survey. 288 p.

Wagner, W.L., D.R. Herbst, and R.S.N. Yee. 1985. Status of the native flowering plants of the Hawaiian Islands. Pp. 23-74 in Stone and J.M. Scott (eds.): Hawaii’s Terrestrial Ecosystems Preservation and Management, C.P. Cooperative National Park Resources Studies Unit, University of Hawai‘i, Honolulu

Wilcox, C. 1996. Sugar Water: Hawaii’s Plantation Ditches. University of Hawai‘i Press, Honolulu. 191 pp.

Wolff, R.H. 2005. Feasibility of using benthic invertebrates as indicators of stream quality in Hawai’i. U.S. Geological Survey Scientific Investigations Report 2005-5079, 78 pp

Yamamoto, M.N. and A.W. Tagawa. 2000. Hawai‘i’s Native & Exotic Freshwater Animals. Mutual Publishing: Honolulu, HI.

Ziegler, A.C. 2002. Hawaiian Natural History, Ecology, and Evolution. University of Hawai‘i Press, Honolulu. 477 pp

Ziegler, A.C., J. Negishi, R.C. Sidle, P. Preechapanya, R.A. Sutherland, T.W. Giambelluca, and S. Jaiaree. Reduction of stream sediment concentration by a riparian buffer: filtering of road runoff in disturbed headwater basins on montane mainland Southeast Asia. J. Environ. Qual. 35:151-162.

Zimmerman, E.C. 1963. Nature of the land biota. Pp 57-64 in F.R. Fosberg (ed): Man’s place in the island ecosystem. Bishop Museum Press, Honolulu

Appendix A. Aquatic species recorded by DAR (2008), Oki et al (2006), and SWCA (this study) in Punaluʻu Stream. Key: Status: E = endemic, I = indigenous, A = alien Location: L = lower, M = middle, U = upper

Scientific Name	Hawaiian Name(s), Common Name(s)	Status	Location
Fishes			
Archocentrus nigrofasciatus	Convict cichlid	A	L
Awaous guamensis	ʻOʻopu nākea	I	L,M,U
Clarias fuscus	Chinese catfish	A	L
Eleotris sandwicensis	ʻOʻopu akupa	E	L,M
Gambusia affinis	Mosquitofish	A	M
Gobiidae sp.	ʻOʻopu	I	L,M
Hemichromis fasciatus	Banded jewel cichlid	A	M
Kuhlia xenura	ʻaholehole	E	L
Kuhlia sandvicensis	ʻaholehole	I	L,M
Lentipes concolor	ʻOʻopu ʻalamoʻo	E	M
Oncorhynchus mykiss	Rainbow trout	A	L,M
Poecilia reticulata	Guppy	A	L,M
Poecilia sp.	Livebearers	A	M
Sicyopterus stimpsoni	ʻOʻopu nōpili	E	M,U
Stenogobius hawaiiensis	ʻOʻopu naniha	E	L,M,U
Tilapia sp.	Tilapia	A	L
Xiphophorus hellerii	Green swordtail	A	L,M
Crustaceans			
Atyoida bisulcata	ʻŌpae kalaʻole	E	L,M,U
Macrobrachium sp.	Prawns	E	L,M
Macrobrachium lar	Tahitian prawn	A	L,M,U
Molluscs			
Cipangopaludina chinensis	Chinese mystery snail	A	--
Corbicula fluminea	Asiatic freshwater clam	A	L
Gastropod sp.	Snails	A	U
Lymnaeid sp.	Pond snails	A	--
Melania sp.	Thiarid snails	A	M
Melanoides tuberculata	Thiarid snail	A	M
Neritina granosa	hihiwai	E	L,M
Physidae sp.	Pouch snails	A	L,M
Tarebia granifera	Thiarid snail	A	L
Thiarid sp.	Thiarid snails	A	M
Sponges			
Sponge sp.	Freshwater sponge	I	M
Insects			
Anax junius	Dragonfly Green darner	I	L
Anax strenuus	Dragonfly	E	M,U
Campsicnemus bicoloripes	Long-legged fly	E	L
Campsicnemus brevipes	Long-legged fly	E	U
Campsicnemus miritibialis	Long-legged fly	E	L,
Cheumatopsyche analis	Caddisfly	A	L,M,U
Chironomid larvae	Non-biting midge	A	L,M
Chrysotus longipalpus	Long-legged fly	A	L
Condylostylus longicornis	Long-legged fly	A	M
Cricotopus bicinctus	Non-biting midge	A	L,M
Crocothemis servilia	Dragonfly	A	L
Culex annulirostris	Mosquito	A	U
Dasyhelea digna	Midge	E	L,M
Dolichopus exsul	Long-legged fly	A	M

Empididae sp.	Dance flies	?	M
Ephydridae sp.	Brine flies	?	M
Hydroptila potosina	Micro-caddisfly	A	L,M,U
Hydroptila sp.	Micro-caddisfly	?	M
Hyposmocoma sp.	Aquatic moth	A	L,M,U
Ischnura posita	Damselfly	A	L,M
Ischnura ramburi	Damselfly	A	L
Limonia advena	Crane fly	A	L
Limonia jacobus	Crane fly	E	L,M,U
Limonia perkinsi	Crane fly	E	M
Limonia sp.	Crane fly	I	M
Megalagrion hawaiiense	Endemic damselfly	E	M
Megalagrion nigrohamatum nigrolineatum	Endemic damselfly	E	M,U
Megalagrion oceanicum	Endemic damselfly	E	UM
Megalagrion sp.	Endemic damselfly	E	L,M,U
Microvelia vagans	Velvet water bug	E	L,M
Orthemis ferruginea	Dragonfly	A	L
Oxythira maya	Caddisfly	A	M
Pantala flavescens	Dragonfly	A	U
Procanace acuminata	Surf fly	E	l
Procanace bifurcata	Surf fly	E	U
Procanace sp.	Surf fly	I	M
Procanace wirthi	Surf fly	E	L,M,U
Saldula exulans	Hairy shore bug	E	M,U
Saldula oahuense	Hairy shore bug	E	L
Scatella cilipes	Shore fly	E	L,M,U
Scatella clavipes	Shore fly	E	L,M,U
Scatella hawaiiensis	Shore fly	E	L
Scatella oahuense	Shore fly	E	L,U
Telmatogeton hirtus	Riffle midge	E	L,U
Telmatogeton sp.	Riffle midge	I	M
Worms			
Dugesia sp.	Flat worm	A	L,M
Hirudinea sp.	Leech	?	M
Oligochaete sp.	Earthworm	?	L,M,U
Prostoma	Ribbon worm	?	--

Appendix D

Kamehameha Schools Punalu‘u Agricultural Lands Soil and Water Conservation Plan

May 2011

Kamehameha Schools Punalu´u Agricultural Lands Soil and Water Conservation Plan - Punalu´u, O´ahu´

Prepared By:

Thomas W. Esgate, *Project Director*, TSP 03-1001
Certified Conservation Planner for USDA programs
twesgate@sbcglobal.net
530-310-0146

Timothy Keesey, *Wildlife and Biological Consultant*
Eastside Environmental
eastsideenvironmental@yahoo.com
(530) 253-4108

Prepared For:
Kamehameha Schools
567 South King St., Suite 200
Honolulu, Hawaii 96813

CERTIFICATION OF PARTICIPANTS

Kamehameha Schools — DATE 6/10/11

CERTIFICATION OF:

CONSERVATION DISTRICT

Windward O'ahu Soil & Water Conservation District — DATE 6/10/11

TABLE OF CONTENTS

INTRODUCTION and BACKGROUND

INTRODUCTION

1.1. Background

Kamehameha Schools (KS), founded in 1887 by the will of Bernice Pauahi Bishop, great-granddaughter of Kamehameha the Great, exists to create high-quality educational opportunities for children of Hawaiian ancestry. KS is the largest private landowner in the state of Hawai´i. KS owns approximately 3,600 acres in the ahupua'a of Punalu´u and recently completed the Punalu´u Ahupua´a Plan, a master plan for KS lands in Punalu´u that includes priority projects that KS will implement in the next 3 to 5 years. Among the priority projects is the development and implementation of a Soil and Water Conservation Plan for KS' Agricultural lands in Punalu´u.

Approximately 505 acres of the lands owned by KS in the ahupua'a of Punalu´u are zoned for agriculture. Approximately 150 acres are currently in agricultural production with 30 or so tenants who conduct small scale agricultural operations growing a variety of crops as well as small pasture and aquaculture operations.

An initial "Agricultural Analysis" for Punalu´u was completed as part of the Punalu´u Ahupua´a Plan. The Agricultural Analysis identified needed agricultural facilities and opportunities for expanding farming operations and optimizing farm crops. A conceptual plan was also developed identifying potential areas for agricultural reclamation and expansion.

This plan builds upon the Agricultural Analysis for Punalu´u, and other previous research and studies conducted for the KS Punalu´u agricultural lands. The Conservation Plan objectives are to:

- Increase agricultural productivity
- Reduce soil erosion and loss
- Improve water quality and quantity by reducing sedimentation from erosion
- Identify best management practices based on Natural Resource Conservation Service (NRCS) Standards and Guidelines that are compatible with the topography, watercourses and soil types present
- Ensure that individual farms develop and operate in a sustainable conservation oriented manner

The plan process has followed a two pronged approach:

1. Address current operations
    - Interpret soil surveys of the properties
    - Inventory assess their current operations
    - Meet on site with producers
    - Map and identify the operating parcels with an eye toward logical minor expansion into areas that have been left fallow.
    - Recommend best management practices pertinent to their operations

2. Address idle lands zoned for agricultural use
    - Interpret soil surveys of the properties
    - Conduct a pedestrian survey of the properties
    - Inventory and assess idle portions of the property that are suitable for productive use. Most of these lands show indications of previous agricultural use but they have been fallow for years.
    - Identify areas for agricultural reclamation of the property
    - Identify best management practices to be used for re-establishing agricultural activities on fallow land

Based on soils, geography, slope, and field evaluation of the property, an additional 271 acres have been identified that offer the potential to be reclaimed for agricultural production.

All lands covered by this plan are owned by KS and ultimately they bear the responsibility for land management. For this reason all the operations within the project area, be they a current venture with a tenant or a new undertaking on fallow land, are covered by this conservation plan. By and large the operating agricultural parcels appear to be functioning in a sound and sustainable manner. This is due in to the fact that KS has solicited knowledgeable and dedicated producers who devote a great deal of their time to their operations. This is further supported by a full time property manager with decades of experience with the property and who also has impressive sociological skills for dealing with the wide variety of tenants. The conservation plan and the accompanying KS staff support will provide critical guidance for the producers and management.

The plan has four components:

1. A landscape level conservation plan that addresses all the resource concerns identified within the project area
2. A landscape level conservation plan in the standard NRCS format
3. Appendices that set forth best management practices in the form of NRCS practice requirements
4. Individual conservation plans in the standard NRCS format for the current producer farm operations that tie back to the landscape level plan and its appendices

Agricultural practices that have been identified in the plan process and will help improve soil and water quality and reduce erosion include:

- Land Clearing (460)
- Riparian Herbaceous (390) and Forest Cover (391)
- Grassed Waterways (412)
- Contour Farming (330)
- Contour Orchard and Other Perennial Crops (331)
- Terracing (600)
- Conservation Cover (327)
- Conservation Crop (340)

- Fencing (382)
- Residue and Tillage Management (329)
- Pipeline (516)
- Windbreak/Shelterbelt Establishment (380)
- Nutrient Management (590)
- Integrated Pest Management (595)
- Brush Management (314)
- Prescribed Grazing (528)
- Field Border (386)
- Tree/Shrub Establishment (612)
- Ponds (378)
- Fish Pond Management (399)

This plan is being presented to the Windward O´ahu Soil and Water Conservation District (SWCD) for an approval that will allow KS to reclaim agricultural lands left fallow and also assist farmers in the implementation of agricultural practices consistent with soil compatibility. Opportunities may also arise for producers to gain technical assistance from NRCS and this plan is intended to assist in meeting the planning requirements for implementation of conservation practices covered by the programmatic National Environmental Policy Act (NEPA) conditions met by NRCS for the expenditure of Environmental Quality Incentive Program (EQIP) and other available funding.

1.2. Location and Vicinity Maps

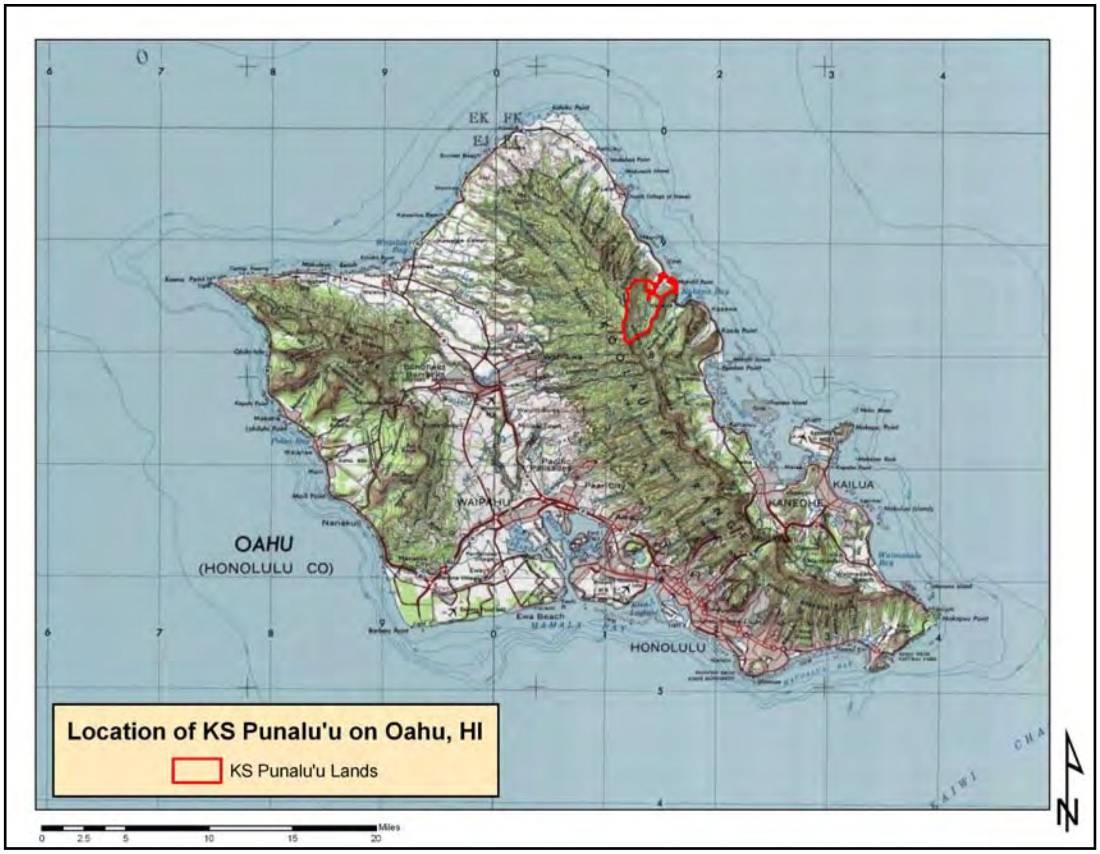


Figure 1: Location of KS Punalu´u on the Island of O´ahu, Hawai´i

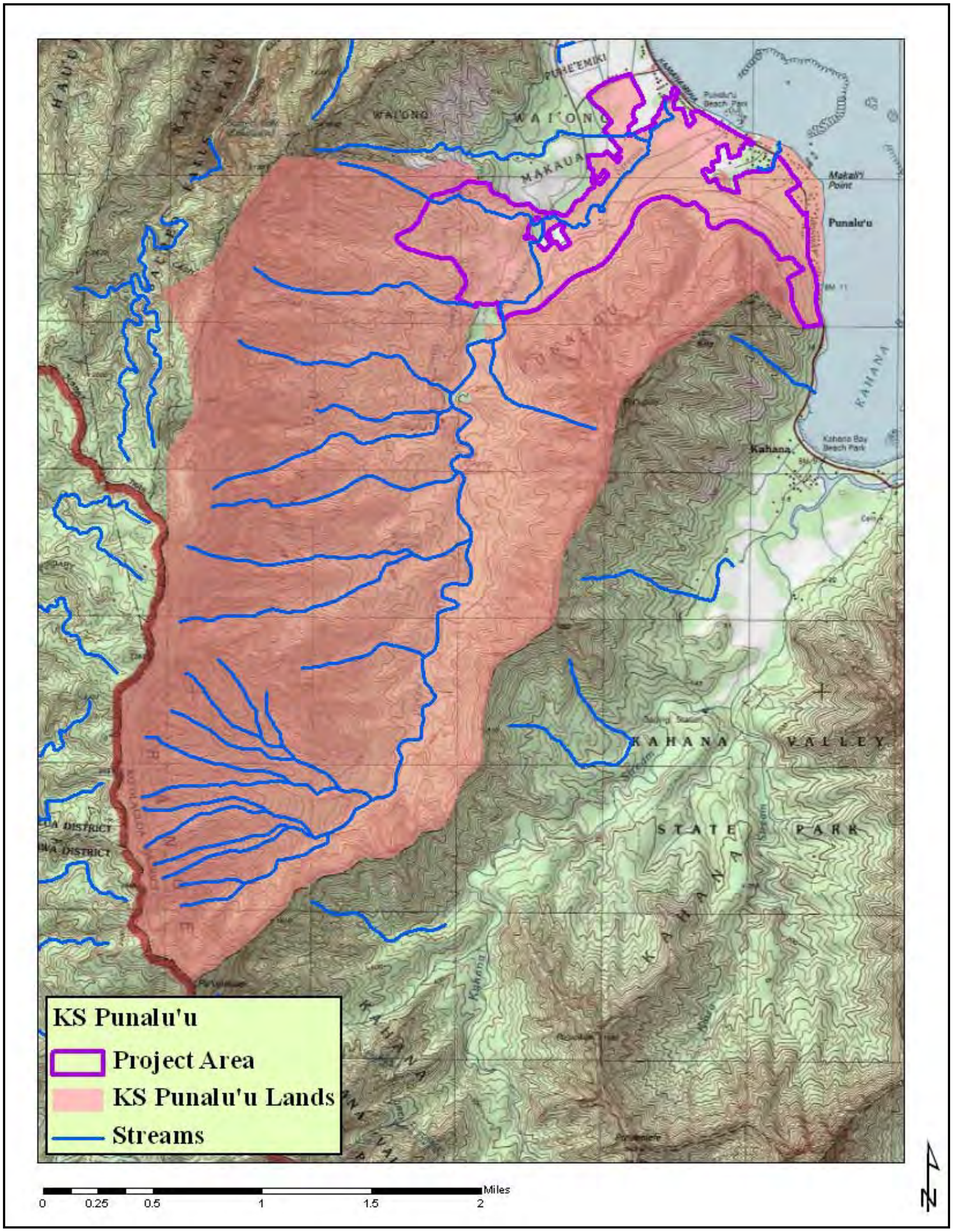


Figure 2: Location Map - Topo

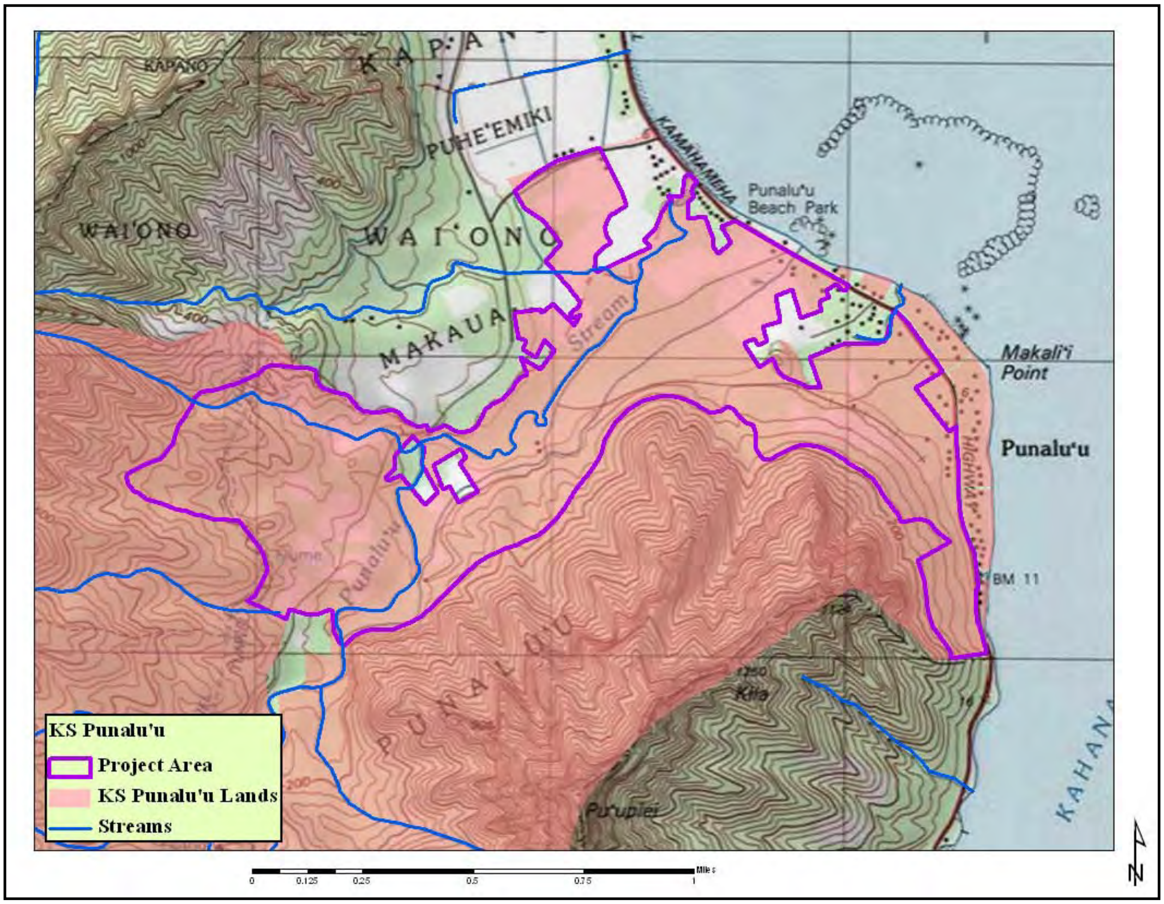


Figure 3: KS Punalu´u Project Area

1.3. Scope of Work

This Soil and Water Conservation Plan is prepared to recommend farm, range and/or forestry management treatments that address the primary natural resource concerns as presented in Section III of the NRCS, Field Office Technical Guide, United States Department of Agriculture, Natural Resources Conservation Service.

This page intentionally left blank

ENVIRONMENTAL SETTING OF PROJECT AREA and SURROUNDING PROPERTIES

2. ENVIRONMENTAL SETTING OF PROJECT AREA AND SURROUNDING PROPERTIES

2.1. Location, Topography, Elevation, and Land Use

The KS Punalu´u project is located in the state of Hawai´i on the northeast side of the island of Oahu near the township of Punalu´u east of State Route 83, Kamehameha Highway (*See* Figures 1 and 2).

The topography of the KS Punalu´u project area is relatively flat and gets steeper as you move west and south toward the Ko´olau mountain range. More than half the project area is relatively flat (0 to 6 % slope) and low in elevation (0 to 100 feet). The project area gets steeper and higher in elevation as you move west up the Ko´olau Mountain Range (*See* figure 3) with approximately 30% of the project area with slopes of 6 to 15% and the eastern and southern sections of the project area reaching slopes of between 15 – 50% slope and an elevation of 600 feet.

Figure 3: Sloped uplands to the west with relatively flat areas located on the lower elevations of the KS Punalu´u Project Area

2.2. Hydrology

The KS Punalu´u project area is located within the Punalu´u Stream sub-watershed of the Windward O´ahu watershed (*See* figure 4). Punalu´u stream is a perennial stream that, along with several ephemeral tributaries, bisects the project area flowing from west to east toward the ocean. There is a man-made flume on the west end of the project area that generally runs from south to north diverting water from Punalu´u stream for irrigation.

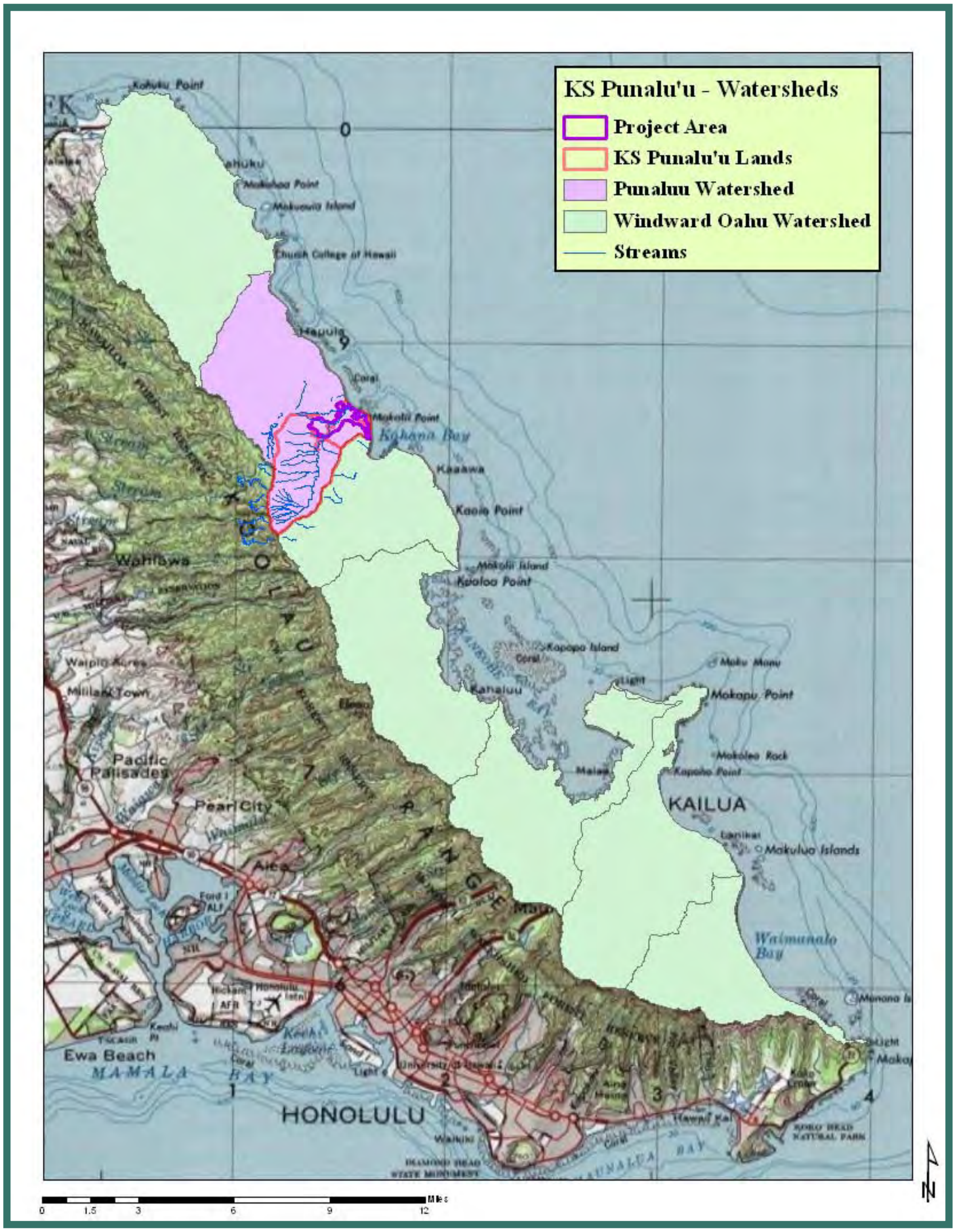


Figure 4: KS Punalu´u Watersheds

O´ahu has been divided up into seven major ground-water areas, primarily on the basis of geologic or hydrologic differences. Each area contains one or both of the islands two principal volcanic-rock aquifers – Ko´olau Basalt and the Wai´anae Volcanics. The project area is located in the Ko´olau rift zone ground-water area (Nichols et al. 1996).

The Ko´olau rift zone ground-water area in eastern O´ahu consists mostly of dike-intruded Ko´olau Basalt but also includes extensive areas of unconsolidated sedimentary deposits and local areas of the Honolulu Volcanics and consolidated sedimentary deposits. Most of the area is mountainous and has been deeply dissected by erosion. The area is wet, exceptionally so in the mountains. The Ko ́olau Basalt is the principal aquifer; sedimentary deposits are poorly permeable and yield little water. These deposits form a caprock that confines water in the Ko ́olau Basalt inland and in the coastal plains. Regional ground-water movement is from the highlands to adjacent ground-water areas and directly to the ocean. Dike-impounded water is most important in this ground-water area, and some water levels are as much as 1,000 feet above sea level. Discharge is to streams and by ground-water outflow to adjacent ground-water areas; withdrawals from wells, shafts, and springs; evapotranspiration; and outflow to the ocean (USGS 2011).

2.3. Climate

O´ahu has two roughly parallel mountain ranges, Ko´olau and Wai´anae, which are oriented approximately perpendicular to the northeast trade winds. Strong uplifting of trade winds along the steep windward Ko´olau slope to the west of the project area result in high rainfall on the northeast side of Oahu. Annual rainfall in Kahana, on the Ko´olau slope just south of the project area is greater than 7000 mm (>275 in.) (Giambelluca et al 1986). The mean annual precipitation in the lower elevations where the project area is about 69 inches and the average minimum annual temperature is 69.8 ° F and the average maximum temperature is 80.1 °F according to the Ka´awa Weather Station, just south of the project area.

The contrast between the dry season of May through October and the wet season of November through April is quite pronounced. Major widespread rains, which account for the bulk of the precipitation for the islands, occur several times during each wet season, but are infrequent in the dry season. Approximately 50 percent of the normal annual rainfall occurs in the three months of December through February, and 80 percent in the six months of the wet season. June and July are generally the driest months.

2.4. Soils

The project area falls within the following Major Land Resource Area (MLRA): Humid Oxidic Soils on Low and Intermediate Rolling Mountain Slopes (167) (*See* Figure 5). Major Land Resource Areas (MLRA) are geographically associated land resource units delineated by the Natural Resources Conservation Service and characterized by a particular pattern that combines soils, water, climate, vegetation, land use, and type of farming.

The ***Humid Oxidic Soils on Low and Intermediate Rolling Mountain Slopes (167) MLRA*** is dominantly on windward, low and intermediate mountain and hill slopes of the older Hawaiian Islands. Many steep and very steep gulches dissect the rolling mountain slopes. Elevation ranges from sea level to 2,000 feet (0 to 610 meters). The headwaters of many streams occur in this area.

This area is covered dominantly by highly weathered ash and basic igneous rock. Alluvial sediments occur on bottom lands and low terraces along streams. In some small areas, the dominant geology is influenced by tropospheric dust. The dominant soil orders in this MLRA are Ultisols, Oxisols, and Inceptisols. The soils in the area have an isohyperthermic soil temperature regime, a udic or ustic soil

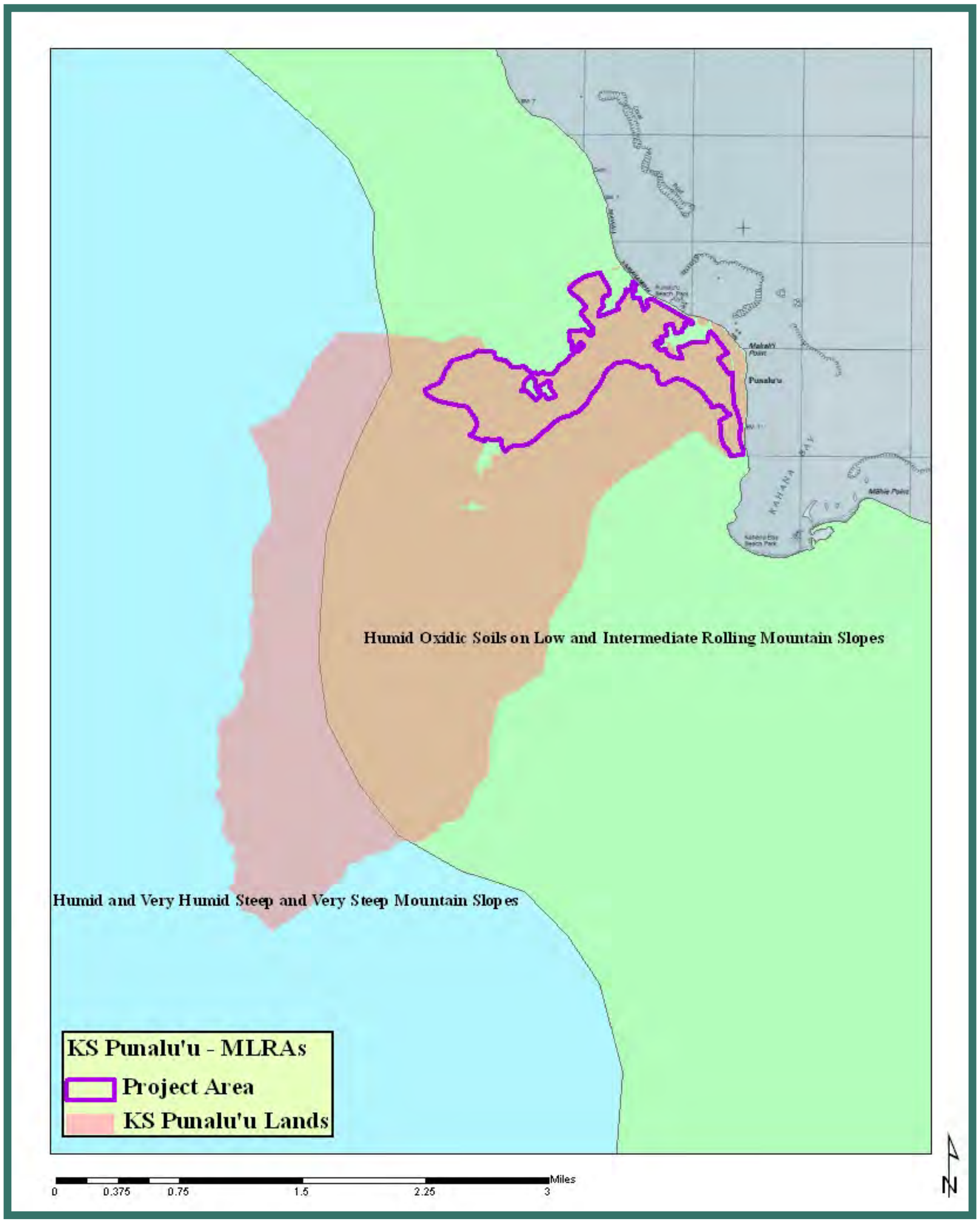


Figure 5: Project Major Land Resource Areas (MLRAs)

moisture regime, and dominantly ferritic, ferruginous, mixed, parasesquic, kaolinitic, or sesquic mineralogy. They generally are very deep, well drained, and very fine textured. The soils on bottom land are well drained to poorly drained. The soils that formed in alluvial material include Endoaquepts (Hanalei series), Natraquerts (Kaena series), and Haplustolls (Waialua series). The soils that formed in areas influenced by tropospheric dust include Palehumults (Haiku series) and Acrudox (Makapili series). The soils that formed in material weathered from basic igneous rock include very deep and deep Palehumults (Honolua, Ioleau, and Kalapa series), Kanhaplohumults (Pauwela series), and Acrudox (Kapaa and Pooku series). The soils that formed in material weathered from basic igneous rock with admixtures of volcanic ash and ejecta include Acroperox (Halii series). The MLRA has a significant acreage of miscellaneous (nonsoil) areas (USDA 2006).

Rangeland and woodland make up most of this area. About one-third of the area is used for bananas, pineapples, sugarcane, pasture, taro, orchards, or other crops. Some coastal areas are used for urban or resort development. The major resource concerns are the spread of invasive plant species, flooding, and beach and water erosion. Wind erosion is a concern in the Kahuku area on O ´ahu. Conservation practices on rangeland and cropland generally include nutrient and pest management, restoration of native plants, prescribed grazing, crop rotations, and windbreaks.

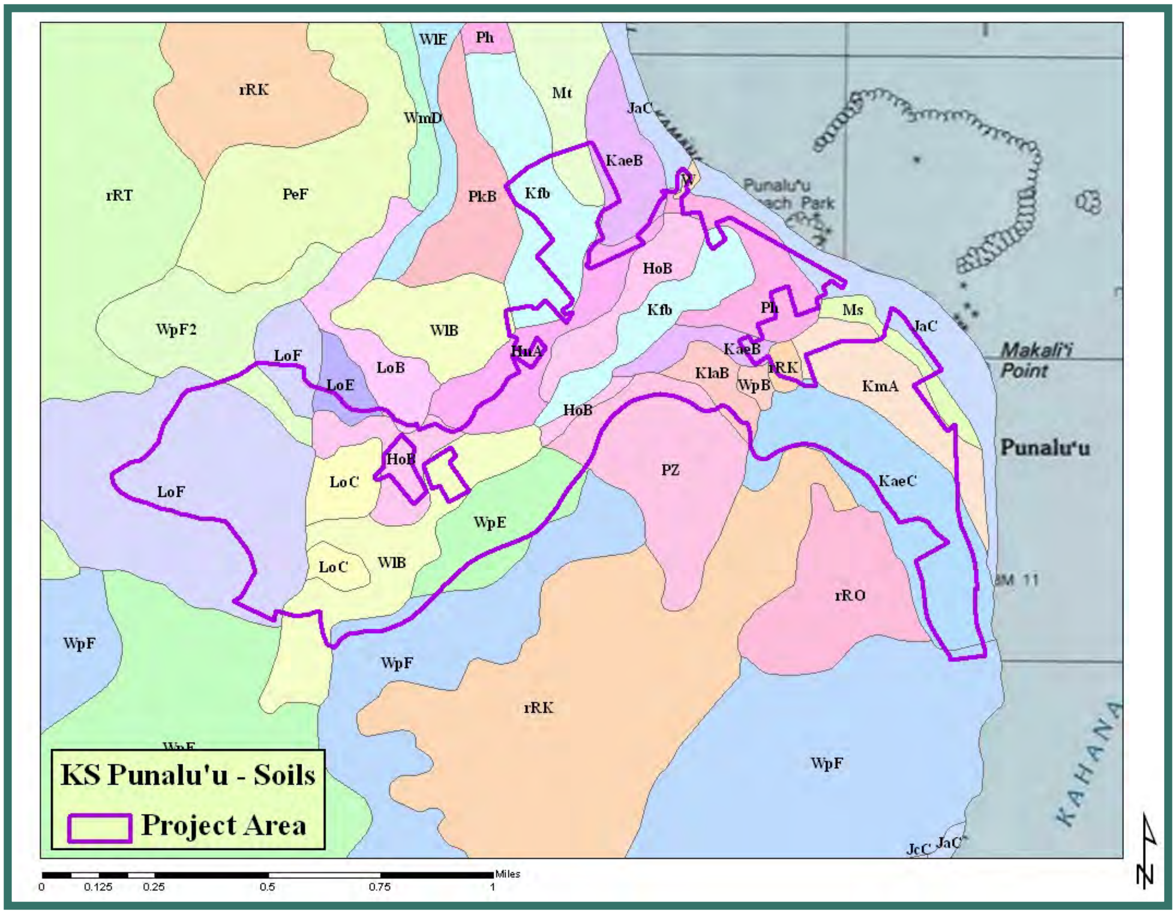


Figure 6: Soil types within the KS Punalu´u project area

The USDA NRCS Soil Survey delineated 25 soil types occurring on the project area (*See* Figure 6 and Appendix 6.1) (NRCS 2011). The percent of the project area and surrounding areas associated with each soil type and the slope associated with that soil type is shown in Table 1.

The soil texture within the project area is predominantly silty clay and stony clay, and clay. The principal soil series found on the flatter lands at lower elevations are ***Hanalei silty clay, Kaena stony clay, Kaloko clay, Kawaihapai stony clay loam, Keaau clay, Mokuleia loam and clay loam, Pearl Harbor clay, Waialua stony silty clay,*** and ***Waikane silty clay***. The upper elevation soils are primarily Kaena clay, ***Lolekaa silty clay***, and Waialua stony silty clay.

Table 1: Percentage of each soil type within the project area with soils representing over 5% of the project area in bold

Map Unit Symbol	Soil Type	Percent Slope	Percentage of Project Area
HnA	Hanalei silty clay	0 to 2	4.5%
HoB	**Hanalei stony silty clay**	**2 to 6**	**7.8%**
JaC	Jaucas sand	0 to 15	1.7%
KaeB	Kaena stony clay	2 to 6	2.6%
KaeC	**Kaena stony clay**	**6 to 12**	**8.6%**
Kfb	**Kaloko clay, noncalcareous variant**	**0 to 2**	**8.8%**
KlaB	Kawaihapai stony clay loam	2 to 6	1.6%
KmA	**Keaau clay**	**0 to 2**	**4.9%**
LoB	Lolekaa silty clay	3 to 8	0.2%
LoC	Lolekaa silty clay	8 to 15	3.3%
LoE	Lolekaa silty clay	25 to 40	1.2%
LoF	**Lolekaa silty clay**	**40 to 70**	**21.4%**
Ms	Mokuleia loam	0 to 2	1.4%
Mt	Moluleia clay loam	0 to 2	1.0%
Ph	Pearl Harbor clay	0 to 2	4.6%
PkB	Pohakupu silty clay loam	0 to 8	0.0%
PZ	Paumalu-Badland complex	-	1.9%
rRK	Rock land	-	1.0%
rRO	Rock outcrop	-	0.2%
rRT	Rough mountainous land	-	0.1%
W	Water >40	-	.2%
WIB	**Waialua stony silty clay**	**3 to 8**	**9.1%**
WpB	Waikane silty clay	3 to 8	0.5%
WpE	**Waikane silty clay**	**25 to 40**	**8.4%**
WpF	Waikane silty clay	40 to 70	2.0%
WpF2	Waikane silty clay, eroded	40 to 70	3.0%

Hanalei soil types (silty clay and ***stony silty clay***)is present on approximately 12.3% of the project site. The Hanalei series consists of somewhat poorly drained to poorly drained soils with slow run-off and moderate permeability that formed in alluvium derived from basic igneous rock. Hanalei soils are on bottom lands and low terraces along streams, have slopes of 0 to 6 percent, and elevation ranging from near sea level to 300 feet. Most of this soil is used for taro, pasture and vegetables. Vegetation on noncultivated areas is californiagrass, sensitive plant, honohono, and

Java plum. These soils are located on the lower elevations along Punalu´u Stream within the project area.

Kaena stony clay (KaeB and KaeC) is present on approximately 11.2% of the project area. The Kaena series consists of deep, poorly drained soils that formed in alluvium and colluvium. Kaena soils are on alluvial fans on steep colluvial slopes and have slopes of 2 to 35 percent at elevations between 50 and 150 feet. These soils have slow to rapid runoff and slow permeability. These soils are located within the alluvial fan of Punalu´u stream and at the transition zone from bottomlands to uplands. Dominantly pasture; small acreage is in irrigated sugarcane and truck crops. Natural vegetation is kiawe, klu, lanatana, koa-haole, and fingergrass.

Kaloko clay is present on 8.8% of the project area within the alluvial fan of Punalu´u stream. The Kaloko series consists of poorly drained soils that formed in alluvium underlain with marly lagoon deposits. Kaloko soils are on coastal plains and have slopes of 0 to 2 percent at elevations ranging from sea level to 20 feet. Kaloko soils have slow to very slow runoff and slow to moderately slow permeability. These soils are used for growing sugarcane.

Kawaihapai stony clay loam is present on approximately 1.6% of the project area. Kawaihapai soils are in stream valleys and on alluvial fans at elevations from sea level to 300 feet. Slopes are most commonly 2 to 6 percent, and range from 0 to 15 percent. The soils formed in alluvium washed from humid uplands where the soils formed in residuum weathered from basic igneous rocks. These soils have slow to medium runoff, depending on slope and moderate permeability. Sugarcane is the most important crop; small areas are in truck crops and pasture. Natural vegetation is kiawe (*Prosopis pallida*), feather fingergrass (*Chloris virgata*), bristly foxtail (*Setaria verticillata*), lantana (*Lantana camara*), koa-haole (*Leucaena glauca*), Bermuda grass (*Cynodon dactylon*), and guava (*Psidium guajava*)

Keaau clay is present on approximately 4.9% of the project area. The Keaau soils are on coastal plains at elevations of 5 to 40 feet. Slope is 0 to 6 percent. The soils formed in alluvium washed from material that weathered from basic igneous rocks and deposited over reef limestone or consolidated coral sand. The Keaau series consists of deep, poorly drained soils Poorly drained with slow to medium runoff and slow permeability. This soil is cultivated to sugarcane and is located along the coast within the Punalu´u stream alluvial fan.

Mokuleia loam(Ms) and clay loam(Mt) are present on approximately 2.4% of the project area. Mokuleia soils are on coastal plains at elevations from near sea level to 100 feet. Slope is 0 to 2 percent. The soils formed in recent alluvium over coral sand. The Mokuleia series consists of well drained soils with very slow runoff and moderate permeability in the A horizon and rapid in the C horizon. This soil type is used for irrigated sugarcane, truck crops and pasture. Natural vegetation is kiawe (*Prosopis pallida*), klu (*Acacia farnesiana*), swollen fingergrass (*Chloris inflata*), bristly foxtail (*Setaria verticillata*), koa-haole (*Leucaena glauca*), lantana (*Lantana camara*) and bermudagrass (*Cynodon dactylon*) in the drier areas and napiergrass (*Pennisetum* *purpurem*), guava (*Psidium guajava*), and joee (*Stachytarpheta jamaicensis*) in the wetter areas.

Pearl Harbor clay is present on approximately 4.6% of the project area within the alluvial fan of Punalu´u Stream. The Pearl Harbor soils are on coastal plains at elevations from near sea level to 5 feet. Slope is 0 to 2 percent. The soils formed in alluvium washed from material weathered from basic igneous rocks and deposited over and mixed with peat or muck. The Pearl Harbor series consists of deep, very poorly drained soils with very slow runoff or ponded and slow permeability. Most of this soil is now urbanized. Some is in taro, bananas, and sugarcane. Much is in pasture. Natural vegetation is panicum, sedges, cattails, and mangrove trees.

Waialua stony silty clay is present on approximately 9.1% of the project area in the along the western most reaches of Punalu´u stream within the project area. Waialua soils are on fans at elevations of 10 to 100 feet. Slope is 0 to 30 percent. The soils formed in alluvium from basic igneous rocks. The Waialua series consists of deep, moderately well drained soils with slow to medium runoff and moderate permeability. These soils are used for Irrigated sugarcane pasture and truck crops. Natural vegetation is koa haole (*Leucaena glauca*), cocklebur (*Xanthium saccharatum*), swollen fingergrass (*Chloris inflata*), sandbur (*Cenchrus echinatua*), and uhaloa (*Waltheria indica*).

Waikane silty clay is located on approximately 13.9% of the project area. The soil type is located within upland areas on southern portions of the project area. Waikane soils are on alluvial fans and terraces at elevations from 200 to 1,000 feet. Slopes range from 3 to 70 percent. The soils formed in alluvium and colluvium from basic igneous material. The Waikane series consists of very deep with slow to very rapid runoff depending on slope and moderately rapid permeability. These soils are used for pasture, truck crops, and urban development. Vegetation is guava (*Psidium guajava*), christmasberry (*Schinus terebinthifolius*), joee (*Stachytarpheta jamaicensis*) creeping Chinese violet (*Centella asiatica*), hilograss (*Paspalum conjugatum*), and ricegrass (*Paspalum orbiculare*).

Lolekaa silty clay is the most prevalent soil type in the project area on approximately 26.1% and makes up the majority of the western uplands of the project area. Lolekaa soils are on terraces and fans at elevations from near sea level to 500 feet. Slopes range from 3 to 70 percent. The soils formed in alluvium and colluvium from basic igneous rocks. The Lolekaa series consists of very deep, well drained soils with slow to rapid runoff depending on slope and permeability is moderately rapid. These soils types are used primarily for pasture. Small areas are used for growing truck crops and orchards. Vegetation is californiagrass (*Brachiaria mutica*), hilograss (*Paspalum conjugatum*), ricegrass (*Paspalum orbiculare*), guava (*Psidium guajava*), christmasberry (*Schinus terebinthifolius*), and koa haole (*Leucaena glauca*).

2.5. Biology

The Humid Oxidic Soils on Low and Intermediate Rolling Mountain Slopes (167) MLRA supports mesic to wet grass and forest vegetation and wetland plants. The naturalized plants include hilograss, California grass, java plum, and guava. Some areas are designated as critical habitat for endangered plants. Critical area plant clusters include different species of haha (*Cyanea sp.*), aupaka (*Isodendrion longifolium*), and *Schiedea kaalae* (no common name) on Oahu. Some of the major wildlife species in the area are hoary bat and elepaio on Oahu. No critical habitat for these species exists within the project area.

2.6. Cultural, Historic, and Scenic Values

An archaeological inventory survey of the project area has been completed and historical and archaeologically significant sites have been identified. An archaeological data recovery plan, and preservation plan will completed according to HRS 6E. As a cultural institution KS places a high priority on the preservation of cultural resources. No ground disturbing activities will occur where significant cultural sites have been identified.

There is a rich agricultural history in the valley documented by legends, historical records, oral histories, and cultural sites. The earliest accounts of the area note that an extensive lo´i kalo and ´auwai system existed in Punalu´u and that significant amounts of kalo were cultivated in the area. Kahana and Punalu ´u were known as the bread baskets of Ko´olau Loa. During the latter half of the 19th century, rice became the predominant cash crop grown in Punalu ´u. Around 1910, rice cultivation declined in Punalu´u and the surrounding areas. As rice production declined, Chinese, and a growing population of Japanese farmers, began to revive and cultivate lo´i in Punalu´u.

In 1906, Bishop Estate entered into a lease agreement for its lands in Punalu ´u with James B. Castle who created the Ko´olau Agricultural Company. In the first years of Castle's management of the lands, hundreds of acres of land were leased to Japanese tenants for the cultivation of taro and pineapples. Castle also constructed the Punalu´u ditch system around this time. The ditch system consisted of a diversion dam, flume, 12 tunnels and a series of smaller ditches that spread across Punalu´u, Makaua, and extended four miles to Hau´ula. Water was diverted from Punalu´u Stream at about the 210 foot elevation. The Punalu´u Ditch system was originally constructed to irrigate sugarcane lands. Concrete lined irrigation channels were added to the ditch system in 1922. During World War II the military established a presence in Punalu´u, calling it "Green Valley". They constructed canon batteries on the southeast facing slopes and conducted other operations further up the valley. Sugar ceased to be a major crop in Punalu ´u in the 1970s.

Kamehameha Schools assumed day-to-day operations of its Punalu´u lands in 2000. In 2009, KS implemented a major irrigation system improvement project to head off the threat of a collapsing tunnel system and reduce maintenance. A new, state of the art intake flume was constructed and several miles of heavy duty polyethylene pipe were installed to improve and secure irrigation water delivery.

Currently, Kamehameha Schools rents out parcels of its Punalu´u farm lands on a three year license basis to small farmers. In addition a heavy emphasis has been placed on educational activities. Through a partnership the University of Hawai ´i 6,000 students come annually to Punalu´u to experience traditional lo´i kalo production. At the entrance to the property another site introduces pre-school to 1st graders to native Hawaiian agriculture.

The highland scenic values of the land are ensured through preservation zoning.

PROJECT ACTIVITIES

3. PROJECT ACTIVITIES

The project area was ultimately determined after a field investigation of the KS Punalu´u parcels conducted by a conservation planner, the KS Punalu´u Asset Manager and the Punalu´u Site manager. The project area is divided up into farm plots based on soils, geography and current use (*See* Figure 7). Implementing conservation practices over a broad landscape containing many individual farm plots, and potentially many different operators, can present many unique challenges in conservation planning. Many practices need to be implemented across multiple operators in order to be effective.

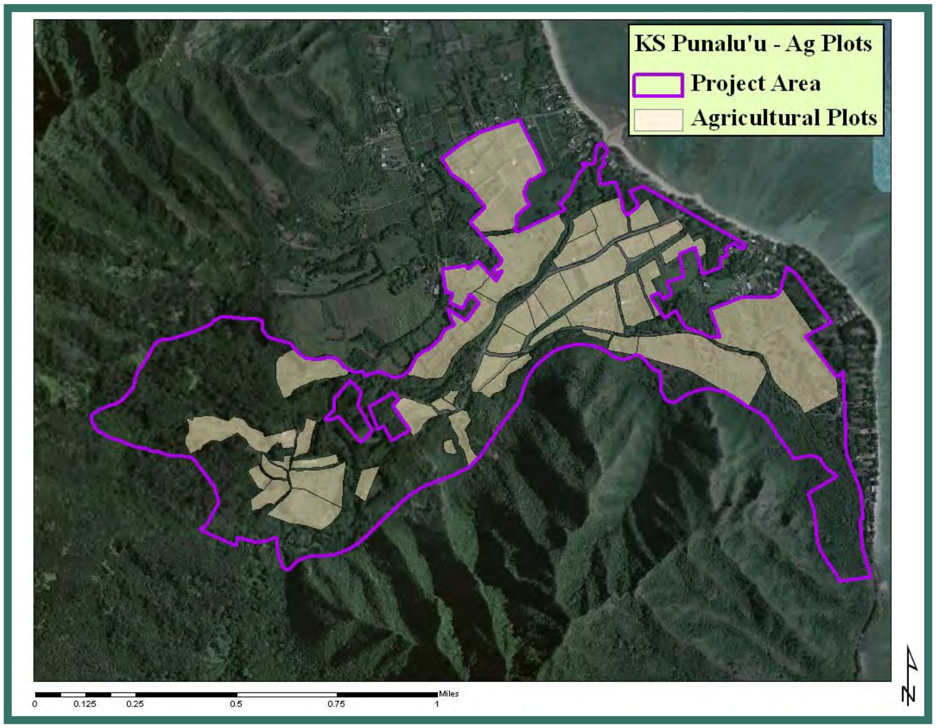


Figure 7: Location of existing agriculture plots within the project area.

The primary objective of this project is to encourage and support small farm operations that will assist in meeting Hawai´i's need and demand for locally grown produce, meat and fish. This includes multi-cropping of fruit trees and vegetables, aquaculture, and animal husbandry. KS is interested in implementing agricultural practices that reduce soil erosion and improve water quality and quantity within riparian areas by reducing sedimentation from erosion. The following practices have been identified to assist landowners within the project area to reduce soil erosion and sedimentation.

3.1. Irrigated Cropland

The project area consisting of Hanalei silty clay, Kaena stony clay, Kawaihapai stony clay loam, Keaau clay, Lolekaa that are not to steep (3-15% slope), Mokuleia, Waialua stony silty clay, and Waikane silty clay that are relatively flat (3 to 8 % slope) are suitable for irrigated cropland (*See* Figure 8).

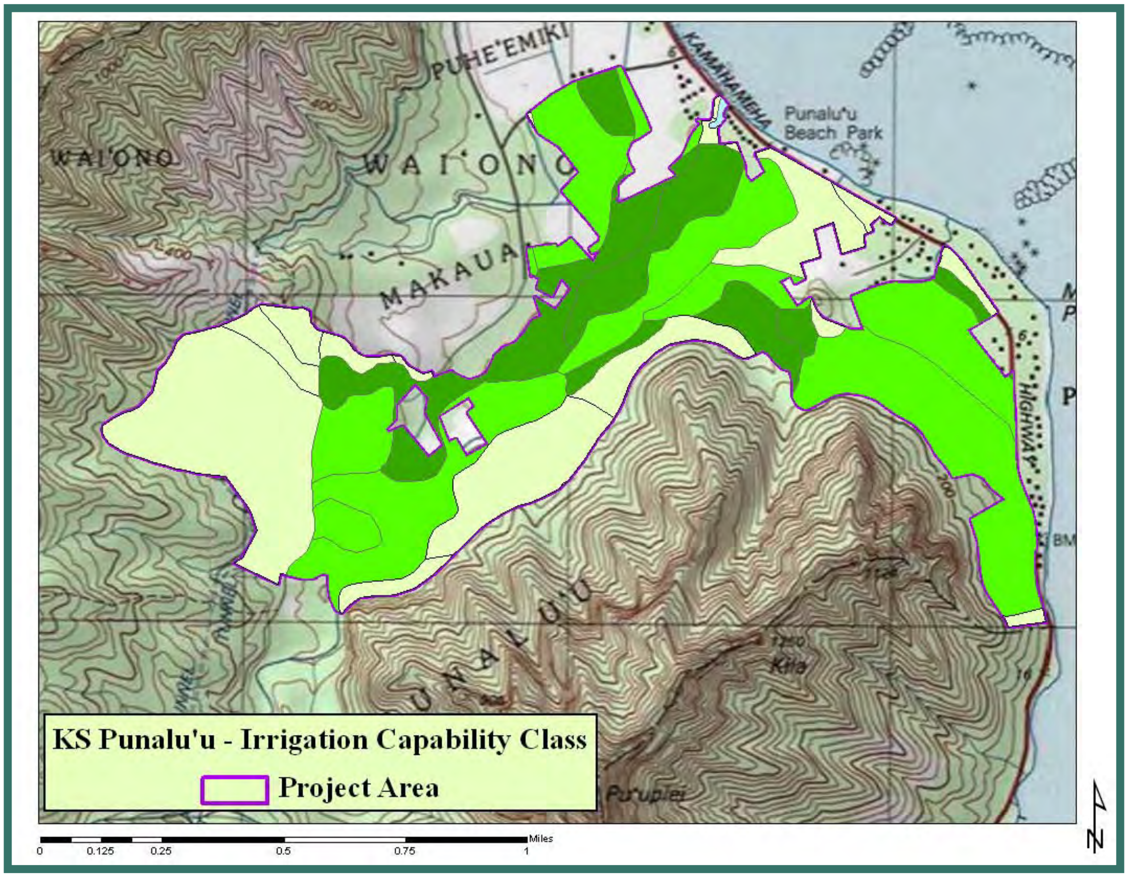


Figure 8: Irrigated capability class for soil types within the project area where: dark green represents soils adequate for irrigation with moderate conservation practices; green presents soils that are adequate but require additional conservation practices; and light green represents soils that require special conservation measures due to slope or other environmental factors.

The following agricultural practices will be implemented within these areas to reduce erosion.

3.1.1. Land Clearing (460)

This practice is intended to allow needed land use adjustments and improvements, such as removing trees, stumps, brush, and other vegetation in order to facilitate the planned use of the land, such as the development of cropland, while limiting disturbance to topsoil. Refer to NRCS Stand and Specification 460 for additional information (See Appendix 6.2).

The following criteria shall be used when conducting land clearing:

- Clearing shall involve methods that do not remove the topsoil layer.
- Clearing shall be done when the soil is dry to minimize disturbance to topsoil such as soil structural damage or compaction.

- A minimum 50-foot wide undisturbed area will be left between the area being cleared and all wetlands, water bodies, and stream courses (See Section 3.1.2.
- Removed materials should be incorporated into the soil as organic matter to the extent possible in order to limit the release of carbon.
- Temporary cover will be established as necessary to control sheet and rill and/or wind erosion on the cleared area until the planned land use is in place. This becomes more important the steeper the terrain that is being cleared. This may be accomplished through the use of a cover crop.
- A debris removal plan that addresses the land clearing criteria shall be developed before initiating land clearing activities.

3.1.2. Riparian Herbaceous Cover (390) and Forest Cover (391)

The purpose of these practices is to: improve water quality by reducing excess amounts of sediment, organic material, nutrients and pesticides and other pollutants in surface runoff and reduce excess nutrients and other chemicals in shallow ground water flow; reduce erosion and improve stability to stream banks; increase net carbon storage in the biomass and soil; enhance pollen, nectar, and nesting habitat for pollinators; create shade to lower water temperatures to improve habitat for aquatic organisms; provide a source of detritus and large woody debris aquatic organisms and riparian habitat and corridors for wildlife; and provide room for water courses to establish geomorphic stability. Refer to NRCS Standard and Specification 390 and 391 for additional information (*See* Appendix 6.3).

The practice applies to areas adjacent to perennial and intermittent watercourses or water bodies and involves creating a riparian buffer of trees, shrubs, and other vegetation adjacent to and upgradient from water bodies (See Figure 10).

The following criteria apply when implementing riparian herbaceous cover and/or riparian forest buffer:

- Select trees, shrubs, and perennial plants that are adapted to site and hydrologic conditions and provide the structural and functional diversity preferred by aquatic organisms and wildlife that will benefit from the installation of the practice.

- Protect riparian vegetation and water quality by reducing or excluding haying and grazing until the desired plant community is well established.
- The cover shall extend a minimum distance of 35 feet from the upper edge of the active channel, measured horizontally on a line perpendicular to the watercourse.

3.1.3. Grassed Waterway (412)

A Grassed waterway is a natural or constructed channel that is shaped or graded to required dimensions and established with suitable vegetation in areas where added water conveyance capacity and vegetative protection are needed to control erosion resulting from concentrated runoff and where such control can be achieved by using this practice alone or combined with other conservation practices. This standard applies to natural or constructed channels. Grassed waterways with stone centers, completely stoned, and non-vegetated waterways are also included. This practice may be applied as part of a conservation management system to convey runoff from terraces, diversions, or other water concentrations without causing erosion, to reduce gully erosion, and to protect/improve water quality.

The following conditions apply when implementing this practice and an engineer will most likely be required to meet NRCS Standards and Specifications – Grassed Waterways (412) (*See* Appendix 6.4):

- Grassed waterways shall be planned, designed, and constructed to comply with all Federal, State, and local laws and regulations
- The minimum ***capacity*** shall be that required to convey the peak runoff expected from a storm of 10-year frequency, 24-hr. duration. Consult NRCS Standard and Specification 412 for information on determining minimum capacity (Appendix 6.4).
- Design ***velocities*** shall not exceed those obtained by using the procedures, "n" values, and recommendations in the NRCS Engineering Field Handbook (EFH), Part 650, Ch. 7 or Agricultural Research Service (ARS) Agricultural Handbook 667. Consult NRCS Standard and Specification 412 for additional information on determining waterway velocity.
- Waterways ***cross sections*** may be parabolic, trapezoidal, or "V" shaped.
- The ***bottom width*** of trapezoidal waterways shall not exceed 100 feet unless multiple or divided waterways or other means are provided to control meandering of low flows.
- ***Side slopes*** shall not be steeper than a ratio of two horizontal to one vertical. The must be designed to accommodate the equipment that will maintain them and cross the waterway.
- The ***minimum depth*** of a waterway that receives water from terraces, diversions, or other tributary channels shall be that required to keep the design water surface elevation at or below the design water surface elevation in the tributary channel, at their junction when both are flowing at design depth.
- Sites with ***drainage*** issues will have to adopt additional NRCS practices to avoid saturated conditions.

- All grassed waterways shall have a stable *outlet* with adequate capacity to prevent ponding or flooding damages.
- Grassed waterways shall be vegetated according to NRCS Standard 327 – Conservation Cover (See Section 3.1.7).

3.1.4. Contour Farming (330)

The purpose of this practice is the reduce sheet and rill erosion, reduce transport of sediment, and increase water infiltration. This practice applies on sloping land where annual crops are grown. Using ridges and furrows formed by tillage, planting and other farming operations to change the direction of runoff from directly downslope to around the hillslope. Contour farming follows the natural shape of the slope without altering it and is most effective on slopes between 2 and 10%. Refer to NRCS Standard and Specification 560 for additional information (*See* Appendix 6.5). For orchards, vineyards and nut crops use the practice Contour Orchard and Other Fruit Areas, code 331.

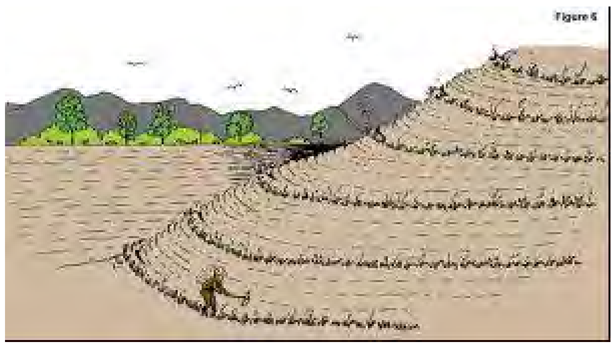


Figure 10: Illustration depicting contour farming technique

The following criteria apply when implementing contour farming:

- Minimum row grade: The crop rows shall have sufficient grade to ensure that runoff water does not pond and cause unacceptable crop damage. The closer t he row grade is to the true contour, the greater will be the erosion reduction.
- Maximum row grade: The maximum row grade shall not exceed 10%
- When row spacing is greater than 10 inches, minimum ridge height shall be 2 inches during the period of the rotation that is most vulnerable to sheet and rill erosion. Ridge height is created by the operation of tillage and planting equipment. The greater the ridge height the more effective the operation is in slowing overland flow.
- When row spacing is less than 10 inches, minimum ridge height shall be one inch for close-grown crops, such as small grains.
- The minimum ridge height criteria are not required when the practice Residue and Tillage Management, No Till/Strip Till/Direct Seed (Code 329) (*See* Section 3.1.10) is used on the contour and at least 50% of the surface residue cover is present between the rows after planting.
- Surface flow from contoured fields shall be delivered to stable outlets.
-

3.1.5. Contour Orchard and Other Perennial Crops (331)

The purpose of this practice is to reduce soil erosion, reduce transport of sediment, and increase infiltration. This practice applies on sloping land where orchards, vineyards, or other perennial crops are to be established so that all cultural operations are done on or near the contour (*See* Appendix 6.6).

The following criteria apply when implementing contour farming:

- Overland flow from adjacent sites shall be diverted as necessary to ensure the proper functioning of this practice.
- The row grade shall be aligned as closely to the contour as feasible, but the maximum row grade shall not exceed 10%.
- Conservation Cover (327) (*See* Section 3.1.7) between crops in order to eliminate bare ground. Vegetative ground cover, particularly in alleys between rows of trees/vines, in row furrows, and on terraces and diversions can increase infiltration, reduce runoff, aid in controlling erosion, provide habitat for beneficial species and pollinators, and facilitate nutrient cycling.
- Where sites are disturbed, temporary erosion control measures should be applied until the planting is established.
- Surface flow from contoured fields shall be delivered to stable outlets.

3.1.6. Terracing (600)

Terracing involves creating an earth embankment, or a combination ridge and channel, constructed across the field slope. Terracing is applied when soil erosion from water is a problem, there is a need to conserve water, the soils and topography are such that terraces can be constructed and farmed with reasonable effort, a suitable outlet can be provided, and excess runoff is a problem. The purpose is to reduce soil erosion and retain runoff for moisture conservation. Contour farming (330 and 331) is the preferred method within the project area due to the decreased impact of implementation. Refer to NRCS Standard and Practice 600 for additional information (*See* Appendix 6.7)

The following criteria apply when implementing this practice:

- Spacing for terraces will be determined using the NRCS RUSLE (Revised Universal Soil Loss Equation) based on the allowable soil loss, the most intensive use planned, and the expected level of management.
- Terraces are not recommended on land slopes greater than 20%
- Cropland terraces shall be as parallel as possible.
- Terraces shall have enough capacity to control the runoff from a 10-year frequency, 24-hr. storm without overtopping.
- Individual site plans shall be developed prior to implementing this practice that include: location of each terrace in a field; land slopes; horizontal spacing; terrace cross section (depth, bottom width, side slopes); length, channel slope,

and the type of outlet. This plan will describe the intended purpose and meet NRCS standard and specification 600.

- An O & M Manual will be provided to the landowner and terraces will be inspected annually and after major storm events.

3.1.7. Conservation Cover (327)

This practice involves establishing and maintaining permanent vegetative cover on lands needing permanent vegetative cover ***(such as ground cover in orchards)***. This practice does not apply to plantings for forage production or to critical area plantings. This practice may be applied to reduce soil erosion and sedimentation; improve water quality and air quality, enhance wildlife habitat, improve soil quality, and manage plant pests (*See* Appendix 6.8)

The following criteria apply when implementing this practice:

- Species shall be adapted to soil and climatic conditions.
- Species planted shall be suitable for planned purpose and site conditions
- No plants on the state or federal noxious weed lists shall be planted.
- Seeding rates and methods shall be adequate to accomplish the planned purpose. Certified seed shall be used.
- Planting dates, planting methods, and site preparation shall be sufficient to establish the conservation cover.
- Timing and use of equipment shall be appropriate for the site and soil conditions.

3.1.8. Access Road (340)

This practice is applied on all lands where a travel-way for equipment and vehicles is constructed as part of a conservation plan. The purpose is to provide a fixed route for vehicular travel for resource activities involving the management of timber, livestock, agriculture, wildlife habitat, and other conservation enterprises while protecting the soil, water, air, fish, wildlife, and other adjacent natural resources. Refer to NRCS Standard and Specification 560 for additional information (*See* Appendix 6.9).

The following criteria apply when implementing this practice:

- Access roads shall be designed to serve the enterprise or planned use with the expected vehicular or equipment traffic. The type of vehicle or equipment, speed, loads, soil, climatic, and other conditions under which vehicles and equipment are expected to operate need to be considered. Planned work shall comply with all federal, state and local laws and regulations.
- Where general public use is anticipated, roads shall be designed to meet applicable federal, state and local criteria.
- **Location.** Roads shall be located to serve the purpose intended, to facilitate the control and disposal of surface and subsurface water, to control or reduce erosion, to make the best use of topographic features, and to include scenic vistas where possible. The roads should generally follow natural contours and

slopes to minimize disturbance of drainage patterns. Roads shall be located where they can be maintained and where water management problems are not created. To reduce potential pollution, roads shall be located away from watercourses. Utilize buffers where possible to protect waterbodies.

- **Alignment.** The gradient and horizontal alignment shall be adapted to the intensity of use, mode of travel, the type of equipment and load weights, and the level of development. Grades normally should not exceed 10 percent except for short lengths.
- **Width.** The minimum width of the roadbed is 14 ft for one-way traffic and 20 ft for two-way traffic. The roadbed width includes a tread-width of 10 feet for one-way traffic or 16 feet for two-way traffic. Each type of road also requires 2 feet of shoulder width on each side.
- **Side Slopes.** All cuts and fills shall be designed to have stable slopes of a minimum of 2 horizontal to 1 vertical on heights of less than 4 feet. For short lengths, rock areas, or very steep hillsides, steeper slopes may be permitted, if soil conditions warrant and special stabilization measures are installed.
- Areas with geological conditions and soils subject to slides shall be avoided or treated to prevent slides.
- **Drainage.** The type of drainage structure used will depend on the intended use and runoff conditions. Culverts, bridges, fords, or grade dips for water management shall be provided at all natural drainage ways. The capacity and design shall be consistent with sound engineering principles and shall be adequate for the class of vehicle, type of road, development, or use. When a culvert or bridge is installed in a drainage way, its minimum capacity shall convey the design storm runoff without causing erosion or road overtopping.
- **Construction Operations.** Construction operations should be carried out in such a manner that erosion and air and water pollution are minimized and held within legal limits.
- **Erosion Control.** If soil and climatic conditions are favorable, road banks and disturbed areas shall be vegetated as soon as possible.
- Watercourses and water quality shall be protected during and after construction by erosion-control facilities and maintenance. Filter strips, water and sediment control basins, and other conservation practices shall be used and maintained as needed.

3.1.9. Fencing (382)

This practice is applied on an area where management of animal or human movement is needed. In the project area, fences are required to exclude feral animals from damaging crops and to keep livestock enclosed. Refer to NRCS Standard and Specification 382 for additional information (*See* Appendix 6.10).

The following criteria apply when implementing this practice:

- Fencing materials, type and design of fence installed shall be of a high quality and durability. The type and design of fence installed will meet the management objectives and site challenges. Based on need, fences may be permanent, portable, or temporary.

- Fences shall be positioned to facilitate management requirements. Ingress/egress features such as gates and cattle guards shall be planned. The fence design and installation should have the life expectancy appropriate for management objectives and shall follow all federal, state, and local laws and regulations.
- Height, size, spacing and type of materials used will provide the desired control, life expectancy, and management of animals and people of concern.

3.1.10. Residue and Tillage Management (329)

This practice applies to all cropland and other land where crops are planted. The practice includes managing the amount, orientation, and distribution of crop and other plant residue on the soil surface year round while limiting soil-disturbing activities to only those necessary to place nutrients, condition residue and plant crops. The purpose is to reduce sheet and rill erosion, reduce wind erosion, improve soil organic matter, reduce CO_2 losses from the soil, reduce soil particulate emissions, increase plant-available moisture, and provide food and escape cover for wildlife. Refer to NRCS Standard and Specification 329 for additional information (*See* Appendix 6.11).

The following criteria apply when implementing this practice:

- Residue shall not be burned
- All residues shall be uniformly distributed over the entire field
- No full-width tillage shall be performed regardless of the depth of the tillage operation.

3.1.11. Pipeline (516)

This practice applies to pipelines having an inside diameter of 8 inches or less and applies to where it is desirable or necessary to convey water in a closed conduit from one point to another for livestock, wildlife, or recreation.

The following criteria apply when implementing this practice:

- For livestock water, the installation shall have the ***capacity*** to provide seasonal high daily water requirements for the number of species of animals to be supplied. Consult NRCS Standard 516 for additional information (*See* Appendix 6.12).
- For recreation areas, the water capacity shall be adequate for all planned uses.
- If water from the pipeline is to be used for human consumption, applicable state and local regulations shall be met and the pipe must be marked or certified for potable water supply by the National Sanitation Foundation (NSF).
- All pipes must withstand the pressure it will be subjected to, including hydraulic transients, internal pressures and external pressures.
- Valves or unions shall be installed at low points in the pipeline so that the line can be drained as needed.

- Design shall provide for entry and removal of air along the pipeline as needed, to prevent air locking or pipe collapse.
- Watertight joints that have a strength equal to that of the pipe shall be used.
- NRCS Standard 430FF shall apply if Steel Pipe is used.
- Plastic pipe installed above ground shall be resistant to ultraviolet light.
- All pipes shall be protected from hazards.
- Disturbed areas shall be established with vegetation or otherwise stabilized as soon as practical after construction in accordance with NRCS Standard 327 – Conservation Cover (See Section 3.1.7).
  The visual design of pipelines and appurtenances in areas of high visibility shall be carefully considered.

3.1.12. Windbreak/Shelterbelt Establishment (380)

This practice involves establishing windbreaks and shelterbelts consisting of single or multiple rows of trees or shrubs in linear configurations in order to reduce soil erosion from wind, protect plants from wind related damage, alter the microenvironment for enhancing plant growth, provide shelter for structures, animals, and people, enhance wildlife habitat, provide noise and visual screens, improve air quality by reducing and intercepting air borne particulate matter, chemicals ,and odors, delineate property and field boundaries, improve irrigation efficiency, and/or increase carbon storage in biomass and soils (*See* Appendix 6.13).

The following criteria apply when implementing this practice:

- The location, layout and density of the planting will accomplish the purpose and function intended within a 20-year period. *A precondition for windbreak/shelterbelt establishment is appropriately prepared sites. If site preparation is needed, consider applying the conservation practice Tree/Shrub Site Preparation (490 (See Section 3.2.4.).*
- The maximum design height (H) for the windbreak or shelterbelt shall be the expected height of the tallest row of trees or shrubs at age 20 for the given site.
- Species must be adapted to the soils, climate and site conditions.
- Spacing between individual plants shall be based on the needed growing space for plant type and species, the accommodation of maintenance equipment, and the desired characteristics of the stem(s), branches and canopy as required for a specific purpose.

- The windbreak will be oriented as close to perpendicular to the troublesome wind as possible.
- The length of the windbreak will be sufficient to protect the site including consideration for the “end effect” and changes in wind direction.
- Avoid planting trees or shrubs where they will interfere with structures and above or below ground utilities.
- Moisture conservation or supplemental watering shall be provided for plant establishment and growth where natural precipitation is too low for the selected species.

3.1.13. Integrated Pest Management (595)

This practice involves developing a site-specific combination of pest prevention, pest avoidance, pest monitoring, and pest suppression strategies to: 1. Prevent or mitigate off-site pesticide risks to water quality from leaching, solution runoff and adsorbed runoff losses; 2. Prevent or mitigate off-site pesticide risks to soil, water, air, plants, animals and humans from drift and volatilization losses; 3. Prevent or mitigate on-site pesticide risks to pollinators and other beneficial species through direct contact; and 4. Prevent or mitigate cultural, mechanical and biological pest suppression risks to soil, water, air, plants, animals and humans (*See* Appendix 6.14).

Figure 10: KS Punalu´u tenant removing weeds from crops.

The following criteria apply when implementing this practice:

- PM strategies (Prevention, Avoidance, Monitoring and Suppression or “PAMS”) shall be employed to prevent or mitigate pest management risks for identified natural resource concerns.
- A comprehensive IPM plan utilizing PAM’s strategies will be developed in accordance with this standard to document how specific pest management risks will be prevented or mitigated. The IPM plan must be crop and/or land use specific and adhere to applicable elements and guidelines accepted by the local Land Grant University or Extension.
- If a comprehensive IPM system is not feasible, utilize appropriate IPM techniques to adequately prevent or mitigate pest management risks for identified natural resource concerns.
- For identified water quality concerns related to pesticide leaching, solution runoff and adsorbed runoff, the current version of the USDA-NRCS WIN-PST

program will be used to evaluate potential risks to humans and/or fish, as appropriate, for each pesticide to be used.

- IPM strategies that keep pest populations below economically damaging levels and minimize pest resistance should be utilized because they also help prevent unnecessary pest management risks to natural resources and humans.
- For noxious weed and invasive species control, the minimum level of pest suppression necessary to meet natural resource objectives should be used, however, for the eradication of invasive species, the acceptable pest threshold may be zero.
- IPM Prevention, Avoidance, Monitoring, and Suppression (PAMS) techniques include:
  - Prevention – Activities such as cleaning equipment and gear when leaving an infested area, using pest-free seeds and transplants, and irrigation scheduling to limit situations that are conducive to disease development.
  - Avoidance – Activities such as maintaining healthy and diverse plant communities, using pest resistant varieties, crop rotation, and refuge management.
  - Monitoring – Activities such as pest scouting, degree-day modeling, and weather forecasting to help target suppression strategies and avoid routine preventative treatments.
  - Suppression – Activities such as the judicious use of cultural, mechanical, biological and chemical control methods that reduce or eliminate a pest population or its impacts while minimizing risks to non-target organisms.

- When providing technical assistance to organic producers, the IPM approach to managing pests should be consistent with the USDA-Agricultural Marketing Service National Organic Program standard which includes:

  - A diverse crop rotation that reduces habitat for major pests and increases habitat for natural enemies
  - Use of "farmscaping" principles to create borders of beneficial species habitat
  - Farming techniques to improve soil quality

3.1.14. Nutrient Management (590)

This practice applies to all lands where plant nutrients and soil amendments are applied. This practice is used in managing the amount, source, placement, form and timing of the application of plant nutrients and soil amendments in order to: budget and supply nutrients for plant production; properly utilize manure or organic by-products as a plant nutrient source; minimize agricultural nonpoint source pollution of surface and ground water resources; protect air quality by reducing nitrogen and/or particulate emissions to the atmosphere; maintain or improve the physical, chemical and biological condition of soil (*See* Appendix 5.16).

The following criteria apply when implementing this practice:

- Plans for nutrient management shall comply with all applicable Federal, state, and local laws and regulations.
- Plans for nutrient management shall be developed in accordance with policy requirements of the NRCS General Manual Title 450, Part 401.03 (Technical Guides, Policy and Responsibilities) and Title 190, Part 402 (Ecological Sciences, Nutrient Management, Policy); technical requirements of the NRCS Field Office Technical Guide (FOTG); procedures contained in the National Planning Procedures Handbook (NPPH), and the NRCS National Agronomy Manual (NAM) Section 503.
- Persons who review or approve plans for nutrient management shall be certified through any certification program acceptable to NRCS within the state.
- Plans for nutrient management that are elements of a more comprehensive conservation plan shall recognize other requirements of the conservation plan and be compatible with its other requirements.
- A nutrient budget for nitrogen, phosphorus, and potassium shall be developed that considers all potential sources of nutrients including, but not limited to animal manure and organic by-products, waste water, commercial fertilizer, crop residues, legume credits, and irrigation water.
- Realistic yield goals shall be established based on soil productivity information, historical yield data, climatic conditions, level of management and/or local research on similar soil, cropping systems, and soil and manure/organic by-products tests.
- For new crops or varieties, industry yield recommendations may be used until documented yield information is available.
- Plans for nutrient management shall specify the source, amount, timing and method of application of nutrients on each field to achieve realistic production goals, while minimizing nitrogen and/or phosphorus movement to surface and/or ground waters.
- Erosion, runoff and water management controls shall be installed, as needed, on fields that receive nutrients.
- Soil amendments shall be applied, as needed, to adjust soil pH to the specific range of the crop for optimum availability and utilization of nutrients.
- Recommended nutrient application rates shall be based on Land Grant University recommendations (and/or industry practice when recognized by the university) that consider current soil test results, realistic yield goals and management capabilities. If the Land Grant University does not provide specific recommendations, application shall be based on realistic yield goals and associated plant nutrient uptake rates.
- **Nutrient Application Rates:** Timing and method of nutrient application (particularly nitrogen) shall correspond as closely as possible with plant nutrient uptake characteristics, while considering cropping system limitations, weather and climatic conditions, and field accessibility.
- **Nutrient Application Methods:** Nutrients shall not be applied to frozen, snow-covered or saturated soil if the potential risk for runoff exists.

- Nutrient applications associated with irrigation systems shall be applied in accordance with the requirements of Irrigation Water Management (Code 449).
- Nutrient values of manure and organic by-products (excluding sewage sludge) shall be determined prior to land application based on laboratory analysis, acceptable “book values” recognized by the NRCS and/or the Land Grant University, or historic records for the operation, if they accurately estimate the nutrient content of the material. Book values recognized by NRCS may be found in the Agricultural Waste Management Field Handbook, Chapter 4 - Agricultural Waste Characteristics.
- The application rate (in/hr) for material applied through irrigation shall not exceed the soil intake/infiltration rate. The total application shall not exceed the field capacity of the soil.
- **Field Risk Assessment.** When animal manures or other organic by-products are applied, a field-specific assessment of the potential for phosphorus transport from the field shall be completed. This assessment may be done using the Phosphorus Index or other recognized assessment tool.
- **Heavy Metals Monitoring.** When sewage sludge is applied, the accumulation of potential pollutants (including arsenic, cadmium, copper, lead, mercury, selenium, and zinc) in the soil shall be monitored in accordance with the US Code, Reference 40 CFR, Parts 403 and 503, and/or any applicable state and local laws or regulations.
- In areas with an identified or designated nutrient-related water quality impairment, an assessment shall be completed of the potential for nitrogen and/or phosphorus transport from the field. The Leaching Index (LI) and/or Phosphorus Index (PI), or other recognized assessment tools, may be used to make these assessments. The results of these assessments and recommendations shall be discussed with the producer and included in the plan.
- Plans developed to minimize agricultural nonpoint source pollution of surface or ground water resources shall include practices and/or management activities that can reduce the risk of nitrogen or phosphorus movement from the field. Incorporate surface applications of solid forms of manure or some commercial fertilizer nitrogen formulations (i.e. Urea) into the soil within 24 hours of application.
- When applying liquid forms of manure with irrigation equipment select application conditions when there is high humidity, little/no wind blowing, a forth coming rainfall event, and/or other conditions that will minimize volatilization losses into the atmosphere. The basis for applying manure under these conditions shall be documented in the nutrient management plan.
- Handle and apply poultry litter or other dry types of animal manures when weather conditions are calm and there is less potential for blowing and emission of particulates into the atmosphere. The basis for applying manure under these conditions shall be documented in the nutrient management plant.
- Nutrients shall be applied in such a manner as not to degrade the soil’s structure, chemical properties or biological condition. Use of nutrient sources

with high salt content will be minimized unless provisions are used to leach salts below the crop root zone.

- Nutrients shall not be applied to flooded or saturated soils when the potential for soil compaction and creation of ruts is high.

3.1.15. Stream Crossing (578)

This practice applies to the development of a stabilized area or structure constructed across a stream to provide a travel way for people, livestock, equipment, or vehicles. The purpose of this practice is to :improve water quality by reducing sediment, nutrient, organic, and inorganic loading of the stream; reduce streambank and streambed erosion; and provide crossing for access to another land unit. This practice applies to all land uses where an intermittent or perennial watercourse exists and a ford, bridge, or culvert type crossing is desired for livestock, people, and /or equipment (*See* Appendix 6.16).

The following criteria apply when implementing this practice:

- The following are legal requirements the cooperator may need to obtain:
    - A 404 permit from the U.S. Army Corps of Engineers may be required when constructing a structure in a stream.
    - A 401 permit from the State Department of Health, Clean Water Branch may be required when constructing a structure in a stream.
    - For County own streams contact the County for applicable permits.
    - For State owned streams contact the State of Hawaii, Department of Land and Natural Resources Engineering Division for applicable permits.

- **Location.** Stream crossings shall be located in areas where the streambed is stable or where grade control can be provided to create a stable condition. Avoid sites where channel grade or alignment changes abruptly, excessive seepage or instability is evident, overfalls exist, or large tributaries enter the stream. Wetland areas shall be avoided if at all possible.
- Locate crossings, where possible, out of shady riparian areas to discourage cattle loafing time in the stream.
- Stream crossings shall provide a way for normal passage of water, fish and other aquatic animals within the channel.
- **Access Roads.** Where high rates of erosion of the adjacent roadways that slope towards the crossing threaten to deliver an excessive amount of sediment to the drainage, install measures to minimize erosion of the roadside ditch, road surface, and/or cut slopes. Where the stream crossing is installed as part of a roadway, the crossing shall be in accordance with NRCS Conservation Practice Standard, 560, Access Road (*See* Section 3.1.8).
- **Width.** The stream crossing shall provide an adequate travel-way width for the intended use. A multi-use stream crossing shall have a travel-way no less than 10 feet wide. "Livestock only" crossings shall be no less than 6 feet wide. Width shall be measured from the upstream end to the downstream end of the stream crossing and shall not include the side slopes.

- **Side Slopes.** All cuts and fills for the stream crossing shall have side slopes that are stable for the soil involved. Side slopes of earth cuts or fills shall be no steeper than 2 horizontal to 1 vertical. Rock cuts or fills shall be no steeper than 1.5 horizontal to 1 vertical.
- **Stream Approaches.** Approaches to the stream crossing shall blend with existing site conditions where possible, and shall not be steeper than 4 horizontal to 1 vertical. Unless the foundation geology is otherwise acceptable, the approaches shall be stable, have a gradual ascent or descent grade, and be underlain with suitable material, as necessary, to withstand repeated and long term use. The minimum width of the approaches shall be equal to the width of the crossing surface. Surface runoff shall be diverted around the approaches to prevent erosion of the approaches. Roadside ditches shall be directed into a diversion or away from the crossing surface.
- **Rock.** All rock shall be chosen to withstand exposure to air and water. When rock is used, it shall be sufficiently large and dense so that it is not mobilized by design flood flows.
- **Fencing.** Areas adjacent to the stream crossing shall be permanently fenced or otherwise excluded as needed to manage livestock access to the crossing. Cross-stream fencing at fords shall be accomplished with breakaway wire, swinging floodgates, hanging electrified chain or other devices to allow the passage of floodwater debris during high flows. All fencing shall be designed and constructed in accordance with NRCS Conservation Practice Standard 382, Fence.
- **Vegetation**. All areas to be vegetated shall be planted as soon as practical after construction. When necessary, use of NRCS Conservation Practice Standard 342, Critical Area Planting shall be considered where vegetation is unlikely to become established by natural regeneration, or acceleration of the recovery of vegetation is desired.
- **Criteria for Culvert and Bridge Crossings**: Design of culverts and bridges shall be consistent with sound engineering principles and shall be adequate for the use, type of road, or class of vehicle. Culverts and bridges shall have sufficient capacity to convey the design flow without appreciably altering the stream flow characteristics.
- Culverts shall be sized to handle at least the bankfull flow or the peak runoff from the 2-year, 24-hour peak discharge, whichever is less. Crossings shall be adequately protected so that out-of-bank flows safely bypass without structure or streambank damage, or erosion of the crossing fill. Additional culverts may be used at various elevations to maintain terrace or floodplain hydraulics.
- The length of the culvert shall be adequate to extend the full width of the crossing, including side slopes. At least one culvert pipe shall be placed on or below grade with the existing stream bottom.
- Acceptable culvert materials include concrete, corrugated metal, corrugated plastic, new or used high quality steel and other materials approved by the engineer.

3.1.16. Irrigation System, Micro Irrigation (441)

This practice involves the use of an irrigation system for frequent application of small quantities of water on or below the soil surface: as drops, tiny streams or miniature spray through emitters or applicators placed along a water delivery line. This practice may be applied as part of a conservation management system to support one or more of the following purposes: to efficiently and uniformly apply irrigation water and maintain soil moisture for plant growth; to prevent contamination of ground and surface water by efficiently and uniformly applying chemicals; and to establish desired vegetation (*See* Appendix 6.17).

The following criteria apply when implementing this practice:

- The system shall be designed to uniformly apply water and/or chemicals while maintaining soil moisture within a range for good plant growth without excessive water loss, erosion, reduction in water quality, or salt accumulation.
- Micro irrigation systems consist of point-source emitter (drip, trickle, and bubbler), surface or subsurface line-source emitter, basin bubbler, and spray or mini sprinkler systems.
- The system shall include all irrigation appurtenances necessary for proper operation. Appurtenances shall be sized and positioned in accordance with sound engineering principles and site-specific features.
- **Water Quality**. The irrigation water supply shall be tested and assessed for physical, chemical and biological constituents to determine suitability and treatment requirements for use in a micro irrigation system.

3.1.17. Irrigation Water Management (449)

This practice is used to determine and control the volume, frequency and application rate of irrigation water in a planned, efficient manner. The purpose is to: manage soil moisture to promote desired crop response; optimize use of available water supplies; minimize irrigation induced soil erosion; decrease non-point source pollution of surface and groundwater resources; manage salts in the crop root zone; manage air, soil, or plant micro-climate; proper and safe chemigation or fertigation; and improve air quality by managing soil moisture to reduce particulate matter movement (*See* Appendix 6.18).

The following criteria apply when implementing this practice:

- Irrigation water shall be applied in accordance with federal, state, and local rules, laws, and regulations. Water shall not be applied in excess of the needs to meet the intended purpose.
- Measurement and determination of flow rate is a critical component of irrigation water management and shall be a part of all irrigation water management purposes.
- The irrigator or decision-maker must possess the knowledge, skills, and capabilities of management coupled with a properly designed, efficient and

functioning irrigation system to reasonably achieve the purposes of irrigation water management.

- An "Irrigation Water Management Plan" shall be developed to assist the irrigator or decision-maker in the proper management and application of irrigation water.

3.1.18. Surface Drainage, Field Ditch (607)

This practice involves developing a graded ditch for collecting excess water in a field. The purpose of the practice is to collect or intercept excess surface water, such as sheet flow from natural and graded land surfaces or channel flow from furrows, and carry it to an outlet and/or excess subsurface water and carry it to an outlet (*See* Appendix 6.19).

The following criteria apply when implementing this practice:

- Drainage field ditches shall be planned as integral parts of a drainage system for the field served and shall collect and intercept water and carry it to an outlet with continuity and without ponding. Compliance with federal, State, and local laws and regulations are required.
- **Investigations.** An adequate investigation shall be made of all sites.
- **Location.** Ditches shall be established, insofar as topography and property boundaries permit, in straight or nearly straight courses. Random alignment may be used to follow depressions and isolated wet areas of irregular or undulating topography. Excessive cuts and the creation of small irregular fields shall be avoided.
- On extensive areas of uniform topography, collection or interception ditches shall be installed as required for effective drainage.
- **Design.** The size, depth, side slopes, and cross section area shall:

  - Be adequate to provide the required drainage for the site.
  - Permit free entry of water from adjacent land surfaces without causing excessive erosion.
  - Provide effective disposal or reuse of excess irrigation water (if applicable).
  - Conduct flow without causing excessive erosion.
  - Provide stable side slopes based on soil characteristics.
  - Permit crossing by field equipment if feasible.
  - Permit construction and maintenance with available equipment.

3.1.19. Composting Facility (317)

This practice involves developing a structure or device to contain and facilitate the controlled aerobic decomposition of manure or other organic material by micro-organisms into a biologically stable organic material that is suitable for use as a soil amendment. The purpose of the practice is to reduce the pollution potential and improve the handling characteristics of organic waste solids; and produce a soil amendment that adds organic matter and beneficial organisms, provides slow-release plant-available nutrients, and improves soil condition (*See* Appendix 6.20).

The following criteria apply when implementing this practice:

- **Laws and Regulations.** Install and operate the facility in compliance with all federal, state, and local laws, rules and regulations.
- **Safety.** Incorporate safety and personal protection features and practices into the facility and its operation as appropriate to minimize the occurrence of equipment and bio-security hazards during the composting process.
- **Facility Siting.** Locate on a base of low permeability soils, concrete, or other liner material that will not allow contamination of ground water. The floor of the composting facility shall be at least two feet above the seasonal high water table.
- Locate outside of floodplains when practical; otherwise protect the facility from inundation or damage from a 25-year flood event.
- Locate so that prevailing winds and landscape elements minimize odors and protect visual resources.
- Direct surface runoff away from the compost facility. Direct contaminated runoff from the composting operation to an appropriate storage or treatment facility for further management.
- Locate so that water is available to the facility during dry periods to ensure proper moisture and acceptable curing times to meet the management goals.
- **Facility Type.** Select the type of composting facility or method based on the type and availability of raw material, the desired quality of finished compost, equipment, labor, time and land available.
- Meet the structural requirements of conservation practice standard 313, Waste Storage Facility when designing slabs, walls, and support structures. Meet the requirements of conservation practice standard 367, Roofs and Covers when designing roofs.
- **Facility Size.** Size the composting facility to accommodate the amount of raw material planned for active composting, with a capacity consistent with the composting processes that will be used to produce the desired compost product, and with sufficient finishing time as required to achieve the desired characteristics. Space for compost storage may be included in the finishing space or in a separate facility. Select dimensions to accommodate handling and processing.
- A facility, for manure and other agricultural organic waste that is to be used on the farm, shall have the capacity to produce compost that can be safely stored without undesirable odors. This requires the temperature of the compost to be maintained above 104 ° F for five days with at least four hours above 130 ° F during that time period.
- A facility to produce compost for use off the farm or for sale shall have the capacity to significantly reduce pathogens. For a static pile or within-vessel facility, this requires the temperature of the compost to be maintained above 130oF for three days. The total compost period shall include time for the initial primary stage of composting and time for secondary stage composting. For a windrow system, this requires the temperature of the compost to be above 130oF for 15 days with a minimum of five turnings of the compost.

- **Use of Finished Compost**. Land application of finished compost shall be in accordance with conservation practice standard 590, Nutrient Management (See Section 3.1.14).

3.2. Pasture, Woodland, Wildlife

A large portion of the project area is suitable for pasture, woodland, and wildlife (*See* Figure 8). The following practices are applicable to these areas to enhance the sustainability of the operation and reduce soil erosion.

3.2.1. Brush Management (314)

This practice applies to rangeland, native or naturalized pasture, pasture, and hay lands where removal, reduction, or manipulation of excessive woody plants (non-herbaceous) is desired. This practice may be applied to restore the natural plant community, create the desired plant community, reduce competition, manage noxious woody plants, restore desired vegetative cover to reduce erosion, maintain or enhance wildlife habitat, improve forage accessibility, quality, and quantity for livestock, and protect life and property from wildfire hazards (*See* Appendix 6.21).

The following criteria apply when implementing this practice:

- Brush management will be designed to achieve the desired plant community in woody plant density, canopy cover, or height.
- Brush management will be applied in a manner to achieve the desired control of the target woody species and protection of desired species. This will be accomplished by mechanical, chemical, biological, or a combination of these methods.
- Brush management will be designed and applied only after determining whether or not the State of Hawaii has a biological control program for the target species so as to avoid injuring beneficials.
- Prescribed Grazing shall be applied to ensure desired response from treatments.

3.2.2. Prescribed Grazing (528)

This practice involves managing the harvest of vegetation with grazing and/or browsing animals. The practice may be applied to, improve or maintain desired species composition and vigor of plant communities, improve or maintain quantity and quality of forage for grazing and browsing animals' health and productivity, improve water quality, improve or maintain riparian and watershed function, reduce soil erosion, improve wildlife habitat, and/or manage fine fuel hazards (*See* Appendix 6.22).

The following criteria apply when implementing this practice:

- Removal of herbage will be in accordance with site production limitations, rate of plant growth, and physiological needs of forage plants and the nutritional needs of the animals.
- Adequate quantity and quality drinking water will be supplied at all times during period of occupancy.
- Adjust intensity, frequency, timing and duration of grazing and/or browsing to meet desired objectives for the plant communities and the associated resources, including the grazing and/or browsing animal.
- Manage kind of animal, animal number, grazing distribution, length of grazing and/or browsing periods, and timing of use to provide grazed plants sufficient recovery time to meet planned objectives.
- Provide deferment or rest from grazing or browsing to ensure the success of prescribed fire, brush management, seeding or other conservation practices that cause stress or damage to key plants.
- Manage grazing and/or browsing animals to maintain adequate vegetative cover on sensitive areas (i.e. riparian, wetland, habitats of concern, karst areas).
- Manage livestock movements based on rate of plant growth, available forage, and allowable utilization *or stubble height* target.
- Develop contingency plans to deal with expected episodic disturbance events e.g. insect infestation, drought, wildfire, etc.
- Minimize concentrated livestock areas, trailing, and trampling to reduce soil compaction, excess runoff and erosion.
- Plan intensity, frequency, timing and duration of grazing and/or browsing to provide adequate ground cover, litter and canopy to maintain or improve infiltration and soil condition.

3.2.3. Field Border (386)

This practice involves the establishment of a permanent strip of vegetation at the edge or around the perimeter of a field in order to reduce erosion from wind and water, protect soil and water quality, manage pest populations, provide wildlife food and cover, increase carbon storage, and improve air quality (*See* Appendix 6.23).

The following criteria apply when implementing this practice:

- Field borders shall be established around the field edges to the extent needed to meet the resource needs and producer objectives. Minimum field border widths shall be based on local design criteria specific to the purpose or purposes for installing the practice.

- The field borders shall be established to adapted species of permanent grass, legumes and/or shrubs that accomplish the design objective and do not function as host for diseases of the field crop.

- Plants selected for field borders will have the physical characteristics necessary to control wind and water erosion to tolerable levels on the field border area.

- Seedbed preparation, seeding rates, dates, depths, fertility requirements, and planting methods will be consistent with approved local criteria and site conditions.
- Ephemeral gullies and rills present in the planned border area will be eliminated as part of seedbed preparation. If present, ephemeral gullies and rills located
- Locate borders to eliminate sloping end rows, headlands, and other areas where concentrated water flows will enter or exit the field.
- Orient plant rows as closely as possible to perpendicular to sheet flow direction.

3.2.4. Tree, Shrub Establishment (612)

This practice involves the establishment of woody plants to create forest products, wildlife habitat, long-term erosion control, waste treatment, storing carbon in biomass, energy conservation, improving or restoring natural diversity, and/or enhancing aesthetics (*See* Appendix 6.24).

The following criteria apply when implementing this practice:

- Composition of species will be adapted to site conditions and suitable for the planned purpose(s).
- Species considered locally invasive or noxious shall not be used.
- Planting or seeding rates will be adequate to accomplish the planned purpose for the site.
- Planting dates, and care in handling and planting of the seed, cuttings or seedlings will ensure that planted materials have an acceptable rate of survival.
- Only viable, high-quality and adapted planting stock or seed will be used.
- A precondition for tree/shrub establishment is appropriately prepared sites.
- Adequate seed sources or advanced reproduction needs to be present or provided for when using natural regeneration to establish a stand.
- Selection of planting technique and timing will be appropriate for the site and soil conditions.
- The acceptability and timing of coppice regeneration shall be based on species, age and diameter.
- The planting will be protected from plant and animal pests and fire. If pesticides are used, refer to standard Pest Management (595) (See Section 3.1.13), as appropriate.
- Each site will be evaluated to determine if mulching, supplemental water or other cultural treatments (e.g., tree protection devices, shade cards, brush mats) will be needed to assure adequate survival and growth.

3.3. Aquaculture

The following practices will be required should landowners pursue these activities.

3.3.1. Ponds (378)

This activity involves developing a water impoundment made by constructing an embankment or by excavating a pit or dugout for the purpose of this providing water for livestock, fish and wildlife, recreation, fire control, and other related uses, and to maintain or improve water quality. This standard establishes the minimum acceptable quality for the design and construction of low-hazard ponds that will not damage life or property.

Figure 11 – Aquaculture within the project area

The following are the general criteria that apply to all ponds. Consult NRCS Standard 378 for additional criteria that relate to specific pond structures such as embankment ponds and excavated ponds (*See* Appendix 6.25).

- All federal, State and local requirements shall be addressed in the design.
- The following are legal requirements the cooperator may be required to meet:
  - A permit to construct a dam may be obtained from the State of Hawaii, Department of Land and Natural Resources, Land Division, Engineering Branch, Dam Safety. Permit requirements are listed in Hawaii Administrative Rules, Title 13, Sub-Title 7, Chapter 190, Dams and Reservoirs.
  - In general, dams less than six feet in height regardless of storage capacity or which has a storage capacity at maximum water storage elevation less than fifteen acre-feet (4.9 million gallons) regardless of height would not require approval. Height is measured from the downstream toe to the maximum water level.

- Permit requirements on the right to use surface and ground water resources will be determined by the State of Hawaii, Department of Land and Natural Resources, Commission on Water Resource Management.

- A protective cover of vegetation shall be established on all exposed areas of embankments, spillways and borrow areas as climatic conditions allow, according to the guidelines in conservation practice standard 327 – Conservation Cover (See Section 3.1.7.)
- **Site conditions.** Site conditions shall be such that runoff from the design storm can be safely passed through (1) a natural or constructed auxiliary spillway, (2) a combination of a principal spillway and an auxiliary spillway, or (3) a principal spillway.
- **Drainage area.** The drainage area above the pond must be protected against erosion to the extent that expected sedimentation will not shorten the planned effective life of the structure. The drainage area shall be large enough so that surface runoff and groundwater will provide an adequate supply of water for the intended purpose unless an alternate water source exists to serve this purpose. The quality shall be suitable for the water's intended use.
- **Reservoir area.** The topography and geology of the site shall permit storage of water at a depth and volume that will ensure a dependable supply, considering beneficial use, sedimentation, season of use, and evaporation and seepage losses. If surface runoff is the primary source of water for a pond, the soils shall be impervious enough to prevent excessive seepage losses or shall be of a type that sealing is practicable.

3.3.2. Fish Pond Management (399)

This practice involves the managing of impounded water for the production of fish or other aquatic organisms in order to provide favorable habitat for fish and other organisms, develop and maintain a desired species composition and ratio, and develop and maintain a desired level of production (*See* Appendix 6.26).

The following criteria apply when implementing this practice:

- Structures will meet the requirements of the appropriate National Standard:

i.e., a constructed pond will meet or exceed the requirements of Pond (378)(See Section 3.3.1.).

- Implement State Aquatic Nuisance Species Management Plan recommendations.
- Protect the site from flooding, sedimentation, and contamination.
- Control undesirable aquatic vegetation.
- If ancient Hawaiian fishponds are involved, the requirements of the State of Hawaii, Historic Preservation Office shall be met.

This page intentionally left blank

REFERENCES

4. References

Foote D. E., E. L. Hill, S. Nakamura, and F. Stephens. 1972. *Soil survey of islands of Kauai, Oahu, Maui, Molokai and Lanai, State of Hawaii.* USDA Soil Conservation Service and University of Hawaii Agricultural Experiment Station, Honolulu, Hawaii, USA

Giambelluca, T.W., M.A. Nullet, and T.A. Shcroeder. 1986. Rainfall Atlas of Hawai'I, Report R76, Water Resources Research Center, University of Hawaii at Manoa, with cooperation from the Department of Meteorology, University of Hawaii at Manoa, p. 26.

Ikawa, H., G.Y. Tsuji, and N. Fujii. 2007. Temperature and Rainfall Data of Oahu, Hawaii http://hikawa.htohananet.com/climate-oahu/

Natural Resource Conservation Service (NRCS). 2010. Soil Survey Staff, Natural Resource Conservation Service, United States Department of Agriculture. Web Soil Survey. Available online at http://websoilsurvey.nrcs.usda/gov/ accessed 11/2/2010.

Nichols, W.D., Shade, P.J., and Hunt, C.D., Jr., 1996. Summary of the Oahu, Hawaii, regional aquifer-system analysis: U.S. Geological Survey Professional Paper 1412-A, 61 p.

U.S. Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS). 2006. Land Resource Regions and Major Land Resource Areas of the United States, the Caribbean, and the Pacific Basin,United States Department of Agriculture Handbook 296, 672 p.

U.S. Geological Survey (USGS). 2011. GROUND WATER ATLAS of the UNITED STATES
Alaska, Hawaii, Puerto Rico and the U. S. Virgin Islands. HA 730-N.
http://pubs.usgs.gov/ha/ha730/ch_n/N-HItext3.html

This page intentionally left blank

Submitted to: Windward O'ahu Soil & Water Conservation District
99-193 AIEA HEIGHTS DR STE 109
AIEA, HI 96701

Thomas W. Esgate
TSP 03-1001
700 7th St SW, #325
Washington, DC 20024

Conservation Plan

Kamehameha Schools
567 South King St., Suite 200
Honolulu, Hawaii 96813

OBJECTIVE(S)

Operate an 420.96 acre parcel of land in an environmentally sensative manner so that soil erosion is reduced and soil & water quality are improved.

Tract:

Land Clearing

Allow needed land use adjustments and improvements, such as removing trees, stumps, brush, and other vegetation in order to facilitate the planned use of the land, such as development of cropland, while limiting disturbance to soil.

Field	Planned Amount	Month	Year	Applied Amount	Date
1	150 ac	12	2012		
Total:	150 ac				

Riparian Herbaceous Cover

Create riparian buffer of herbaceous vegetation adjacent to and upgradient from perennial and intermittent watercourses or waterbodies

Field	Planned Amount	Month	Year	Applied Amount	Date
1	14 ac	12	2012		
Total:	14 ac				

Riparian Forest Cover

Create riparian buffer of tree, shrubs, and other vegetation adjacent to and upgradient from perennial and intermittent watercourses or waterbodies

Field	Planned Amount	Month	Year	Applied Amount	Date
1	10 ac	12	2012		
Total:	10 ac				

Grassed Waterway

A natural or constructed waterway will be shaped or graded and established in vegetation suitable to safely dispose or runoff water from field diversions or terraces.

Field	Planned Amount	Month	Year	Applied Amount	Date
1	1 ac	12	2012		
Total:	1 ac				

Contour Farming

Plant crops on the contour to allow cultural operations to follow the lands contour to reduce erosion and runoff.

Field	Planned Amount	Month	Year	Applied Amount	Date
1	20 ac	12	2012		
Total:	20 ac				

Contour Orchard and Other Fruit Area

Plant orchards and vineyards on the contour to allow cultural operations to follow the lands contour to reduce erosion and runoff.

Field	Planned Amount	Month	Year	Applied Amount	Date
1	30 ac	12	2012		
Total:	30 ac				

Terrace

Terraces are constructed to: reduce slope length; reduce erosion; reduce sedimentation in runoff water; intercept and conduct runoff at a nonerosive velocity to a stable outlet; prevent gully development; and improve water quality.

Field	Planned Amount	Month	Year	Applied Amount	Date
1	80,000 sq. ft.	12	2012		
Total:	80,000 sq. ft.				

Conservation Cover

Establish and maintain permanent vegetative cover on lands needing permanent vegetative cover in order to reduce soil erosion and sedimentation.

Field	Planned Amount	Month	Year	Applied Amount	Date
1	5 ac	12	2012		
Total:	5 ac				

Cover Crop

To be applied to provide seasonal cover to achieve conservation purposes.

Field	Planned Amount	Month	Year	Applied Amount	Date
1	20 ac	12	2012		
Total:	20 ac				

Fence

Construct a fence for use as a barrier to wildlife, livestock, or people. A "Fencing Plan" will be provided specifying the type of fencing materials and installation specifications.

Operation and Maintenance:
Inspect the fences on a regular basis. Inspect fences after storm events. Maintenance and repairs will be performed in a timely manner as needed.

Field	Planned Amount	Month	Year	Applied Amount	Date
1	10,000 ft	12	2012		
Total:	10,000 ft				

Residue Management

Manage amount, orientation and distribution of organic residue so maximum amounts are left on the soil surface by using mulch tillage techniques and implements such as chisels, sweeps and harrows.

Field	Planned Amount	Month	Year	Applied Amount	Date
1	271 ac	12	2012		
Total:	271 ac				

Integrated Pest Management

To be applied on active crop lands where herbicides such as roundup and honcho are used.

Field	Planned Amount	Month	Year	Applied Amount	Date
1	200 ac	12	2012		
Total:	200 ac				

Nutrient Management

Practice to be applied for managing the application of commercial nutrients such as chemical fertilizer, pelletized manure, or processed compost.

Field	Planned Amount	Month	Year	Applied Amount	Date
1	200 ac	12	2012		
Total:	200 ac				

Pipeline

Pipeline will be installed according to NRCS standards and specifications for the safe conveyance of water for livestock from tank to troughs. Plastic pipes shall be buried 6 inches if there are no hazards from traffic or farm operations, and a minimum of 18 inches if hazards are present. All pipe sizes, fittings, reduces, etc. will be installed according to NRCS standards and specifications.

Field	Planned Amount	Month	Year	Applied Amount	Date
1	500 ft	12	2012		
Total:	500 ft				

Windbreak/Shelterbelt Establishment

Plant single or multiple rows of trees or shrubs.
A [# rows] row tree windbreak/shelterbelt will be established. Banana may be used within crops.

Field	Planned Amount	Month	Year	Applied Amount	Date
1	1,000 ft	12	2012		
Total:	1,000 ft				

Brush Management

Control undesirable woody vegetation by mechanical, chemical, or biological means to improve plant cover for livestock, wildlife, and erosion control.

Field	Planned Amount	Month	Year	Applied Amount	Date
1	50 ac	12	2012		
Total:	50 ac				

Prescribed Grazing

Grazing will be managed according to a schedule that meets the needs of the soil, water, air, plant and animal resources and the objectives of the resource manager.
A “Prescribed Grazing and Maintenance Plan” will be provided to you that outline the grazing and rest periods for your specific operation.

Field	Planned Amount	Month	Year	Applied Amount	Date
1	39 ac	12	2012		
Total:	39 ac				

Field Border

Establishment of a permanent strip of vegetation at the edge or around the perimeter of a field in order to reduce erosion. In most cases existing vegetation will be used.

Field	Planned Amount	Month	Year	Applied Amount	Date
1	10,000 ft	12	2012		
Total:	10,000 ft				

Tree/Shrub Establishment

Chiseling and subsoiling will be done, without inverting and with a minimum of mixing of the surface soil, to shatter restrictive layers below normal plow depth that inhibit water movement or root development, to improve water and root penetration and aeration. (less than 5% slopes, across the slope) (over 6% slopes shall be on contour). Primarily banana and papaya.

Field	Planned Amount	Month	Year	Applied Amount	Date
1	50 ac	12	2012		
Total:	50 ac				

Ponds

Development of a water impoundment made by constructing an embankment or by excavating a pit or dugout for the purpose of providing water for livestock, fish and wildlife, recreation, fire control, and other related uses, and to maintain or improve water quality. No new ponds are contemplated. This practice is included to provide guidance for possible modifications to exisitng ponds.

Field	Planned Amount	Month	Year	Applied Amount	Date
1	18 ac	12	2012		
Total:	18 ac				

Fish Pond Management

Management of impounded water for the production of fish or other aquatic organisms in order to provide favorable habitat for fish and other organisms, develop and maintain a desired species composition and ratio, and develop and maintain a desired level of production.

Field	Planned Amount	Month	Year	Applied Amount	Date
1	18 ac	12	2012		
Total:	18 ac				

Recreational Land Grading and Shaping

Establish or improve effective use of land for recreation use while minimizing on-site and off-site damage to resources from recreational land use.

Field	Planned Amount	Month	Year	Applied Amount	Date
1	10 ac	12	2012		
Total:	10 ac				

Road

Maintain exisiting roads and restore unused roads where necessary to reclaim and utilize cropland. Improve drainage to minimize erosion while limiting disturbance of soil.

Field	Planned Amount	Month	Year	Applied Amount	Date
1	98,059 sq. yd.	12	2012		
Total:	98,059 sq. yd.				

Stream Crossing

Provide a travel way for people, livestock, equipment, or vehicles for the purposes of improving water quality and/or reducing streambank and stream bed Applies to one existing crossing

Field	Planned Amount	Month	Year	Applied Amount	Date
1	1 ea.	12	2012		
Total:	1 ea.				

Irrigation System, Micro Irrigation

Efficiently and uniformly apply existing irrigation water supplies or to achieve water supplies or to achieve other allowable conservation purposes

Field	Planned Amount	Month	Year	Applied Amount	Date
1	271 ac.	12	2012		
Total:	271 ac.				

Irrigation Water Management

Efficiently and uniformly apply existing irrigation water supplies or to achieve water supplies or to achieve other allowable conservation purposes

Field	Planned Amount	Month	Year	Applied Amount	Date
1	271 ac.	12	2012		
Total:	271 ac.				

Surface Drainage, Field Ditch

Applies to Farm Plot 17. Engineering to be completed in stream restoration plan/phase. Manage water supplies to achieve conservation purposes.

Field	Planned Amount	Month	Year	Applied Amount	Date
1	9 ac.	12	2012		
Total:	9 ac.				

Composting Facility

Structure to contain and facilitate the decomposition of organic material. Anticipate that one or more existing ponds may be retired and used to compost vegetation removed from reclaimed areas.

Field	Planned Amount	Month	Year	Applied Amount	Date
1	20,000 sq. ft.	12	2012		
Total:	20,000 sq. ft.				

CERTIFICATION OF PARTICIPANTS

Kamehameha Schools DATE

CERTIFICATION OF:

CONSERVATION DISTRICT

Windward O'ahu Soil & Water Conservation District DATE

Appendix E

Hydraulic Modeling Output of 90% Level Restoration Design

Memorandum

Date:	January 6, 2014
To:	Kaeo Duarte Kamehameha Schools - Land Assets Division 78-6831 Alii Drive Suite 235 Kailua-Kona, Hawaii 96740
Cc:	Imiola Lindsey; Rocky Hrachovec; Tim Abbe; Leo Lentsch
From:	Brendan Belby ICF International
Subject:	**Punaluʻu Flood Modeling of 90% Design**

This memo summarizes the results of Punaluʻu Stream flood modeling of the 90% design.

The 90% design elevation surface was used to update the HEC-RAS model for the project and map the predicted areas that would be flooded for annual recurrence intervals of 2, 5, 10, 25, 50, and 100-yr events. Manning's n roughness values were also updated in the model to reflect the proposed land use changes at the site. Note the results include all the features depicted in the 90% drawings, including work on the north bank of Punaluʻu Stream.

The attached pdf contains plots comparing the modeled water surface elevations for the 90% design and the existing condition. The design does not create a rise in the 100-yr flood in the lower reach compared to existing conditions for the first 2,600 feet upstream of the bridge. The 90% design 100-yr water surface is up to 0.8 feet lower than the existing condition for stream stations 1200-2600. The 90% design produces up to 1.1 feet higher 100-yr water surface elevations for stations 2700-3900. The relocated and elevated Green Valley Road contains the increased water surface elevations in this reach. The rise in water surface elevations in this reach is due to increased flow resistance in the 90% design (use of higher Manning's n roughness values) to reflect the conversion of agricultural and fallow land, and aquaculture ponds, within the corridor into more flow restrictive forest and orchard. Similar trends are exhibited in the other recurrence interval plots. The effect of creation of the estuary and removing the stream's artificial berms on lowering 90% design water surface elevations in the lower reach is evident on the 2 and 5-yr plots.

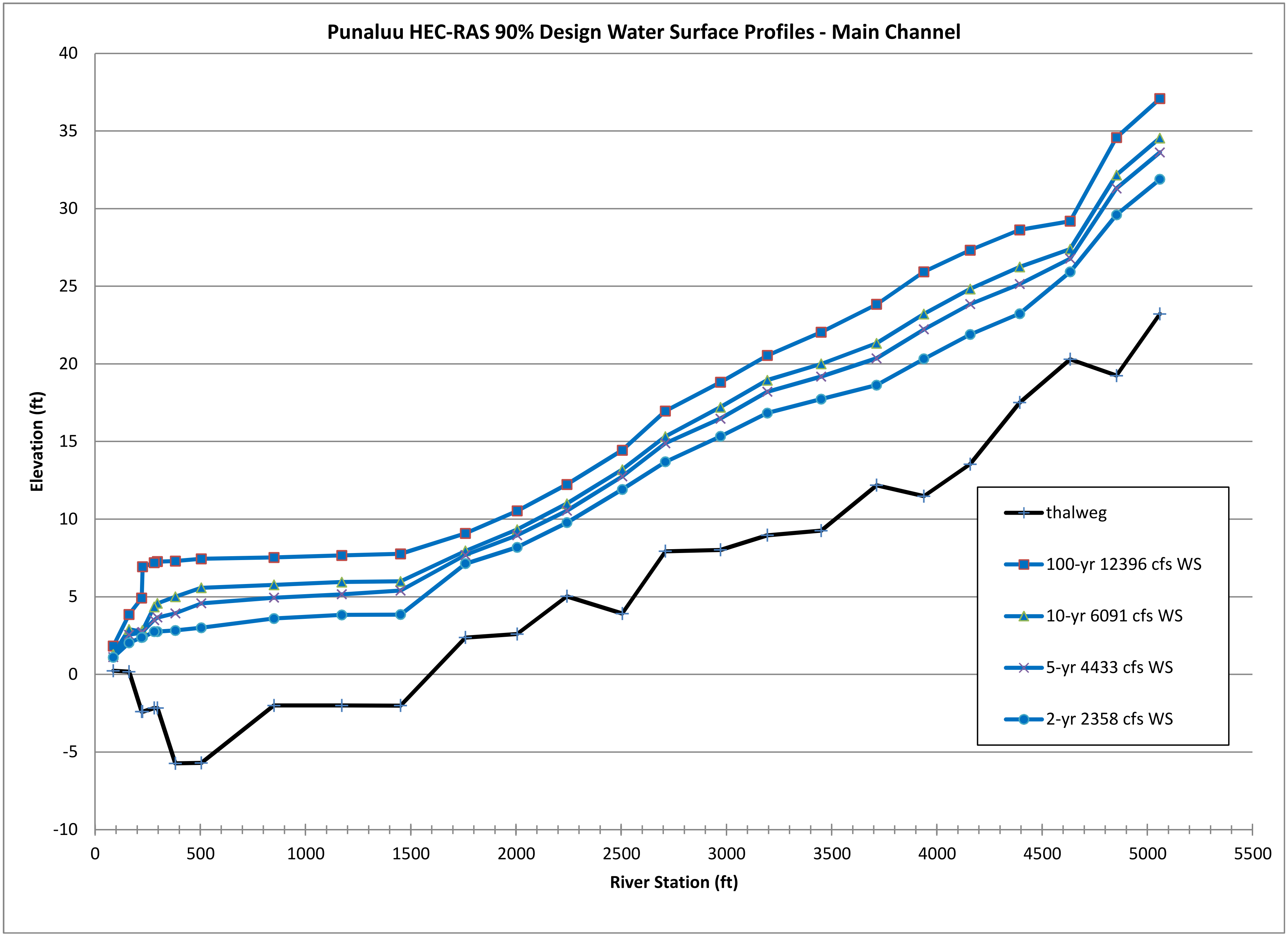
A label is placed on all the maps to state that the flood maps only depict flooding from overbanking of Punaluʻu Stream, and they do not depict other sources of water that could also result in flooding (e.g., rainfall ponding, hillslope runoff, flooded ditches). The label is added in part due to the responses we received from the community when they reviewed the existing condition flood maps and pointed out additional areas that flood due to rainfall and poor drainage. We want to be clear with local residents who may see the maps on what the map is depicting and what it is not depicting. Please let me know if you want to remove or modify the disclaimer.

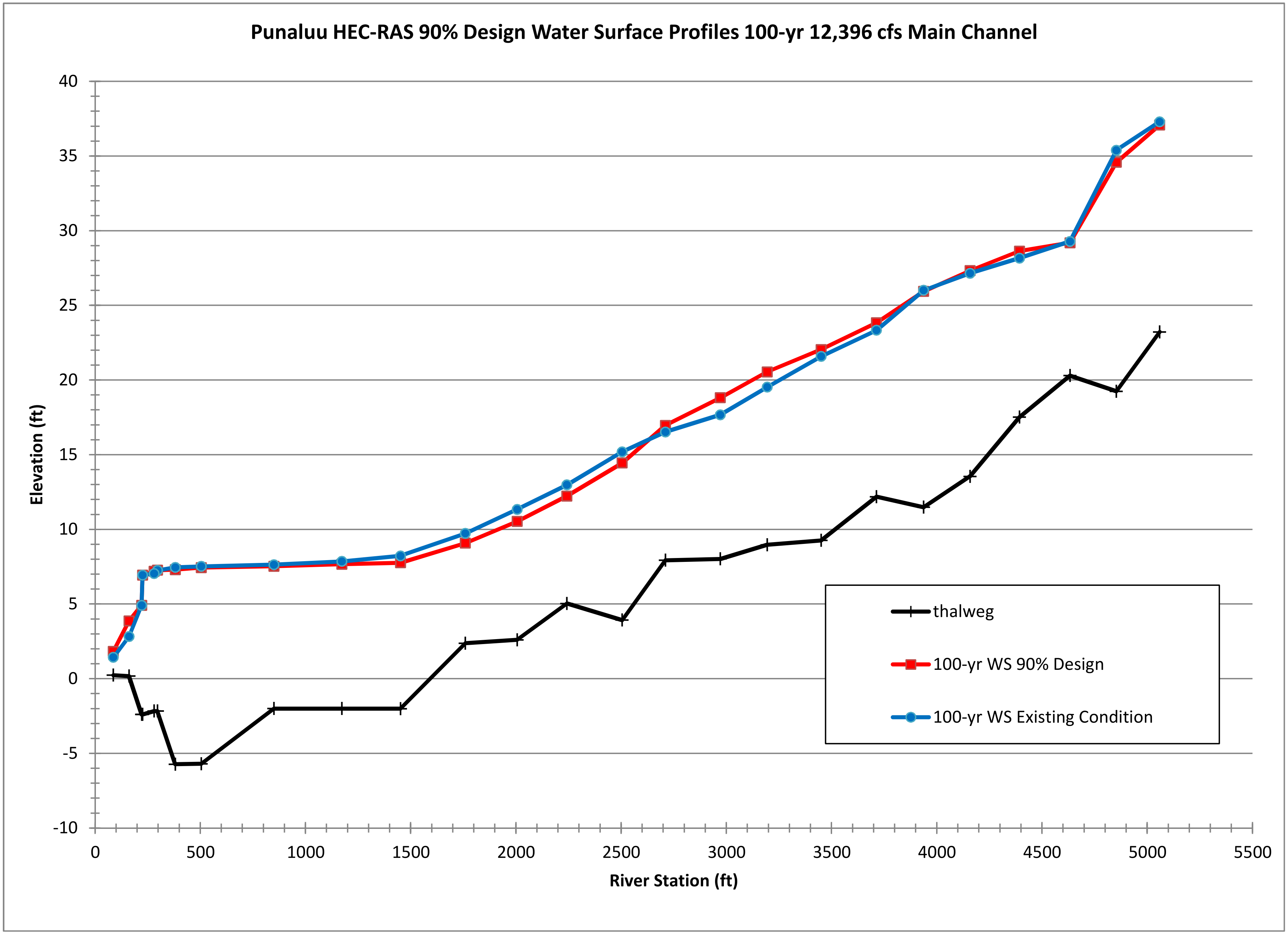
The maps in the attached pdf illustrate how placing fill on KS land to create the agriculture terrace south of relocated Green Valley Road is effective at keeping this area dry during for all flows modeled. Placement of additional fill on the south side of Punaluʻu Ditch upstream of the highway, including the proposed Farmers Market area, has a similar effect of preventing flood water inundation. Areas on non-KS land further to the south and east would continue to flood, as under existing conditions. The project does not make flooding worse for the non-KS parcels. This area is in a depression (lower elevations than the land closer to the highway) and is inundated with backwater due to water ponding at the highway. The maps depict proposed cut and fill at 2 foot intervals to illustrate where work would occur and show how the proposed earthwork is related to predicted flood conditions.

Placement of fill in the pasture near Darrell's house prevents Punaluʻu Stream flood water from inundating the land where the fill is placed. The strip of land between the fill placement and the highway, which includes Darrell's house, would still be inundated from Punaluʻu Stream flood water at the 50 and 100-yr flows.

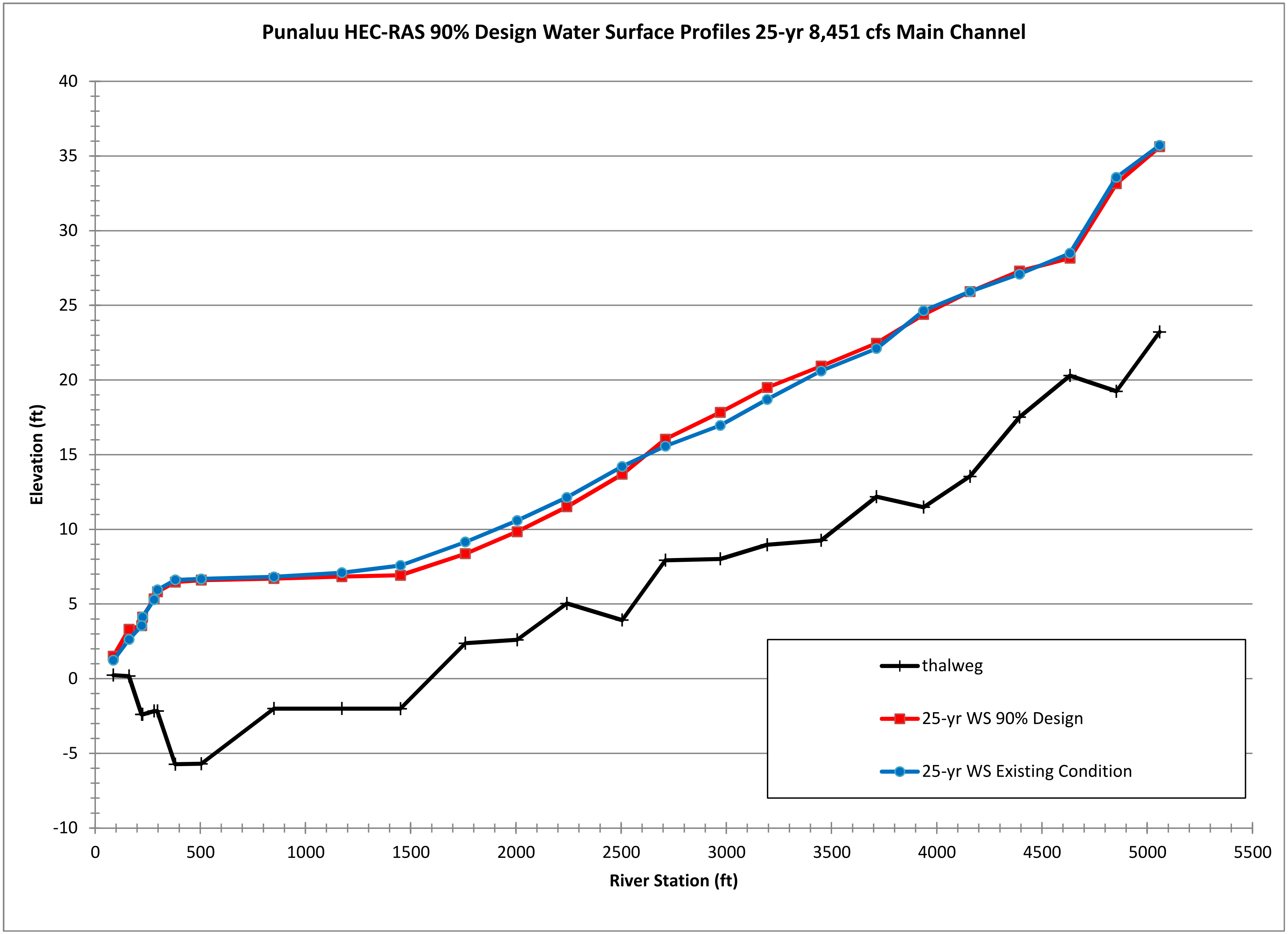
Some minor modifications will be made to the 90% grading plan based on the modeling results to slightly adjust cut elevations in a few of the berm removal areas to improve floodplain connectivity.

Please let me know of any other concerns or design changes you think should be made based upon your review of the flood profiles and maps.

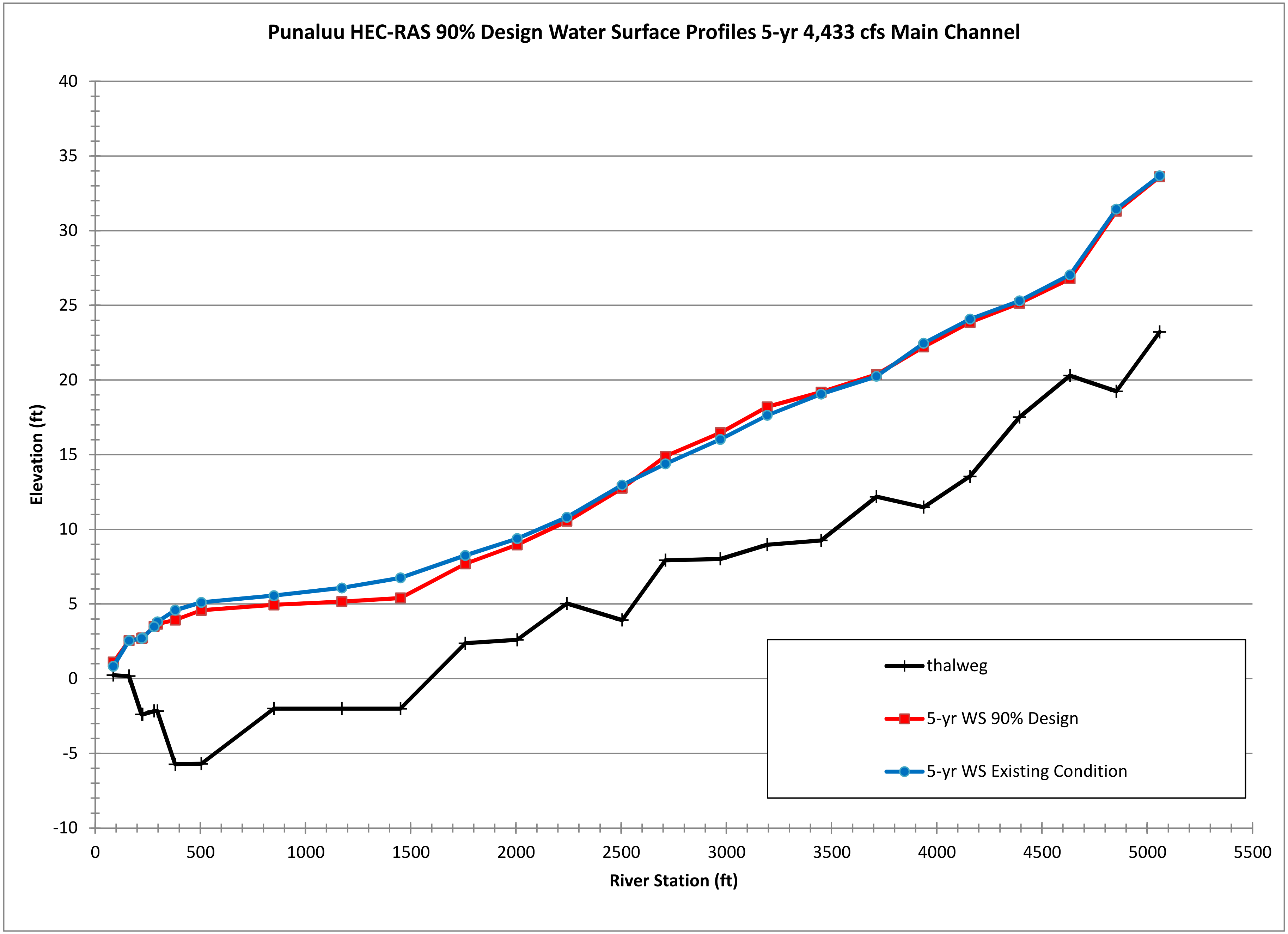

Punaluu HEC-RAS 90% Design Water Surface Profiles - Main Channel
Elevation (ft)
River Station (ft)
40
35
30
25
20
15
10
5
0
-5
-10
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
thalweg
100-yr 12396 cfs WS
10-yr 6091 cfs WS
5-yr 4433 cfs WS
2-yr 2358 cfs WS



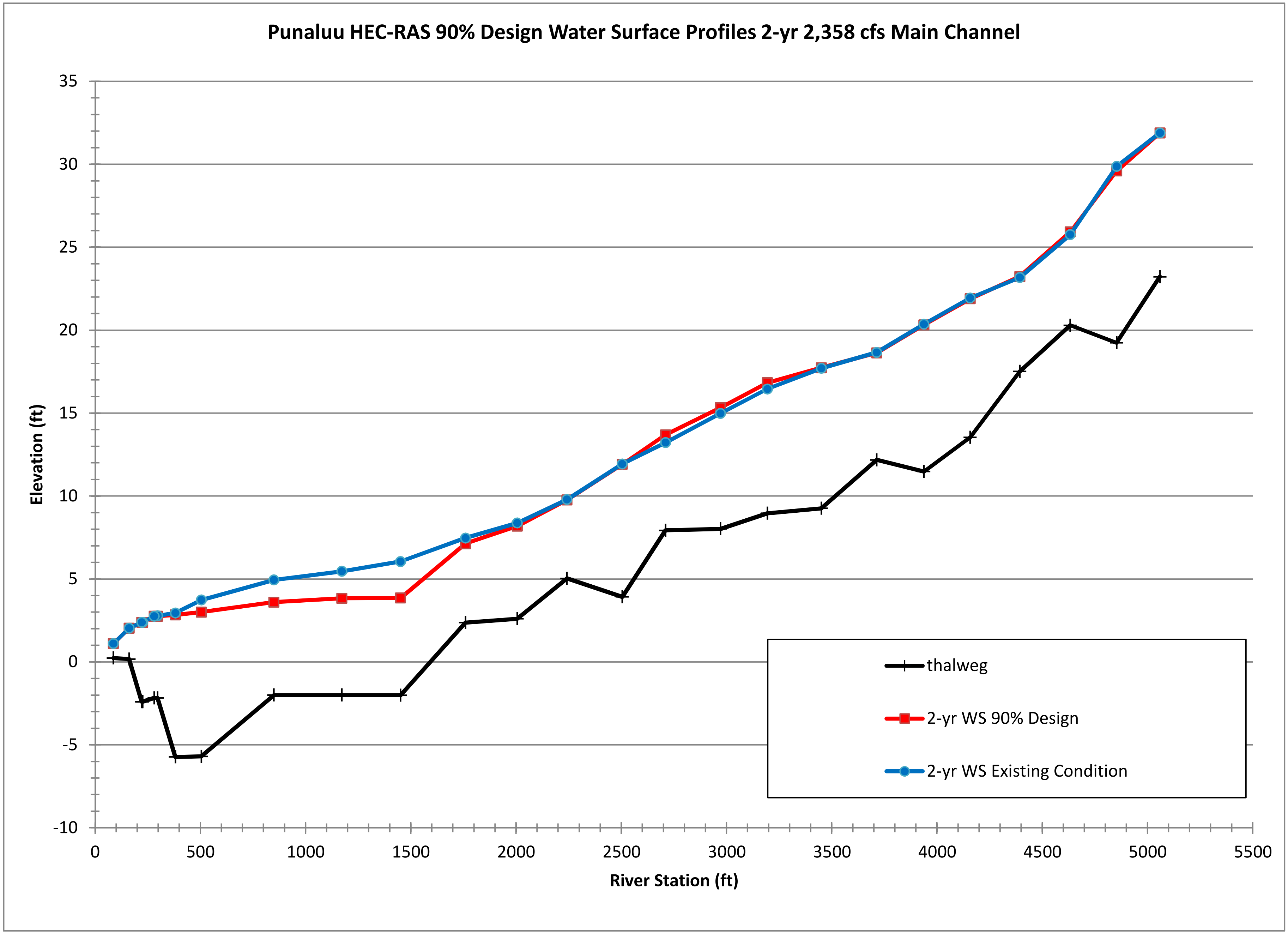
Punaluu HEC-RAS 90% Design Water Surface Profiles 100-yr 12,396 cfs Main Channel
Elevation (ft)
40
35
30
25
20
15
10
5
0
-5
-10
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
River Station (ft)
thalweg
100-yr WS 90% Design
100-yr WS Existing Condition



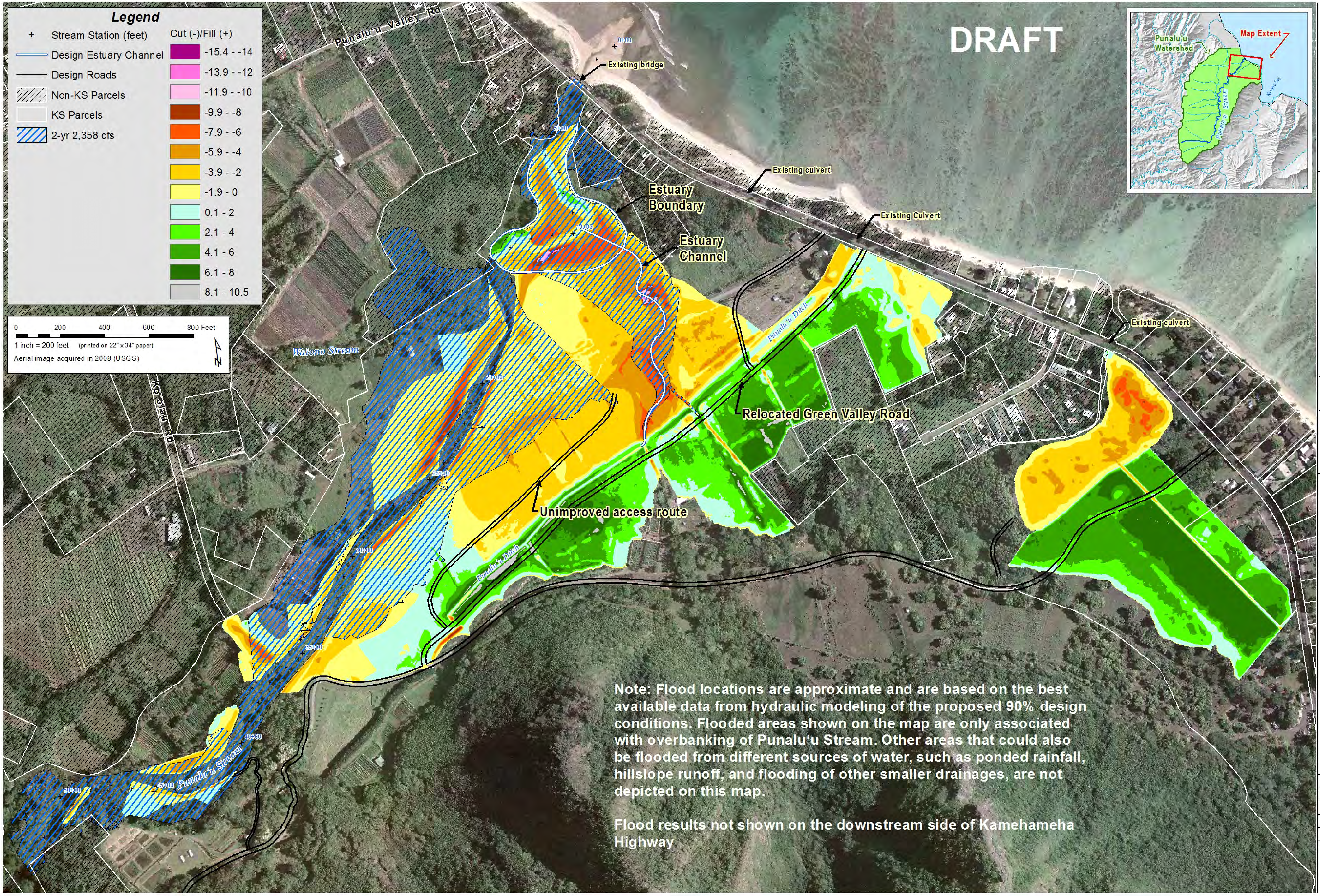
Punaluu HEC-RAS 90% Design Water Surface Profiles 25-yr 8,451 cfs Main Channel
Elevation (ft)
40
35
30
25
20
15
10
5
0
-5
-10
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
River Station (ft)
thalweg
25-yr WS 90% Design
25-yr WS Existing Condition



Punaluu HEC-RAS 90% Design Water Surface Profiles 5-yr 4,433 cfs Main Channel
Elevation (ft)
River Station (ft)
40
35
30
25
20
15
10
5
0
-5
-10
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
thalweg
5-yr WS 90% Design
5-yr WS Existing Condition



Punaluu HEC-RAS 90% Design Water Surface Profiles 2-yr 2,358 cfs Main Channel
Elevation (ft)
35
30
25
20
15
10
5
0
-5
-10
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
River Station (ft)
thalweg
2-yr WS 90% Design
2-yr WS Existing Condition



Natural Systems Design
P.O. Box 15609
Seattle, WA 98115

ICF INTERNATIONAL
630 K STREET, SUITE 400
SACRAMENTO, CA 95814
TEL: (916) 737-3000 icfi.com

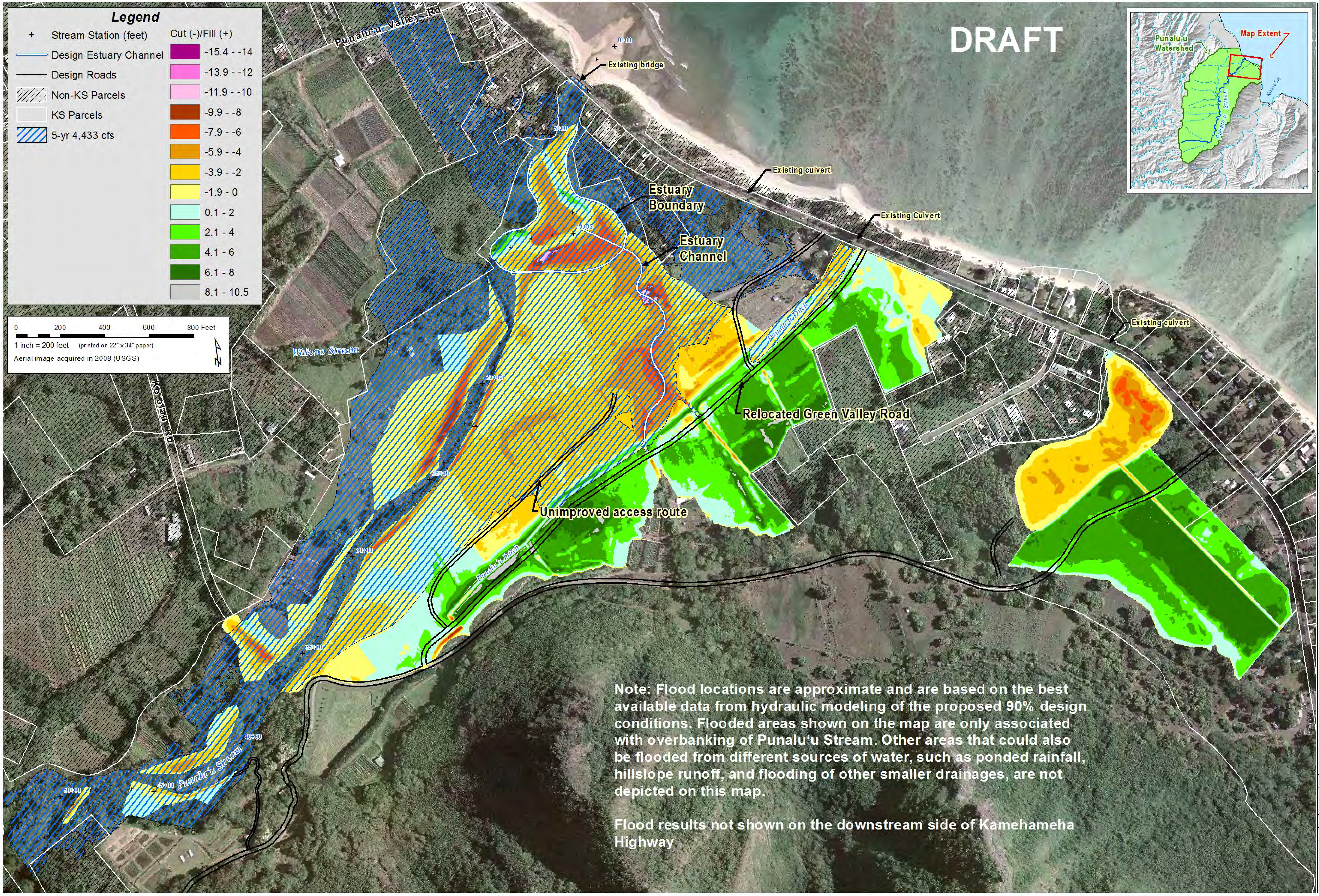
KAMEHAMEHA SCHOOLS · 1887 · IMUA

90% Design Plan Modeled Flooding
2-yr Recurrence Interval 2,358 cfs

Punalu'u Flood Mitigation and Stream Restoration

Punalu'u Stream O'ahu, Hawai'i

DATE:	01/03/2014
DESIGNED BY:	BB, TA, MH
DRAWN BY:	BB
CHECKED BY:	__
PROJECT NO:	00640.12
PLAN NO:	1
SHEET	1 of 1



Natural Systems Design
P.O. Box 15609
Seattle, WA 98115

ICF INTERNATIONAL
630 K STREET, SUITE 400
SACRAMENTO, CA 95814
TEL: (916) 737-3000 icfi.com

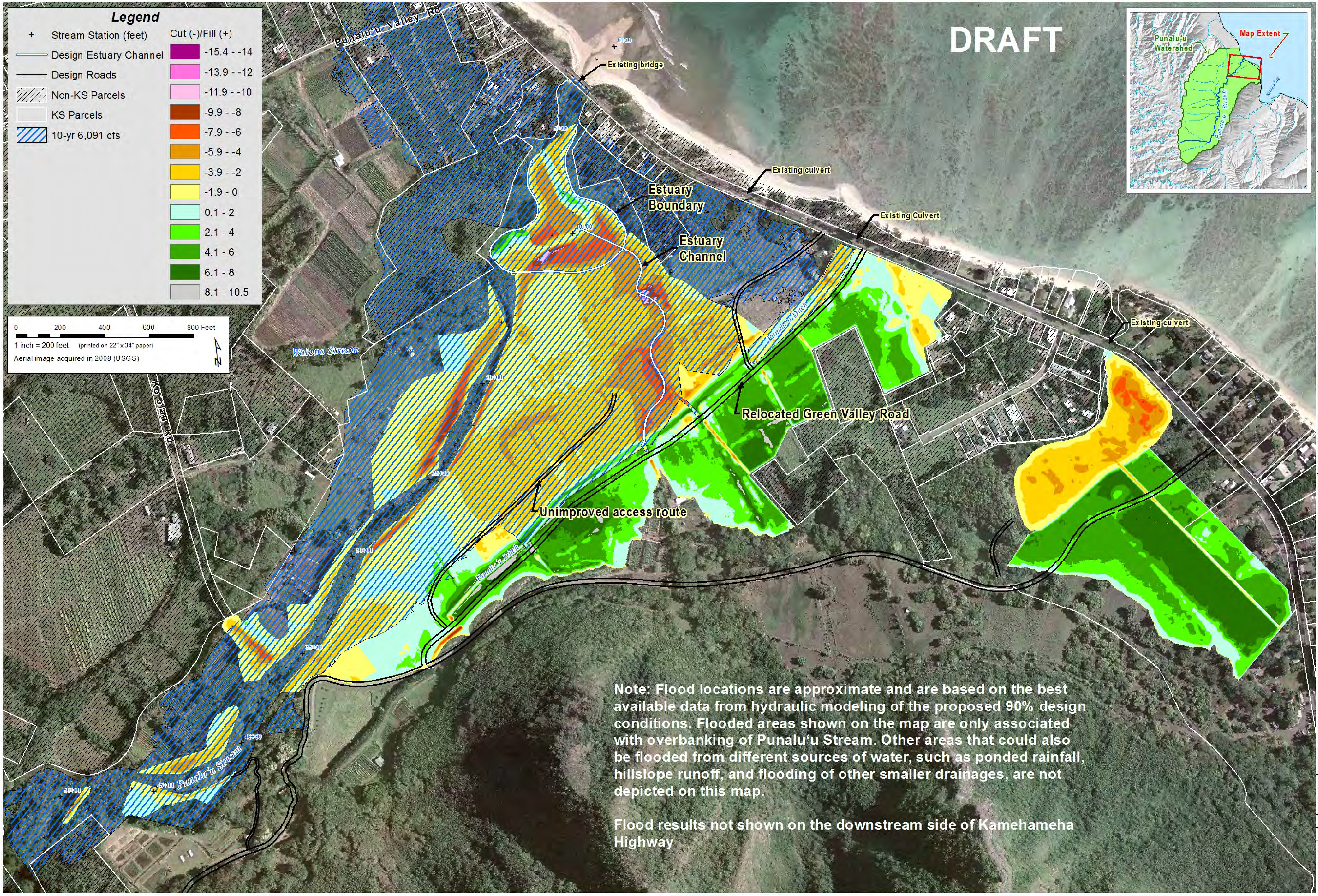
KAMEHAMEHA SCHOOLS · 1887 · IMUA

90% Design Plan Modeled Flooding
5-yr Recurrence Interval 4,433 cfs

Punalu'u Flood Mitigation and Stream Restoration

Punalu'u Stream O'ahu, Hawai'i

DATE:	01/03/2014
DESIGNED BY:	BB, TA, MH
DRAWN BY:	BB
CHECKED BY:	__
PROJECT NO:	00640.12
PLAN NO:	1
SHEET	1 of 1



Note: Flood locations are approximate and are based on the best available data from hydraulic modeling of the proposed 90% design conditions. Flooded areas shown on the map are only associated with overbanking of Punalu'u Stream. Other areas that could also be flooded from different sources of water, such as ponded rainfall, hillslope runoff, and flooding of other smaller drainages, are not depicted on this map.

Flood results not shown on the downstream side of Kamehameha Highway

Natural Systems Design
P.O. Box 15609
Seattle, WA 98115

630 K STREET, SUITE 400
SACRAMENTO, CA 95814
TEL: (916) 737-3000 icfi.com

90% Design Plan Modeled Flooding
10-yr Recurrence Interval 6,091 cfs

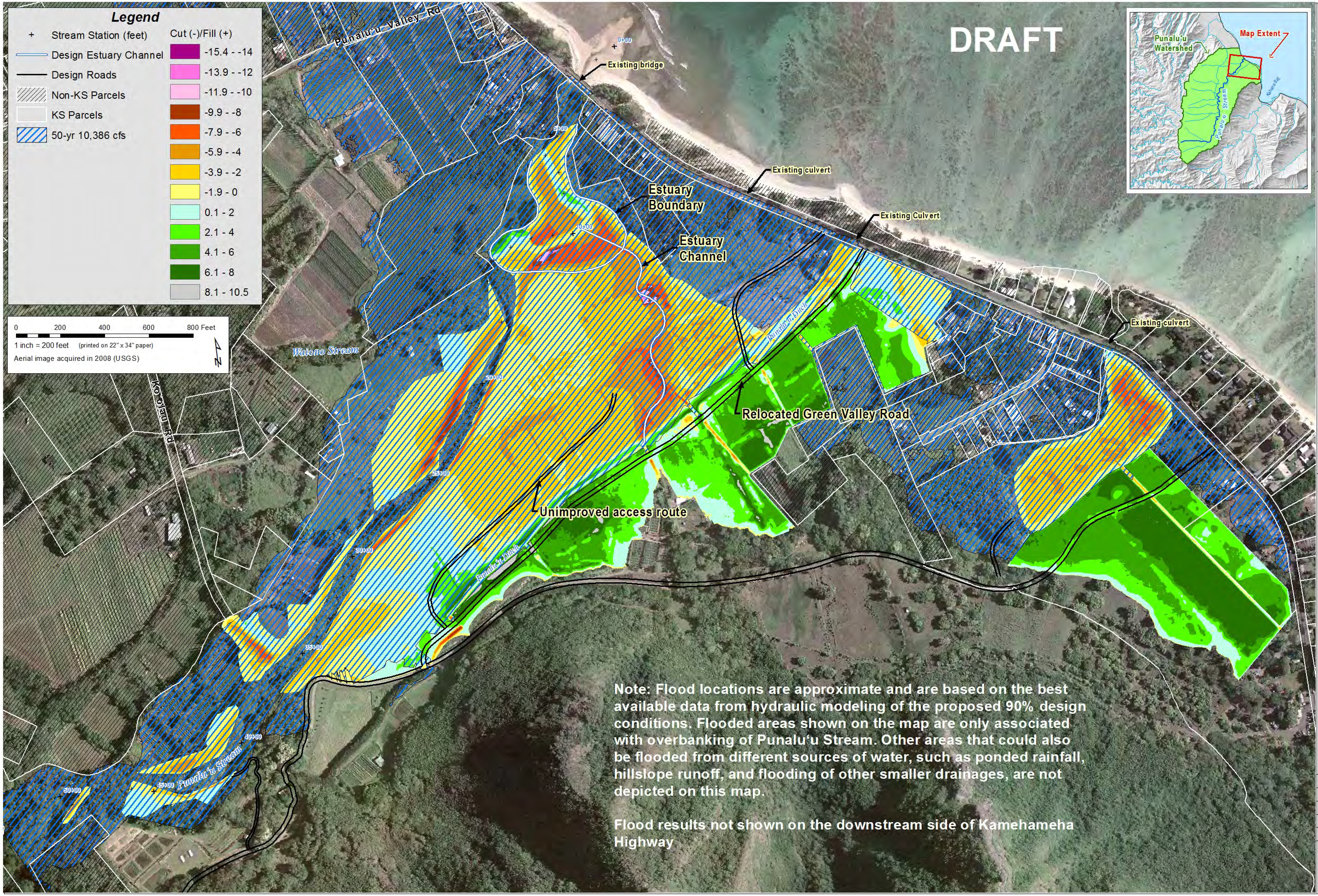
Punalu'u Flood Mitigation and Stream Restoration

Punalu'u Stream   O'ahu, Hawai'i

DATE:	01/03/2014
DESIGNED BY:	BB, TA, MH
DRAWN BY:	BB
CHECKED BY:	__
PROJECT NO:	00640.12
PLAN NO:	1

SHEET 1 of 1


DRAFT
Legend
Stream Station (feet)
Design Estuary Channel
Design Roads
Non-KS Parcels
KS Parcels
25-yr 8,451 cfs
Cut (-)/Fill (+)
-15.4 - -14
-13.9 - -12
-11.9 - -10
-9.9 - -8
-7.9 - -6
-5.9 - -4
-3.9 - -2
-1.9 - 0
0.1 - 2
2.1 - 4
4.1 - 6
6.1 - 8
8.1 - 10.5
0 200 400 600 800 Feet
1 inch = 200 feet (printed on 22" x 34" paper)
Aerial image acquired in 2008 (USGS)
Punalu'u Valley Rd
Existing bridge
Existing culvert
Existing Culvert
Existing culvert
Estuary Boundary
Estuary Channel
Relocated Green Valley Road
Unimproved access route
Waiono Stream
Punalu'u Stream
Punalu'u Watershed
Map Extent
Note: Flood locations are approximate and are based on the best available data from hydraulic modeling of the proposed 90% design conditions. Flooded areas shown on the map are only associated with overbanking of Punalu‘u Stream. Other areas that could also be flooded from different sources of water, such as ponded rainfall, hillslope runoff, and flooding of other smaller drainages, are not depicted on this map.
Flood results not shown on the downstream side of Kamehameha Highway
Natural Systems Design
P.O. Box 15609 Seattle, WA 98115
630 K STREET, SUITE 400 SACRAMENTO, CA 95814 TEL. (916) 737-3000 icfi.com
ICF INTERNATIONAL
KAMEHAMEHA SCHOOLS · 1887 · IMUA
90% Design Plan Modeled Flooding
25-yr Recurrence Interval 8,451 cfs
Punalu'u Flood Mitigation and Stream Restoration
Punalu'u Stream O'ahu, Hawai'i
DATE: 01/03/2014
DESIGNED BY: BB, TA, MH
DRAWN BY: BB
CHECKED BY: __
PROJECT NO: 00640.12
PLAN NO: 1
SHEET 1 of 1



Natural Systems Design
P.O. Box 15609
Seattle, WA 98115

ICF INTERNATIONAL
630 K STREET, SUITE 400
SACRAMENTO, CA 95814
TEL: (916) 737-3000 icfi.com

KAMEHAMEHA SCHOOLS · 1887 · IMUA

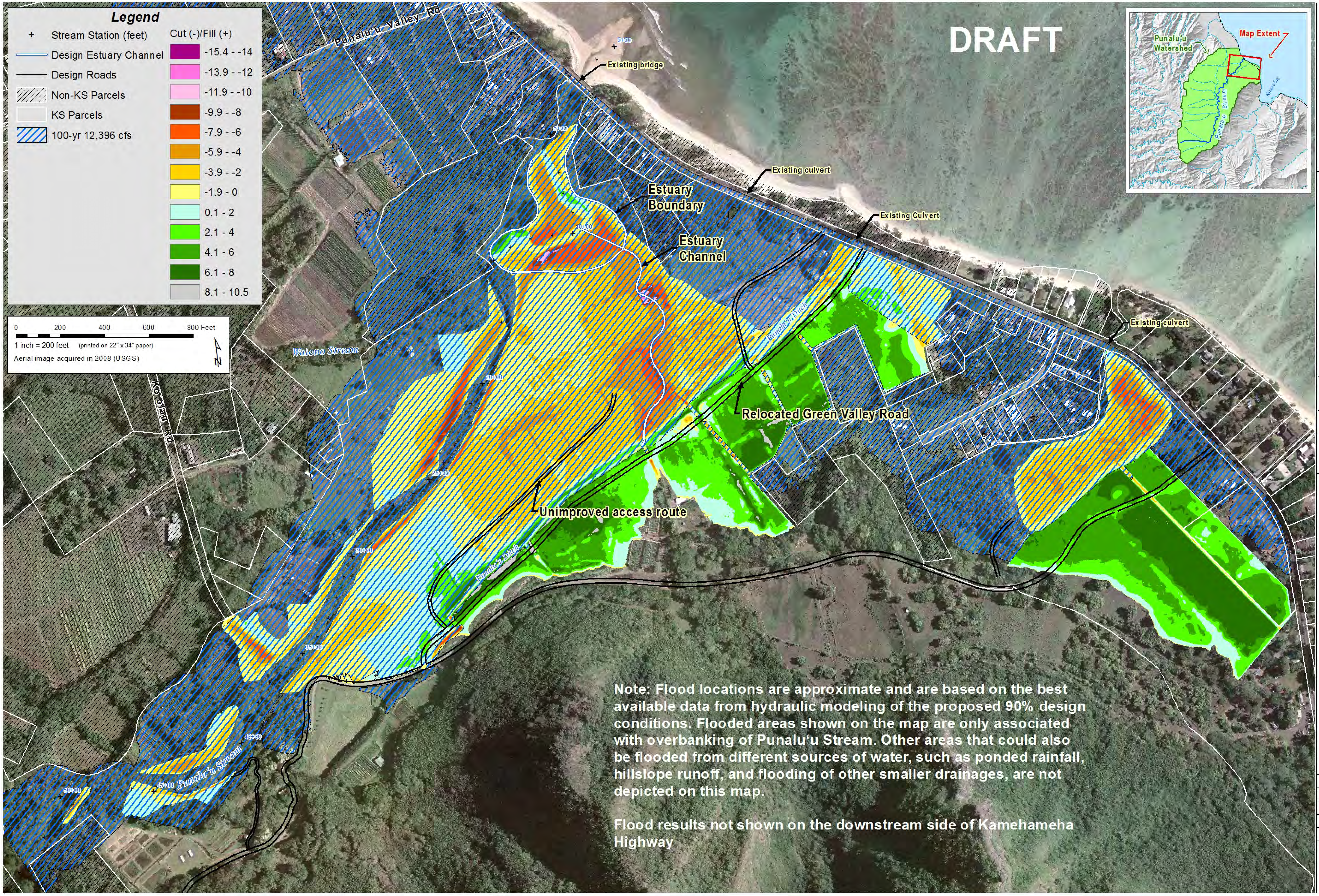
90% Design Plan Modeled Flooding
50-yr Recurrence Interval 10,386 cfs

Punalu'u Flood Mitigation and Stream Restoration

Punalu'u Stream O'ahu, Hawai'i

DATE:	01/03/2014
DESIGNED BY:	BB, TA, MH
DRAWN BY:	BB
CHECKED BY:	__
PROJECT NO:	00640.12
PLAN NO:	1

SHEET 1 of 1



Natural Systems Design
P.O. Box 15609
Seattle, WA 98115

630 K STREET, SUITE 400
SACRAMENTO, CA 95814
TEL: (916) 737-3000 icfi.com

ICF INTERNATIONAL

KAMEHAMEHA SCHOOLS · 1887 · IMUA

90% Design Plan Modeled Flooding
100-yr Recurrence Interval 12,396 cfs

Punalu'u Flood Mitigation and Stream Restoration

Punalu'u Stream O'ahu, Hawai'i

DATE:	01/03/2014
DESIGNED BY:	BB, TA, MH
DRAWN BY:	BB
CHECKED BY:	__
PROJECT NO:	00640.12
PLAN NO:	1

SHEET 1 of 1

Appendix F

Archaeological Inventory Survey

— Draft —

Archaeological Inventory Survey for the Punaluʻu Habitat Bank and Stream Restoration Project, Makaua, Punaluʻu, and Waiʻono Ahupuaʻa, Koʻolauloa Moku, Oʻahu

TMK (1) 5-3-001:041 (portion), (1) 5-3-001:052 (portion), and (1) 5-3-003:001 (portion)

Prepared by:

Chris Filimoehala
Myra J. Tomonari-Tuggle
and
Timothy M. Rieth

Prepared for:

Kamehameha Schools
1887 Makuakane Street
Honolulu, Hawaiʻi 96817

INTERNATIONAL ARCHAEOLOGICAL RESEARCH INSTITUTE, INC.
December 2014

— Draft —

ARCHAEOLOGICAL INVENTORY SURVEY FOR THE PUNALU‘U HABITAT BANK AND STREAM RESTORATION PROJECT, MAKAUA, PUNALU‘U, AND WAI‘ONO AHUPUA‘A, KO‘OLAULOA MOKU, O‘AHU

TMK (1) 5-3-001:041 (PORTION), (1) 5-3-001:052 (PORTION), AND (1) 5-3-003:001 (PORTION)

Prepared by:

Chris Filimoehala, M.A.
Myra J. Tomonari-Tuggle, M.A.
Timothy M. Rieth, M.A.

Prepared for:

Kamehameha Schools
1887 Makuakane Street
Honolulu, Hawai‘i 96817

International Archaeological Research Institute, Inc.
2081 Young Street
Honolulu, HI 96826

December 2014

ABSTRACT

International Archaeological Research Institute, Inc., completed an archaeological inventory survey of the planned Punaluʻu Habitat Bank and Stream Restoration Project, encompassing 119.8 acres within Punaluʻu, Makaua, and Waiʻono Ahupuaʻa. The work was conducted to fulfill Kamehameha School's historic preservation obligations per Section 106 of the National Historic Preservation Act (NHPA) and Hawaiʻi Revised Statute Chapter 6E-42. The inventory survey included a pedestrian survey and the excavation of 25 backhoe trenches within the two project parcels (identified as the Punaluʻu Valley and Kahana Components). Pedestrian survey was accomplished via three methods: re-location of previously recorded sites; re-survey of previously surveyed areas, and; inventory-level survey of previously unsurveyed areas. Survey work included textual feature descriptions, photography, and mapping of most features. During backhoe trench investigations, scaled stratigraphic profiles were drawn and soils recorded for each trench. Locations of all features and trenches were recorded with submeter accuracy using a Global Positioning System (GPS) unit.

Six archaeological sites were identified. These sites are a valley-bottom irrigation network dating to the early to mid-20th century (Site 50-80-06-7236), a mid-20th century complex of concrete foundations and a pond (Site 50-80-06-7718), an isolated buried *imu* (Site 50-80-06-7727), a buried pondfield terrace (Site 50-80-06-7728), and two buried 19th century *loʻi* soils (Sites 7733 and 7734).

Site 7236, a historic irrigation ditch network, is significant under Criteria a and d per Hawaii Administrative Rule (HAR) §13-284-6, and Criteria A and D following the National Register of Historic Places (NRHP) significance evaluation criteria. Site 7236 is a local (Punaluʻu Valley) example of the 20th century agricultural infrastructure that was engineered across vast swaths of the islands as part of the archipelago-wide plantation agricultural economy (Criterion a/Criterion A). Plantation agriculture during the 19th and 20th centuries had wide-ranging and dramatic effects on the landscape, food and agricultural commodity production, larger economy, politics, and demography. This ditch network, which includes branches constructed as early as 1907 through the mid- to late-20th century, was an integral component of historic agricultural activities in the valley. The layout and orientation of these ditches provides important information pertaining to individual agricultural plots, the integration of these plots into a larger irrigated planting system, and the types of plants that could have been grown (Criterion d/Criterion D).

Site 7718, a complex of concrete foundations and a stone-lined pond, is significant under Criterion d (HAR §13-284-6) and Criterion D (NRHP). Following this criterion, recording of this site provides general information about habitation in this part of the valley during mid-20th century.

Site 7727, an *imu*, was destroyed and data recovered by excavation, and therefore is no longer significant. Data from this site does relate late pre- to early post-Contact habitation in the valley.

Site 7728, a buried terrace, is significant under Criterion d (HAR §13-284-6) and Criterion D (NRHP). Following these criteria, recording of this feature provides information about agriculture in this portion of the

valley. This site is particularly informative because surface remnants of older agricultural infrastructure has been destroyed or modified by 19th and 20th century activities.

The Sites 7733 and 7734, buried 19th century *lo'i* soils, are significant under Criterion d (HAR §13-284-6) and Criterion D (NRHP). The agricultural soil relates to *lo'i* in production during the first half of the 19th century, and as such documents the last stage of traditional agriculture in the valley before the significant changes initiated by commercial agriculture.

Data recorded at all sites is recommended to be sufficient documentation; however, archaeological monitoring (based on an approved Archaeological Monitoring Plan) is recommended during all ground-disturbing construction activities. Monitoring will also include educating the construction personnel about the presence of the archaeological site and the potential for additional discoveries.

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

LIST OF FIGURES

LIST OF FIGURES (continued)

LIST OF PHOTOGRAPHS

LIST OF TABLES

I. INTRODUCTION

At the request of Kamehameha Schools (KS) Land Assets Division, International Archaeological Research Institute, Inc., (IARII) conducted an archaeological inventory survey (AIS) of KS-owned lands at Punaluʻu, Makaua, Punaluʻu, and Waiʻono Ahupuaʻa, Koʻolauloa Moku, Oʻahu (TMK [1] 5-3-001:041 [portion], [1] 5-3-001:052 [portion], and [1] 5-3-003:001 [portion]) (Fig. 1). Kamehameha Schools' proposed Punaluʻu Habitat Bank and Stream Restoration Project prompted the AIS. The project area is 119.8 acres, divided between a larger area in Punaluʻu Valley (98.7 acres) and a smaller area (21.1 acres) at the nose of the ridge separating Punaluʻu and Kahana Valleys (Fig. 2). This archaeological inventory survey is meant to fulfill KS's historic preservation obligations per Section 106 of the National Historic Preservation Act (NHPA) and Hawaiʻi Revised Statute Chapter 6E-42. This project is considered a federal undertaking because of federal permitting requirements.

As stated in the Draft Environmental Assessment for the stream restoration project (KS 2014:6), the primary objective of the project is the development of "sustainable flood protection while restor[ing] hydrologic processes in the watershed with a focus on the lower reach of Punaluʻu Stream, its floodplain, and estuary." The plan for attaining this objective includes the development of habitat banks and habitat restoration. Both of these activities will entail substantial amounts of excavation and grade modification through cutting and filling of areas along Punaluʻu Stream, the valley bottom, Punaluʻu estuary, and an area to the south of the estuary termed the Kahana Project Component.

PROJECT AREA

The project area is located within and adjacent to Punaluʻu Valley on the windward coast of the island of Oʻahu. It consists of two parts: the primary portion includes the lower 1,200 m of Punaluʻu Stream and the adjacent valley bottom to the north and south, an area with a width of 60 to560 m; the secondary portion, the Kahana Project Component, is an area of coastal plain between the nose of the Punaluʻu/Kahana ridge and Kamehameha Highway. Both areas were subject to pedestrian survey and subsurface testing.

SCOPE OF WORK

The project areas had been previously surveyed by Keala Pono (KP) in anticipation of possible expansion of agricultural development. The present project involved [1] re-locating sites identified by KP and collecting additional data (e.g., written descriptions, photographs, more detailed maps, and GPS locations) to clarify and revise site descriptions and interpretations; [2] conducting reconnaissance-level survey transects through portions of the project area that KP had surveyed at an inventory-level and had identified as devoid of archaeological features to assess their findings; [3] completing an inventory-level survey of a previously unsurveyed area; and [4] excavation of 25 backhoe trenches across the valley bottom to record stratigraphic data and test for buried agricultural soils, agricultural infrastructure (e.g., buried *loʻi* [pondfield] walls), and other, non-agricultural cultural deposits/features. Historical and archival background research was conducted and the results have been incorporated into the site descriptions.

An AIS Work Plan was not completed for the project, but the scope of work was accepted by the SHPD at a meeting on June 5, 2014 (meeting between Nona Naboa [SHPD], Jason Jeremiah [KS], and Chris Filimoehala [IARII]).

PROJECT PERSONNEL AND DATES OF FIELDWORK

Timothy Rieth, M.A., was the Principal Investigator (PI) for the project, and was responsible for overall management, ensuring that appropriate research standards were maintained, and providing research direction and oversight. Myra Tomonari-Tuggle, M.A., and Chris Filimoehala, M.A., were the co-Project Directors (PD). Ms. Tomonari-Tuggle was responsible for archival and background research while Mr. Filimoehala directed the fieldwork. The PD was assisted in the field by Field Technicians Trever Duarte, M.A., Darby Filimoehala, B.A., Dan Knecht, B.A., Brian Lane, M.A., Adam Lauer, M.A., Raquel Macario, M.A., Lisa Manirath, B.A., John O'Connell, M.A., and Robert Pacheco, M.A. Pedestrian survey was performed July 14-18, 2014, November 10 and 11, 2014, and December 24, 2014. Backhoe trenching was performed July 14-18 and August 19-26, 2014.

ORGANIZATION OF THE REPORT

Section I is the introduction to the project. Section II presents background information on the physical and cultural geography of the project area, the history of land use and settlement, previous archaeological and oral historical investigations in and near the project area, and previously identified archaeological sites. Section III presents the field and laboratory methods. Section IV provides the field and laboratory results. Section V is a summary of community consultations completed for the project. Section VI is a discussion of the project results in relation to the history of the project area and larger questions relating to O'ahu and archipelago-wide research issues. Section VII presents the project conclusions, site significance evaluations following state (HAR §13-284-6) and federal (Department of the Interior, 36 CFR 60) criteria, and recommendations for further archaeological services.

Soil descriptions for each backhoe trench (Appendix A), trench profiles (Appendix B), and radiocarbon dating result forms from Beta Analytic, Inc., (Appendix C) are included as appendices.

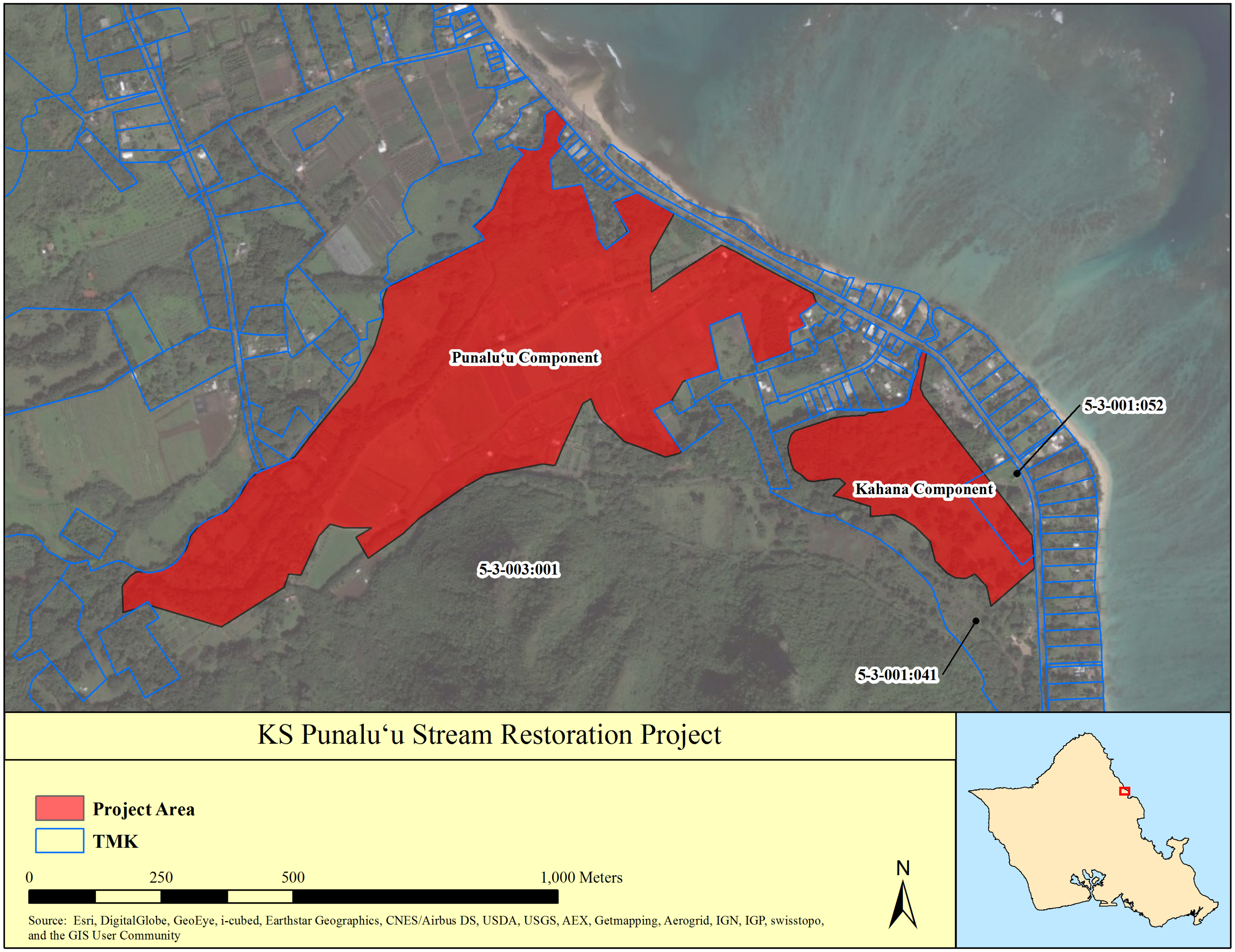


Figure 1. Punalu‘u Stream Restoration Project survey areas with TMK boundaries.

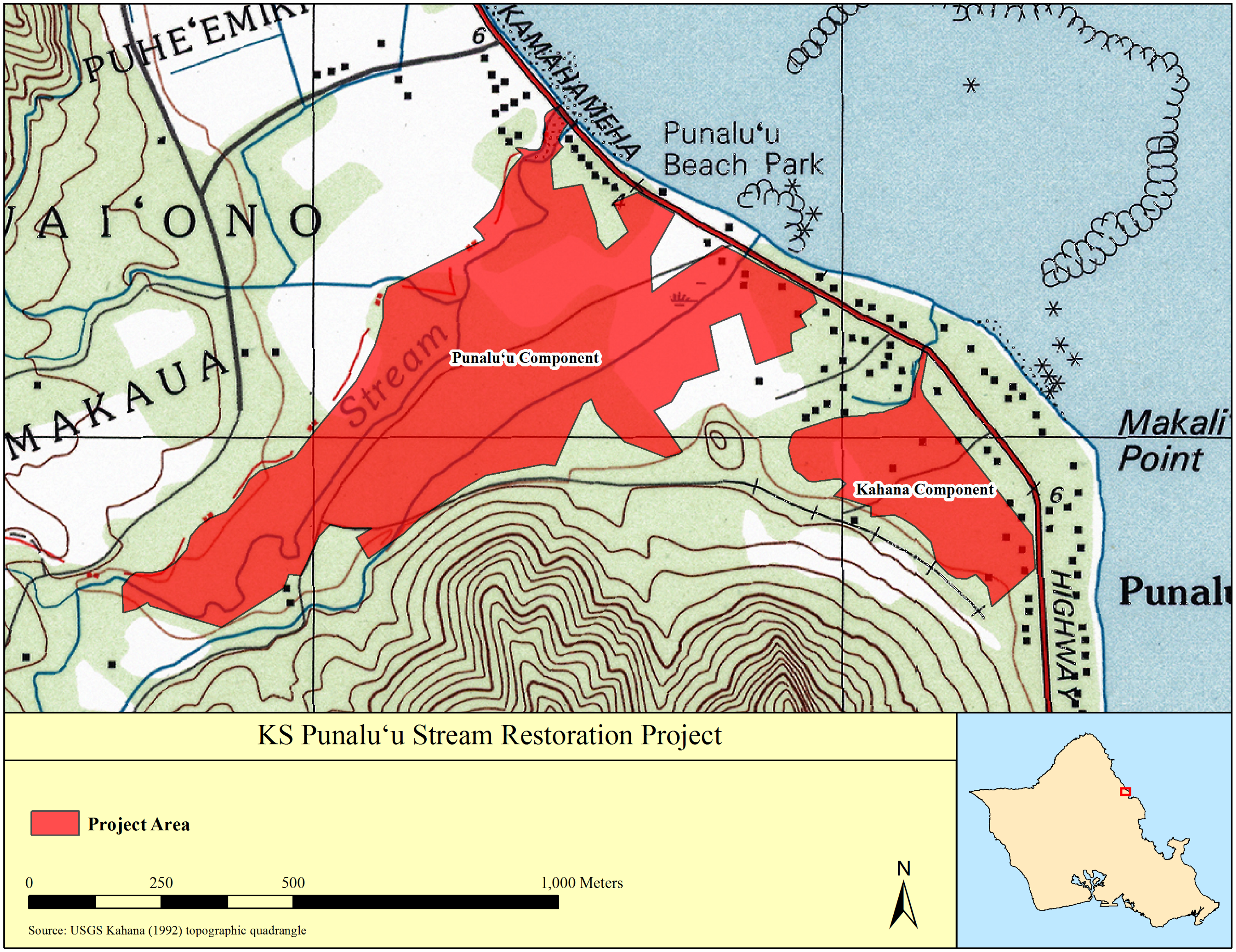


Figure 2. Punalu‘u Stream Restoration Project survey areas.

II. BACKGROUND

This chapter presents background information on the physical and cultural geography of the project area, the history of land use and settlement, previous archaeological and oral historical investigations in and near the project area, and previously identified archaeological sites.

The history section of this chapter integrates data from primary and secondary sources, of which a major source of data is Maly and Maly (2005a, 2005b). This document in two volumes compiles reproductions and translations of 19th century land records, land transaction records from the Bureau of Conveyances, translations of Hawaiian texts, and oral history interviews. Of particular use in analyzing mid-19th century land use and settlement are the records of the Land Commission (Maly and Maly 2005a:39-146). Historical maps provided by Kamehameha Schools and through the Hawaiʻi State Survey Office, particularly Bishop (1885a, 1885b), Alexander (1905, 1907), Podmore (1923), and Thoene (1953), present land use information in graphical form.

The history of the Chinese community in the valley is based largely on Chun (1983), Haraguchi (1987), Chang et al. (1988), and Char and Char (1988); Maly and Maly (2005b) includes transcriptions of interviews with descendants of the early Chinese settlers in the valley. Military use of Punaluʻu during World War II is documented in reports related to the Formerly Used Defense Sites (FUDS) program (U.S. Army Engineer District 1993; Parsons 2008; O'Hare et al. 2013).

Information in planning documents prepared for KS (Townscape 2010; Esgate and Keesey 2011) has also been integrated into the background chapter.

PHYSICAL SETTING

The project area covers the lower section of Punaluʻu Valley and the coastal plain to the north and south of Punaluʻu Stream. Elevation ranges from sea level to about 30 meters (m; 100 feet) above sea level (asl). The horizontal extent of the main Punaluʻu Valley Component extends about 1.2 kilometers (km; 0.75 miles) inland of Kamehameha Highway, while the Kahana Component extends approximately 290 m (951 feet) inland of the highway.

About two-thirds of the present project area is under cultivation or used as pasture by tenant farmers with short-term licenses from Kamehameha Schools (Esgate and Keesey 2011:16). Crops include bananas, pineapples, sugarcane, taro, and orchards (Esgate and Keesey 2011:10). The remaining areas are forested, although some of these areas are fallow farmlands. In addition, a partnership with the University of Hawaiʻi brings 6,000 elementary grade students to Punaluʻu annually to experience traditional taro production. Another site in the valley introduces pre-school and first graders to native Hawaiian agriculture.

TERRAIN

Punalu‘u Valley can be roughly divided into three sections. The upper valley, which lies inland of the present project area, is defined by the down-cutting of Punalu‘u Stream and numerous small tributaries that has created a rugged, undulating landscape; the valley floor along Punalu‘u Stream, which is roughly oriented north-south, is narrow. The middle valley is slightly wider with only three main tributaries feeding into Punalu‘u Stream, which continues in a north-south orientation. About 1.6 km (1 mile) inland of the coast, the valley opens up into a relatively flat and broad, northeast-southwest oriented floor that merges with a coastal plain extending to the north and south of the valley. The lower valley is formed by the floodplains of the combined Punalu‘u and Wai‘ono Streams.

Punalu‘u Valley is defined by knife-edged ridges that extend about 4.8 km (3 miles) inland to the crest of the Ko‘olau Range. The western/northwestern ridgeline rises to over 762 m (2,500 feet), separating Punalu‘u and Kaluanui Valleys. The eastern/southeastern ridgeline that marks the boundary of Punalu‘u and Kahana Valleys is lower, and is dominated by the imposing prominence of Pu‘u Pī‘ei, which rises to just over 427 m (1,400 feet) above the middle valley (Photo 1). Pu‘u Kila is another named peak on the eastern ridge and stands at 384 m (1,260 feet) asl, just seaward of Pu‘u Pī‘ei. The eastern ridge extends inland to Pu‘u Pauao, the southern point of the valley at the crest of the Ko‘olau Range; it stands at over 823 m (2,700 feet) asl.

Photo 1. The seaward end of the southeastern ridgeline of Punalu‘u Valley, showing the high point of Pu‘u Pī‘ei. Note the pronounced gulch facing onto the coastal plain.

The valley sides are deeply incised by permanent and intermittent drainages. Dropping onto the coastal plain are numerous dry gulches that are cut into the east-facing ends of the valley ridges. The largest gulch originates just above Pu‘u Kila, exiting to the coastal plain just northwest of the low hill on which Hanawao Heiau is situated (see Photo 1).

The coastal plain is level to slightly sloping, rising up to about 12 m (40 feet) asl within the project area. Inland of the project area, the landform slopes gently upward to about the 61 m (200 foot) elevation where it meets the base of steep, near vertical cliffs.

HYDROLOGY

Punalu‘u Stream is the central drainage of Punalu‘u Valley. Fed by numerous tributary streams that originate on the western side of the valley, the stream takes a meandering course down the center of the narrow upper valley. About 2 km (1.3 miles) inland of the coast, the middle valley widens slightly and the stream meanders create several large, level stream flats. The main stream is joined by large tributary drainages, two from the northwest side of the valley and one from the south side of the valley. Near the coast in the lower valley, Wai‘ono Stream feeds into Punalu‘u Stream from the west, emanating out of the short Wai‘ono Valley.

Maipuna Stream is a small, short intermittent drainage at the southeast corner of the valley. The earliest graphical evidence for this stream is the 1923 Podmore map, on which it is shown as a relatively large outflow of several irrigation ditches.

Punaluu Ditch, which was constructed in the early 1900s, taps Punalu‘u Stream at the approximate 61 m (200 foot) elevation, just under 3.2 km (2 miles) from the coast. It historically drew water directly from the stream, and channeled it north through a series of tunnels and flumes on the west slope of Punalu‘u Valley. From the outflow at Tunnel 12 along the south tributary to Wai‘ono Stream, the ditch system continued northwest to Kaluanui. The ditch system was recently improved with the installation of a pipe delivery system (City and County of Honolulu, Board of Water Supply, http://www.boardofwatersupply.com/cssweb/display.cfm?sid=2141).

RAINFALL AND TEMPERATURE

The mean annual precipitation in the project area is about 175 centimeters (cm; 69 inches) (Esgate and Keesey 2011:9). Approximately 50 percent of the normal annual rainfall occurs between December and February. June and July are generally the driest months of the year. The average minimum annual temperature is 69.8° F and the average maximum temperature is 80.1°F.

SOILS

Figure 3 displays the project areas on soil series polygons defined by Foote et al. (1972). The main Punalu‘u Stream Component includes nine soil types plus wetland (W). The dominant soils are Hanalei silty clay (HnA), Hanalei stony silty clay (HoB), and Kaloko clay, noncalcareous variant (Kfb). Hanalei silty clay, 0 to 2 percent slopes, is found on stream bottoms and flood plains, and is a strongly acid to very strongly acid soil developed from alluvium derived from basic igneous rock. The surface layer is dark gray to very dark gray with dark brown and reddish mottles, underlain by a very dark gray or dark gray stratum. The subsoil is mottled dark gray or dary grayish brown. This soil has moderate permeability, very slow runoff, and has a slight erosion hazard (Foote et al. 1972:38). Hanalei stony silty clay is similar to Hanalei silty clay with the addition of stone inclusions. Kaloko clay, noncalcareous variant, is a poorly drained, slightly acid to neutral, coastal soil developed in alluvium derived from basic igneous rock. The surface layer is dark gray with a gray or grayish brown subsoil. The soil has slow permeability, ponded to very slow runoff, and poses a slight erosion hazard. These soils have historically been used for agriculture and pasture.

Secondary and minor soils in the Punaluʻu Stream Component are Jaucas sand (JaC), Kaena stony clay (KaeB), Kawaihapa stony clay loam (KlaB), Paumalu-Badland complex (PZ), Pearl Harbor clay (Ph), and Waialua stony silty clay (WlB). Jaucas sand, present along the seaward margin of the project area, is derived from the weathering of coral, algal, and shell fragments (Foote et al. 1972:48). It is very well drained but is poor for agriculture unless amended with organic matter. Kaena stony clay, 2 to 6 percent slopes, is found on alluvial fans and talus slopes (Foote et al. 1972:49). It is a very deep, poorly drained soil with slow runoff and a slight erosion hazard. The surface layer is very dark gray with underlying dark gray and dark grayish brown strata. Kawaihapa stony clay loam, 2 to 6 percent slopes, is part of a series of well-drained soils found in drainages and on alluvial fans (Foote et al. 1972:63). This is a stony variant of Kawaihapai clay loam, 0 to 2 percent slopes. It has moderate permeability, slow runoff, and poses a medium erosion hazard. This is a dark brown soil. Paumalu-Badland complex areas are have 40 to 80 percent coverage with Paumalu silty clay, 15 to 25 percent slopes, with the remainder being nearly barren land created through wind and water erosion (Foote et al. 1972:111). These areas have 10 to 70 percent slopes, medium to rapid runoff, and pose a moderate to severe erosion hazard. The soil is dark reddish brown and developed in alluvium and colluvium. Pearl Harbor clay is a very dark gray coastal soil developed in alluvium overlying organic material (Foote et al. 1972:112). It has very slow permeability, very slow to ponded runoff, and no more than a slight erosion hazard. Waialua stony silty clay is a well-drained alluvial soil with slow runoff and a slight erosion hazard (Foote et al. 1972:128). It is a dark reddish brown soil.

Three soils are present within the Kahana Component: Jaucas sand (JaC); Mokuleia loam (Ms); and, Keaau clay, 0 to 2 percent slopes (KmA). Jaucas sand is present within the northeastern-most portion of the Kahana area, with Mokuleia loam forming a band immediately to the west. Mokuleia loam is nearly level coastal soil with a dark grayish-brown surface layer overlying a thick, dark-brown to light-gray sand or loamy sand (Foote et al. 1972:96). Permeability is moderate for the surface layer with slow runoff and a slight erosion hazard; permeability is rapid for the sand subsoil. Keaau clay, 0 to 2 percent slopes, covers the majority of the area. This soil has a dark grayish-brown surface layer overlying a very dark grayish-brown or dark-brown mottled clay subsoil and a reef limestone or consolidated coral sand substrate (Foote et al. 1972:65). This soil has slow permeability and runoff and poses a slight erosion hazard.

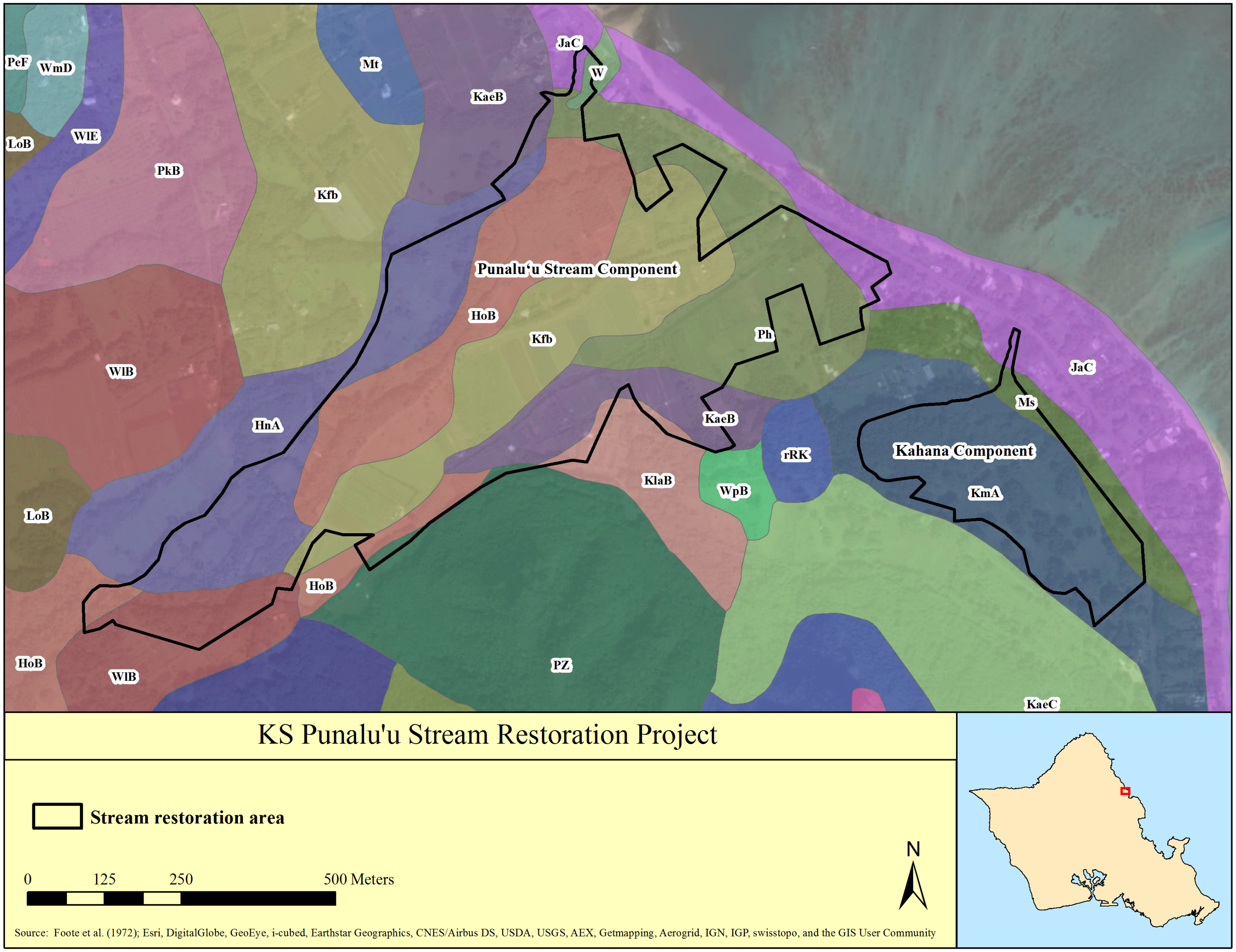


Figure 3. Overlay of the project area on the soil series polygons defined by Foote et al. (1972).

VEGETATION

Much of the present project area is under active cultivation. In areas not cultivated, vegetation largely consists of introduced species, although there are extensive and dense growths of the native *hau* (*Hibiscus tiliaceus*). Remnant stands of the Polynesian-introduced *hala* (*Pandanus* sp.), which is referred to in traditional accounts, are also present. Pukui (1983:169) recounts a saying related to the Punaluʻu rain: *Ka ua kīkē hala o Punaluʻu* (the *hala*-pelting rain of Punaluʻu). The *hala* grows throughout the valley, even in inland areas (Handy 1940:91). Maly and Maly (2005b:82) note the occurrence of a coconut tree (*Cocos nucifera*) in the far inland part of the valley near Tunnel 3 of the Punaluʻu Ditch. They also describe extensive patches of *ʻawa* (*Piper methysticum*), as well as stands of *koa* (*Acacia koa*), above the Punaluʻu Ditch (Maly and Maly 2005b:84).

CULTURAL GEOGRAPHY

The present project area falls almost completely in the traditional *ahupuaʻa* (traditional subdistrict land division) of Punaluʻu in the *moku* or district of Koʻolauloa. The AIS area also includes small portions of the neighboring *ahupuaʻa* of Makaua and Waiʻono, although in consideration of the slight variations in these boundaries as depicted in 19th and 20th century maps it is possible that the project area is actually solely within Punaluʻu Ahupuaʻa. Regardless, Makaua and Waiʻono are the largest of six small coastal *ahupuaʻa* that separate Punaluʻu from Kaluanui Ahupuaʻa to the north (Fig. 4). The other four land areas (from south to north)—which are beyond the current project area—are Pūheʻemiki, Kapano, Haleʻaha, and Papaʻakoko. These six *ahupuaʻa* are often included as part of Punaluʻu (e.g., on modern tax maps and in present community identification[1]). An 1874 map of the northeast coast of Oʻahu showing *ahupuaʻa* by name but without boundaries (Lyons 1874) does not show any of the six land areas.

Punaluʻu lies near the geographic center of Koʻolauloa District, and is the northernmost of the three well-watered valleys of the district (Kahana and Kaʻaʻawa are to the south). To the north of Punaluʻu, the valley streams run intermittently and the lands grow more arid beyond Kaluanui. Handy and Handy (1972:436-437) include Punaluʻu in their "type area" of Oʻahu, which exemplifies the island landscape in contrast to Kauaʻi, Maui, and Hawaiʻi; they point out that the "location and terrain made this type area and its contiguous localities one of the early centers of colonization as is evidenced by lore, and hence a center of myths and legends." Maly and Maly (2005a:6) translate Punaluʻu as "diving spring," which emphasizes the richness of the valley's water resources and therefore its agricultural productivity.

---

[1] In the mid-19th century Hawaiian government land disposition, several claimants for *kuleana* lands in this area made claims for parcels in multiple *ahupuaʻa*. Some, like Ukeke (LCA 3752), received an award for five parcels in Punaluʻu, Waiʻono, and Kapano. Others, like Kauoalani (LCA 4350), claimed land in Pūheʻemiki and Punaluʻu, but received an award for only the Pūheʻemiki parcel.

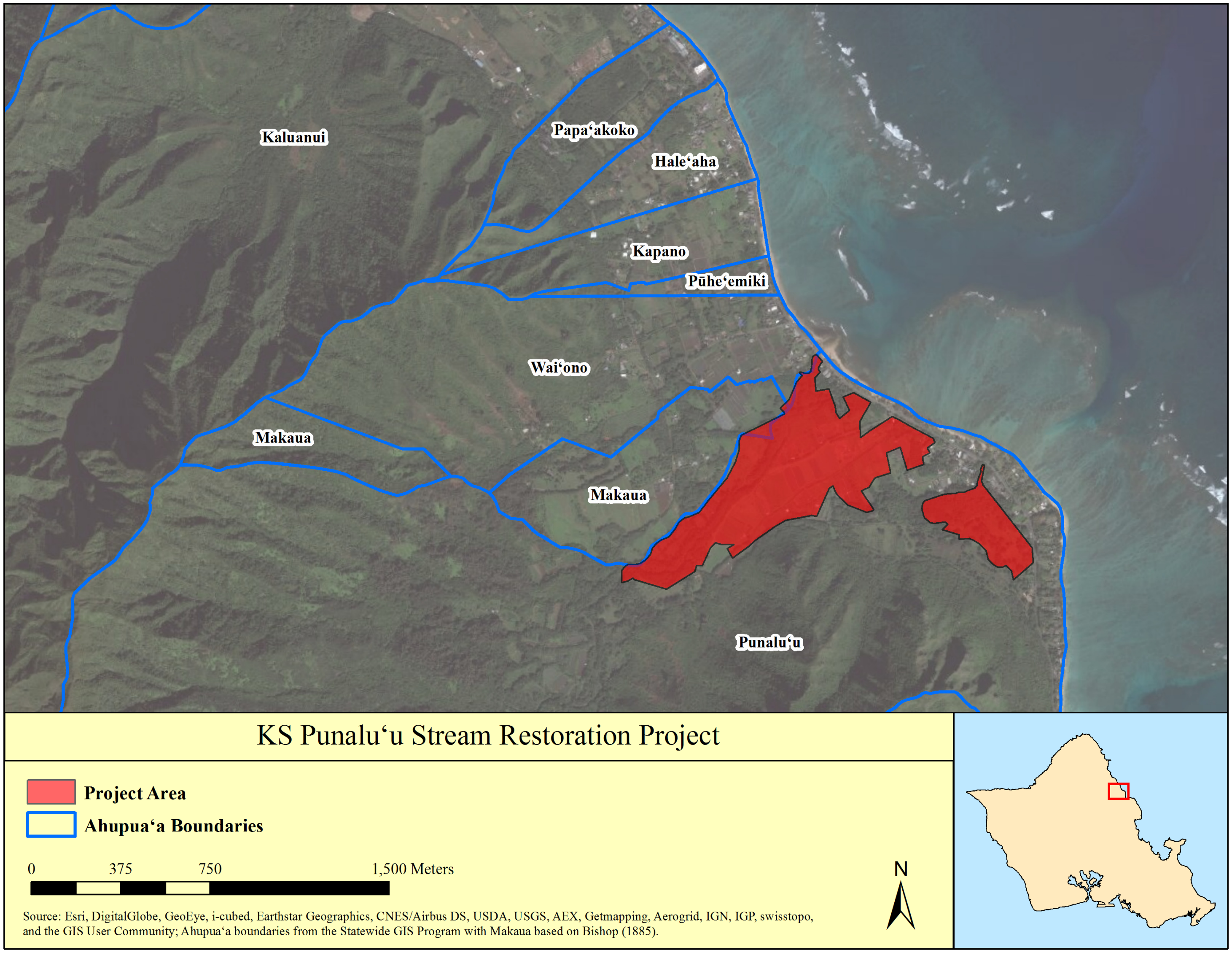


Figure 4. Traditional Hawaiian land units in and adjacent to the project area. Note that several 19th century maps depict boundaries for the *ahupua‘a* north of Punalu‘u that vary from each other and also the modern Statewide GIS program historic land division shapefile and the USGS land divisions.

Makaua and Wai‘ono lie to the north of Punalu‘u and are the largest of the six *ahupua‘a* on the coastal plain. They share the waters of Wai‘ono Stream, the seaward-most tributary drainage to Punalu‘u Stream. Both land areas extend inland to the crest of the ridge separating Punalu‘u and Kaluanui Valleys; the inland point of Makaua is just under 2,100 feet asl and the inland point of Wai‘ono is at about 1,500 feet asl. The other *ahupua‘a* rise to no more than 1,000 feet asl and have no surface water flow. Makaua has an unusual configuration in that its inland section is detached from its seaward section and thus is composed of two discontiguous parcels (Turner 1851, 1853).

A large portion of Makaua Ahupua‘a falls within an *‘ili* or *lele* of the *ahupua‘a*. This subdivision is alternatively called Mahikee (McAllister 1933:160), Nahikee (Podmore 1923), or Nahiku (Alexander 1907; Thrum 1915:91), which are likely variations of the same name. Pukui and Elbert (1986:258) indicate that the spelling of the last variation, with diacritical marks, is Nāhiku, which is a reference to the constellation of the Big Dipper (i.e., literally, the sevens).

Table 1 lists traditional and historic place names for the project area that have been collected from historical maps and written accounts. The table does not include the names of the numerous land areas referenced in the Land Commission documents of the mid-19th century (reproduced in large part by Maly and Maly 2005a:39-146). Maly and Maly (2005a:Table 1) list these names and link them to the Land Commission records in which they are mentioned.

Table 1. Place Names of Punalu‘u and Vicinity.

Place Name	Description	Translation (source*)	Text Source	Map Source (Listed Chronologically)
Haleaha Hale‘aha	*ahupua‘a* north of Punalu‘u	meeting house	various	Turner (1853), Bishop (1885a, 1885b), Alexander (1905), Chaney (1918)
Hanawao	*‘ili* and *heiau* inland of highway on south side of valley	none	Thrum (1908:42); McAllister (1933:162); O’Hare et al. (2005); Maly and Maly (2005a, 2005b)	Sterling and Summers (1978:166)
Hong Lai Road	road extending from coast to rice mill and then inland along east side of valley	n/a	Maly and Maly (2005a:140, 144)	Thoene (1953)
Kaluaolohe Kalua‘ōlohe	fishpond on coastal plain seaward of Hanawao Heiau	none	McAllister (1933:162-163)	none
Kapano	*ahupua‘a* north of Punalu‘u	none	various	Bishop (1885a, 1885b), Alexander (1905), Chaney (1918)
Kaumakaulaula Kaumaka‘ula‘ula	*heiau* at coast on north side of Maipuna Stream	“Thy Red Eyes” (Thrum 1923)	Kea‘unui (1915:92); Thrum (1915:91, 1923:117); McAllister (1933:163); Maly and Maly (2005a, 2005b); see other references in Sterling and Summers (1978:167)	oral history map (Maly and Maly 2005b)
Ko‘olauloa	district	long Ko‘olau	various	various
Ko‘olaupoko	district	short Ko‘olau	various	various

Table 1. Place Names of Punaluʻu and Vicinity (continued).

Place Name	Description	Translation (source*)	Text Source	Map Source (Listed Chronologically)
Kukaiole Kukaiʻiole Kūkaeʻiole	pool in upper Punaluʻu Valley (legendary location)	*kūkae*=feces, *ʻiole*=rat (Pukui and Elbert 1986); alternatively, could refer to "taro found growing in inaccessible spots, as a tree crotch, believed carried there by rats" (Pukui and Elbert 1986:176)	McAllister (1933:163)	none
Maipuna	stream at southeast side of Punaluʻu Valley mouth	none	Sterling and Summers (1978:167)	Podmore (1923), Thoene (1953)
Maka	*heiau* in upper Makaua	point, eye	Thrum (1915:91), McAllister (1933:161)	
Makaiwa	landing place for canoes; in 1923, it was the location of the pier and warehouses "for the convenience of the shipping public" (Thrum 1923)	mother-of-pearl eyes, as in an image, especially of the god Lono (Pukui and Elbert 1986:226)	Keaʻunui (1915:92); Thrum (1923:118-120)	
Makaliʻi	point on coast at boundary between Kahana and Punaluʻu	tiny or Pleiades		Sterling and Summers (1978:Koolauloa Map)
Makaua	*ahupuaʻa* north of Punaluʻu	unfriendly	various	Bishop (1885a, 1885b), Alexander (1905), Alexander (1907), Chaney (1918), Podmore (1923)
Makaua Aupuni Makaua no ke Aupuni	Government Land in Makaua Ahupuaʻa	*aupuni*=government, kingdom, nation (Pukui and Elbert 1986:33)	various	Turner (1853), Bishop (1885b), Alexander (1907)
Makaua-uka	inland area of Makaua Ahupuaʻa	*uka*=inland, upland (Pukui and Elbert 1986:365)	Thrum (1915:91), McAllister (1933:161)	

Table 1. Place Names of Punaluʻu and Vicinity (continued).

Place Name	Description	Translation (source*)	Text Source	Map Source (Listed Chronologically)
Māliko	coastal area near Maipuna Stream; residence of district chief Kekuaokalani	to bud, as leaves (Pukui and Elbert 1986:233)	Keaʻunui (1915:92), Thrum (1923:117)	None
Māmalu	bay at mouth of Punaluʻu Valley	to protect, make shady (Pukui and Elbert 1986:235)	Keaʻunui (1915:92)	none
Nahiku Nāhiku Nahikee Mahikee	*ʻili* of Makaua Ahupuaʻa	*Nāhiku*=constellation of the Big Dipper; literally, the seven (Pukui and Elbert 1986:258)	Bishop (1886), McAllister (1933:161 [Mahikee])	Bishop(1885b [Nahiku]), Alexander (1907 [Nahiku]), Podmore (1923 [Nahikee]), Thoene (1953 [Nahikee])
Papakoko Papaakoko Papaʻakoko	*ahupuaʻa* north of Punaluʻu	secured blood (once a place of refuge)	various	Bishop (1885a, 1885b) Alexander (1905), Chaney (1918)
Puʻuakeau	*heiau* in Kapano Ahupuaʻa	none	Thrum (1908:42), McAllister (1933:198)	none
Puʻu Kila	point on ridge between Kahana and Punaluʻu; north and below Puʻu Pīʻei	*puʻu*=hill, peak (Pukui and Elbert 1986:358); *kila*=high place; strong, stout, bold (Pukui and Elbert 1986:150)	*Hoku o Hawaiʻi*, January 26, 1926, in Sterling and Summers (1978:171)	Podmore (1923)
Puʻu Piei Puʻu Pīʻei	point on ridge between Kahana and Punaluʻu	*puʻu*=hill, peak (Pukui and Elbert 1986:358); *pīʻei*=rare Kauaʻi variation of *kiʻei*, to peer (Pukui and Elbert 1986:326)	*Hoku o Hawaiʻi*, January 26, 1926, in Sterling and Summers (1978:171)	Chaney (1918), Podmore (1923)
Puhemiki Puheʻemiki Pūheʻemiki	*ahupuaʻa* north of Punaluʻu	to steal and run away (Pukui and Elbert 1986:349)	various	Turner (1853), Bishop (1885a, 1885b), Alexander (1905), Chaney (1918)
Punaluʻu	*ahupuaʻa*, valley	spring dived for, coral dived for	various	various

Table 1. Place Names of Punalu‘u and Vicinity (continued).

Place Name	Description	Translation (source*)	Text Source	Map Source (Listed Chronologically)
Pupuka	*heiau* in Hale‘aha or Papa‘akoko Ahupua‘a	ugly, unattractive (Pukui and Elbert 1986:357)	Thrum (1908:41), McAllister (1933:198)	None
Waiono Wai‘ono	*ahupua‘a*	honey, sweet liquid (Pukui and Elbert 1986:380)	Bishop (1886)	Turner (1853), Bishop (1885a, 1885b), Alexander (1907), Chaney (1918), Podmore (1923), Thoene (1953)
Waihi‘i	valley in Punalu‘u	lifted water	LCA 5813	Alexander (1907 [Waihii]), Podmore (1923 [Waihee])
Waihoi Waioi Waiho‘i	spring, land area, valley in Punalu‘u	returning water	LCA 3724	Alexander (1907 [Waihoi]), Podmore (1923 [Waioi])

* Source of translation is Pukui et al. (1974) unless otherwise noted

THE TRADITIONAL LANDSCAPE

In 1839, E.O. Hall toured Oʻahu in the company of a group from the church mission in Honolulu. In his "Notes of a Tour around Oahu," he describes the district of Koʻolauloa (quoted in Maly and Maly 2005a:18):

> The district of Koolauloa is of considerable extent along the sea coast, but the arable land is generally embraced in a narrow strip between the mountains and the sea, varying in width from one half to two to three miles. Several of the vallies are very fertile, and many tracts of considerable extent are watered by springs which burst out from the banks at a sufficient elevation to be conducted over large fields, and in a sufficient quantity to fill many fish ponds and taro patches.

Within this regional context lay Punaluʻu Ahupuaʻa, part of the "type area" landscape that offered a variety of resources (Handy and Handy 1972:436):

> (a) bay and reef coast line which make cultivation feasible right to the shore where coconuts thrive; (b) extensive wet-taro plantations with ample water; (c) swampy areas where taro and fish were raised; (d) sloping piedmont and level shore-side areas well adapted to sweet-potato farming; (e) ample streams whose mouths are ideal seaside spawning pools; (f) fishponds in which systematic fish farming was practiced; (g) upstream terraced stream-side *loʻi*; (h) accessible forested slopes and uplands, for woodland supplies and recourse in famine times.

Handy and Handy (1972:445) go on to describe Punaluʻu specifically:

> The broad seaward end of the main stream flows through an extensive swampy area which was formerly all terraced for taro, and into a very shallow bay open to the sea through a rather wide pass. The flatlands along the stream and sloping hillsides were terraced for *loʻi*. A branch of the main stream called Maipuna circles the swampy land and breaks through to the beach south of the swamp. This stream irrigated many *loʻi* right down to the shore. There is another small stream, Waielelu, draining a little valley at the north end of Punaluʻu. There was more wet-taro land in Punaluʻu than in Kahana. Coconuts flourished, and still grow abundantly, along the shore. The beach is the best on this part of the coast. The lagoon and reef are famous for fishing of one sort or another the year round. Punaluʻu must have supported a large population in old Hawaiian times.

THE VALLEY LAND USE

Handy (1940:91-92, brackets added) provides a description of the agricultural landscape of Punaluʻu in 1940 that can be projected back in time to traditional Hawaiʻi:

> These flats were terraces. On the steep western hillside above the upper flats there are old breadfruit trees. At the lower end of the valley on the southern side is a flourishing plantation with about 25 terraces now in taro. From here the valley becomes increasingly broad for about three quarters of a mile and is planted in cane, with some grasslands along the stream and on the hillsides, and a few banana groves. All the way to the sea the grasslands and the canefields, when cut over or newly planted, show clearly the outlines of old terraces. This, then, was formerly a continuous area of terraces, watered by Punaluu Stream, widening from a quarter of a mile above to half a mile at the base of the valley and spreading out like a fan on the coastal plain over an area four tenths of a mile long and eight tenths of a mile wide.

Taro was certainly a major cultivar on the Punalu‘u landscape, as evidenced by its mention in legends like the one related to the god Kanaloa (McAllister 1933:163):

> When Kanaloa came to Kahana Valley, he was evidently of unusual proportions, for with one foot placed on Pu‘u a Mahie, he stepped with the other to Punaluu Point. Then, over the ridge, he could see two men planting taro up Punaluu Valley. Kneeling on the Kahana side of the ridge, where his knee prints are still to be seen, he watched the two men at work. It annoyed him that they planted their taro in uneven rows, so he said, "Your rows of taro are not straight." The men heard the voice but could see no one. Kanaloa repeated this statement several times, yet the men were never able to see the speaker. Soon Kanaloa grew tired of this teasing and went to Kukaiole pool up Punaluu Valley and drank of the waters. Near the pool there grew *awa*, which the rats were fond of chewing. It made them giddy and dizzy and they fell into the water, for which reason the pond was given its name.

The name Kūkae‘iole for the pond can be translated as rats' excrement (*kūkae*=excrement, *‘iole*=rat). However, O'Hare et al. (2005:12) suggest an alternative interpretation:

> The association of taro cultivation with the name Kukai‘iole may also be based on an alternate interpretation of the meaning of the word. According to the Hawaiian Dictionary (Pukui and Elbert 1986:176), *kūkae"iole* literally means "rat dung", but this word was also used for "taro found growing in inaccessible spots, as a tree crotch, believed carried there by rats."

Handy (1940:8) explains in more detail the belief by Hawaiians that taro growing in inaccessible places was brought there by rats.

> …On Kauai the name Mimi-iole (rat's urine) is applied to various taros growing under special conditions. According to native belief, wild rats come down to the fields or to patches of wild taro and carry away some of the smaller corms to their holes in the trees. Fragments of these, after the taros are eaten, take root in notches and knot-holes of the trees, and are fertilized by the rats.

Taro pondfields were also used in raising fish. In describing Kalua‘ōlohe Fishpond, McAllister (1933:164; Site 294) notes that "it is said … that in the low swampy land around Punaluu the taro was planted in mounds artificially built in the water and that the fish in these patches were quite numerous."

Sweet potato was another traditional crop of Punalu‘u. It was planted along with taro on the lower *kula* lands and near the shore (Handy 1940:156). In the 1930s, Handy (1940:132) found "old sweet potato vines … running wild on sites that were once cultivated." Breadfruit was planted in sheltered places inland of the coast (Handy 1940:190). Punalu‘u was also the location of a famous coconut grove (Handy 1940:193). Natural resources of the valley included *pili* (*Heteropogon contortus*) grass[2], bamboo (*Schizostachyum glaucifolium* and *Bambusa vulgaris*; later post-contact varieties), *hau* (*Hibiscus tiliaceus*), *‘awa* (*Piper methysticum*), *wauke* (*Broussonetia papyrifera*), and *koa* (*Acacia koa*).

---

2 *Pili* was still growing in the valley in the 1920s, when it was being collected for construction material by David Ka‘apu, a Punalu‘u resident who lived a traditional Hawaiian lifestyle, including living in a thatched house (Wah Chan Ching and Walter Wah Chu Ching interviews, in Maly and Maly 2005b:48). Ka‘apu also harvested bamboo for house purlins, *hau* bark for rope, and *hala* leaves for weaving material for mats.

SETTLEMENT IN THE VALLEY

Most residences were likely along the coast, where there was ready access to the near-shore and ocean resources of Māmalu Bay. A natural break in the reef provided a protected access to the open ocean. Mid-19th century land records suggest that people were also living in inland areas (e.g., LCAs 4358 and 7694 in the middle valley), but whether this was a traditional settlement pattern or one that evolved in the early post-Contact period is not known. Deceased were buried in the sand dunes along the shore.

HEIAU OF PUNALUʻU, MAKAUA, AND WAIʻONO

Based on traditions and archaeology, the *heiau* (temples) of Punaluʻu Ahupuaʻa were located near the coast to the southeast of the valley mouth. The only known inland *heiau* was Maka, which was situated in Nāhiku ʻIli on the north side of Punaluʻu Stream at least a half-mile from the coast.

Five *heiau* in Punaluʻu and Makaua were documented in the early 20th century by Thrum (1908:42, 1915:91) and McAllister (1933). Three are named and have associated traditions: Hanawao, Maka, and Kaumakaʻulaʻula. The other two were recorded by McAllister (1933:162-163) as archaeological features (Sites 292 and 206).

Hanawao, Kaumakaʻulaʻula, and one of the archaeological sites (Site 292) fall in a cluster of chiefly and ceremonial places that was located around the coastal extent of Maipuna Stream at the southeast mouth of the valley. Hanawao is on a low hill (Photo 2); Kaumakaʻulaʻula was on the northwest side of the stream near its mouth; and Site 292 was just inland of Hanawao (McAllister 1933:162-163). A fourth *heiau* (Site 296) was located at the foot of the ridge near the boundary between Punaluʻu and Kahana. Between Hanawao Heiau and the sea was "an alii fishpond and the only one which is remembered in the region" (McAllister 1933:164).

Hanawao Heiau was first identified by Thrum (1908:42) with the notation "no particulars learned." Two decades later, McAllister (1933:162) reported that a cemetery[3] on the top of the *heiau* had obliterated most of the temple features, although some remnants were still in existence:

> The present remains indicate that it was a large heiau, 100 feet or more in width, and 200 feet or more in length. The longest side faced almost due east. On the southeast side of the hill a portion of a rock terrace remains which was built up with small rocks, less than 1 foot in size. On the west side is a portion of a terraced wall, about a 15-foot portion of which remains nearly intact. The bottom wall is 4.5 feet high, of large stones 2 to 3 feet in size, built up on a steep slope. The top of this wall forms a small step-like terrace 2.5 feet in width paved with stones 1 inch or less in size. From this step a wall built of 1-foot stones rises 3 feet to what was probably the top of the heiau platform.

3 The cemetery is documented on the 1907 Alexander map of Punaluʻu so it was certainly in existence at the time of Thrum's survey.

Photo 2. View of the hill on which Hanawao Heiau is located (McAllister 1933:Plate 2A; courtesy of the B.P. Bishop Museum, Photo SP_15284). Note the tracks of the Koolau Railroad in the foreground.

Kaumakaʻulaʻula Heiau was a sacrificial *heiau* located on the north side of Maipuna Stream on the inland side of Kamehameha Highway (just outside of the present project area). In 1915, the structure was described as "now but a level field lying in desolation but recently put under cultivation (Keaʻunui 1915:94); Thrum (1915:91) adds that it was "famed as of very ancient tradition, the site only of which now remains." The *heiau* was a single structure, divided into two sections: one where "the priests performed their ritual services" and the other was the "altar of sacrifice … where the bodies of men and other sacrifices were offered up in solemn service." The residence of the priest was north of the temple. Keaʻunui (1915:92) writes:

> Kaumakaulaula was the temple, and Kamehaikaua the one who built and laid the foundation thereof after the great flood, Kai-a-Kahinalii. Kahonu was the priest, and Kekuaokalani the king. Maliko was the location of the king's house, while Kawaiakane and Kawaiakanalo were the places where the king was reared in the Punaluu division of land, district of Koolauloa, island of Oahu-alua.

Thrum (1923:117) describes the origin of the name of the *heiau*, Kaumakaʻulaʻula ("Thy Red Eyes"):

On the approach of the sacred nights of the temple these omens of wonder and mystery would be observed: the eyes of all the pigs which were near the boundaries of this temple would turn red, and this has been known to happen even down to the present time. That is how the name Kaumakaulaula became applicable.

A Punaluʻu resident with long-time family ties to the valley says that the *heiau* at the coast that is identified as Kaumakaʻulaʻula was actually a fishing *heiau* (Deldrene Nohealani Herron, in O'Hare et al. 2005:59):

Makaʻulaʻula was a time in the month of the *kapu* nights of Kāne when our ancestor Kamapuaʻa used to come from Kaliuwaʻa. He would come to visit the relatives here (at the *puʻu*) and during those nights when you are up in the valley all the eyes of the pig would glow bright red. You could see them going around the tops of the ridge coming from Kaliuwaʻa to visit each other. That is where the name Makaʻulaʻula came from. There is a *heiau* up on the mountain at the central part between Punaluʻu and Kaliuwaʻa that they call Maka, but that is truly Makaʻulaʻula Heiau, not the one they call by the sea. The one by the sea was used by the fishermen.

Maka Heiau was situated in the *ʻili* of Nāhiku in upper Makaua (called Makaua-uka by Thrum 1915:91), near the seaward base of the northwestern ridge of Punaluʻu Valley (see Plate 2B in McAllister 1933). It was a terraced structure with two main levels, measuring 70 by 150 feet in total (McAllister 1933:160-161). The front (southern) face of the lower terrace was 15 feet high; the lower, east face was 13 to 20 feet high. At the time of McAllister's survey in 1933, the structure was "located within a cane field, and as the interior of the heiau is under cultivation, any smaller features have been obliterated" (McAllister 1933:161).

Two other small *heiau* are located north of Punaluʻu: Puuakeau in Kapano; and Pupuka in Haleʻaha or Papaʻakoko. Nothing is known of the former (Thrum 1908:31; McAllister 1933:198). The latter is "a small heiau 30x50 feet, little of which now remains" (Thrum 1908:41; McAllister 1933:198).

HISTORICAL BACKGROUND

Following is a discussion of Punaluʻu's post-contact history.

PUNALUʻU IN THE EARLY POST-CONTACT PERIOD

After his conquest of Oʻahu in the battle of Nuʻuanu in 1795, Kamehameha divided the lands among his supporters in the traditional way called *Kālai ʻāina*[4] ("to carve the land") (Kameʻeleihiwa 1992:51). To some of his closest advisors, he gave a combination of parcels in Waikīkī, "where the chiefs liked to live because of the surfing" (ʻIʻi 1959:69), and large *ahupuaʻa* in windward Oʻahu. Punaluʻu, along with the *ʻili ʻāina* of Kaneloa in Waikīkī, was given to Kamehameha's younger brother, Keliʻimaikaʻi (ʻIʻi 1959:69-70).

4 It should be noted that *Kālai ʻāina* did not bestow control of the land in the Western sense of ownership. Rather, upon the death of the king, the land reverted to the new king for a new distribution; also, the land reverted to the king upon the death of the *aliʻi* who had received the land (Kameʻeleihiwa 1992:51). Keliʻimaikaʻi died in 1810 (ʻIʻi 1959:81).

In 1826, the missionary Levi Chamberlain conducted an inspection tour of schools on Oʻahu and stopped at Punaluʻu, providing one of the earliest descriptions of the valley (quoted in Maly and Maly 2005a:16-17). Chamberlain and his party arrived at Punaluʻu in the late afternoon and was "received cordially by the head man of the place." They stayed in the head man's residence which was "large and commodious and appeared to be the residence of several families." More than 50 people attended the evening prayer, and even more came to the service on Sunday. On Monday morning, Chamberlain conducted an examination of the three schools belonging to Punaluʻu and the adjoining areas.

In 1837, Punihaole, a native Hawaiian teacher, conducted a similar inspection of schools (Maly and Maly 2005a:17). At Punaluʻu, 74 men, women, and children gathered at the house in which he was staying. His next stop was at Pūheʻemiki, where the people of that *ahupuaʻa*, as well as Waiʻono and Kapano, met.

By the end of the decade, the effects of disease and outmigration that were affecting the Hawaiian population throughout the islands, were taking their toll in the Punaluʻu community as well. In his 1839 tour of the island, Hall (1839, quoted in Maly and Maly 2005a:18) remarked that large tracts of land were uncultivated and "much taro land now lies waste, because the diminished population of the district does not require its cultivation." In the land disposition of the mid-century (see below), government records indicate that many claims to land went unawarded because the claimant was deceased.

PUNALUʻU AT MID-CENTURY

At mid-century, the Hawaiian government instituted a fundamental change in the manner in which land in Hawaiʻi was held. In 1848, the traditional system of land tenure was replaced with a western system of fee-simple land ownership. This radical restructuring, called the Great Mahele (Great Division), divided all lands among the king, 245 high-ranking chiefs, and the government. Subsequently, commoners were offered the opportunity to claim fee-simple title to the land on which they lived or improved; these lands became known as *kuleana* lands and were awarded in the form of Land Commission awards (LCAs), called such after the Board of Commissioners to Quiet Land Titles (also called the Land Commission). Successful awards were issued a Royal Patent (RP).

Mahele Awards

The *ahupuaʻa* of Punaluʻu, encompassing 4,215 acres, was awarded to William Pitt Leleiōhoku in the Mahele. Leleiōhoku was the great-grandson of one of Kamehameha's most trusted supporters, Kamanawa, and the son of another of Kamehameha's advisors, Kalanimōkū; his mother was Kiliwehi, the daughter of Peleuli, one of Kamehameha's wives (Barrère 1994:410). In 1848, the 28-year old Leleiōhoku died of the whooping cough and his lands were divided between his son, J.P. Kīnaʻu, and his widow, Ruta Keʻelikōlani (Barrère 1994:316-317). Keʻelikōlani received Punaluʻu in this estate division. Keʻelikōlani died in 1883, leaving her estate to her cousin, Bernice Pauahi Bishop.

The *ahupuaʻa* of Makaua was given to two chiefs in the Mahele. Hewahewa claimed the larger portion of the *ahupuaʻa*, which he subsequently relinquished to the Government (Barrère 1994:37; Maly and Maly 2005a:33); this area became Government Land. Kekaha was given a portion of the *ahupuaʻa* consisting of 113.17 acres in two parcels as LCA 8308 (Barrère 1994:318). The larger parcel of 72.17 acres was in the area called Nāhiku (see Place Names, above, for variations on the name); 1886 Boundary Commission records (in Maly and Maly 2005a:156-157) call this "the land of Nahiku … a lele[5] of Makaua." Both *'āpana* (parcels) of LCA 8308 lie just outside the northwest boundary of the project area.

On historical maps such as Alexander (1907), the government portion of Makaua is referred to as "Makaua Aupuni" (*aupuni* being government). Turner's 1853 map of Makaua labels the government portion as "Makaua no ke aupuni" (i.e., "Makaua belonging to the government").

The *ahupua'a* of Wai'ono was given to Abnera Pākī in the Mahele. He relinquished his claim and the *ahupua'a* became Government Land (Barrère 1994:508; Maly and Maly 2005a:33).

The small *ahupua'a* north of Wai'ono (Pūhe'emiki, Kapano, Hale'aha, and Papa'akoko) were also awarded to chiefs in the Mahele, but each recipient relinquished their claim and, like Makaua and Wai'ono, these *ahupua'a* became Government Lands.

Kuleana Awards

Kuleana awards to commoners covered the valley floor of Punalu'u up to 3.2 km (2 miles) inland, as well as much of the coastal plain of Makaua and Wai'ono (Fig. 5, Table 2-4). There were 54 claims to land in Punalu'u, of which 32 claims were awarded, including the Mahele award to Leleiohōkū (LCA 9971). At least four of the claims were for parcels in Punalu'u and one or two of the smaller *ahupua'a* to the north (e.g., LCAs 3724, 3752, 4350, and 8172). In Punalu'u, parcels lined the narrow upper stream channel, and where the lower valley floor broadened, it followed the south edge of the valley. A cluster of parcels lay on the southeast side of the mouth of Punalu'u Stream and another cluster lay at the base of the low hill on which Hanawao Heiau is located. Twelve of the 32 awards in Punalu'u encompass land wholly or partially within the Punalu'u Component with two additional awards within the Kahana Component (see Fig. 5).[6]

---

5 *Lele* in this case is interpreted to refer to "two *'ili* parcels within an *ahupua'a* that are separated from each other" (Lucas 1995:66). The second parcel of LCA 8308 was located just seaward of, and detached from, the larger Nāhiku parcel (Alexander 1905).

6 The locations of the unawarded claims are ambiguous since they do not appear on the historical maps of the valley (e.g., Alexander 1907, Podmore 1923, and Thoene 1953).

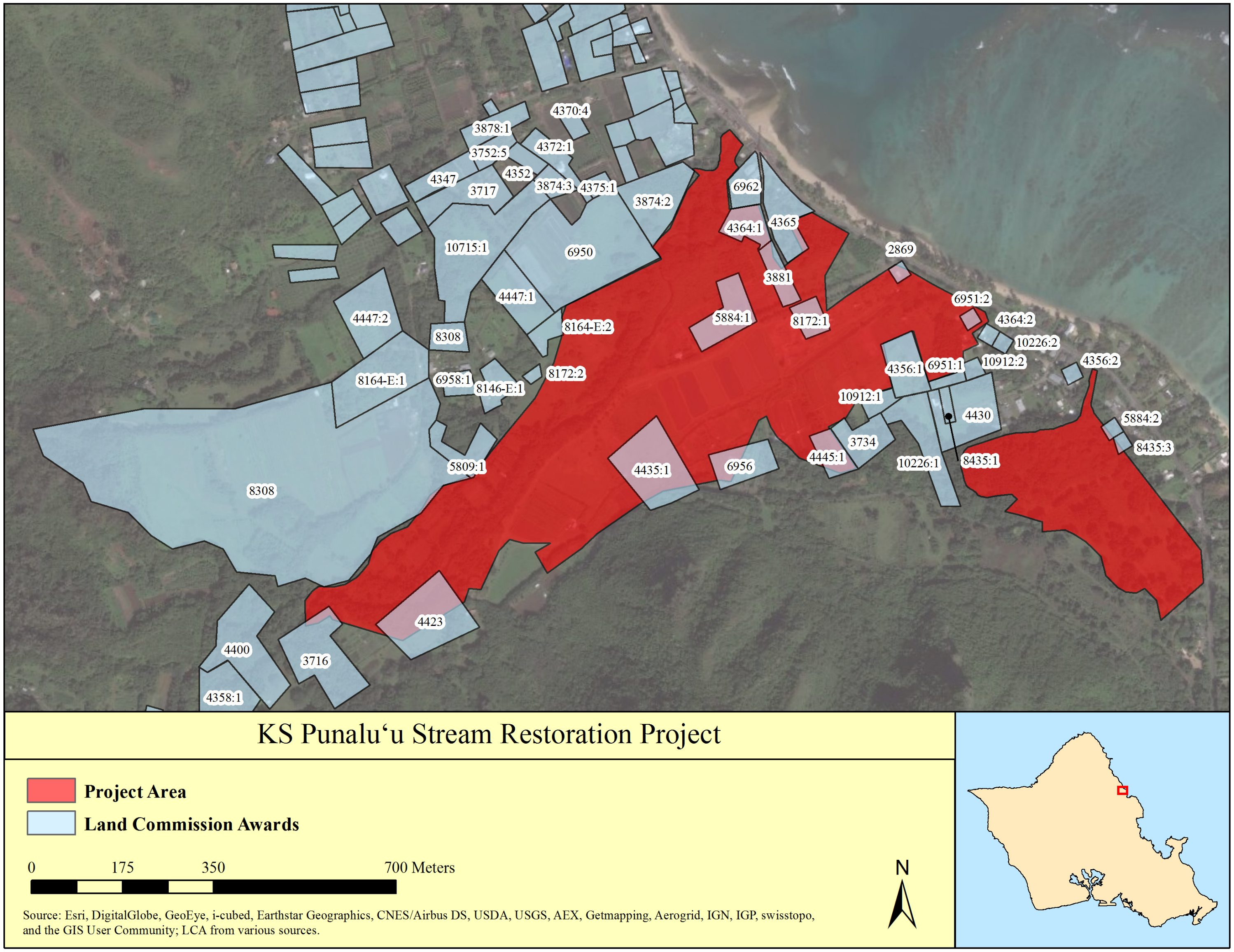


Figure 5. Land Commission awards in Punalu‘u, Makaua, and Wai‘ono.

Table 2. Land Commission Awards in Punalu‘u Ahupua‘a, including Claims Not Awarded.*

LCA No.	Awardee/ Claimant	RP No.	No. of *‘Āpana* *	Acre *	Geographic Location	Notes	Land Use Within Project Area **
2869	Kaopupahi	6324	1	0.25	coast (central)		house?
3716	Mikikolo	1286	1	3.149	middle valley		*lo‘i*, guava tree
3719	Manuela	n/a	?			not awarded	
3724	Maiahe (Waiahe)	none	2	0.85	Waioi Valley (Podmore 1923)	other *‘āpana* in Pūhe‘emiki	
3734	Ikeole	1292	1	1.7	Hanawao cluster		
3746	Wahineomua	n/a	?			not awarded	
3752	Ukeke	4939	1	0.05	Waioi Valley (Podmore 1923)	four other *‘āpana* in Wai‘ono and Kapano	
3779	Aha	n/a	?			not awarded	
3810	Liki	n/a	?			not awarded	
3879	Paele	n/a	?			not awarded	
3881	Pahakea	1293	1	1.0	lower valley		*lo‘i*
3957	Nawaa	n/a	?			not awarded	
3959	Nakolo	3924	1	9.25	upper valley		
3964	Nohomalie	n/a	?			not awarded	
4016	Hauna	n/a	?			not awarded	
4349	Kenao	n/a	?			not awarded	
4350	Kauoalani	7865	3	2.9	unknown	Punalu‘u *‘āpana* not awarded, other *‘āpana* in Pūhe‘emiki	
4356	Kaikuaana	3510	2	2.14	Ap. 1: Hanawao cluster; Ap. 2: coast (Maipuna Stream)	only Ap. 1 in project area	

Table 2. Land Commission Awards in Punaluʻu Ahupuaʻa, including Claims Not Awarded (continued).

LCA No.	Awardee/ Claimant	RP No.	No. of *ʻĀpana* *	Acre *	Geographic Location	Notes	Land Use Within Project Area **
4358	Kaumualii	8024	2	2.95	Ap. 1: middle valley: Ap. 2: middle valley (on ridge above Ap. 1)		*loʻi*, *ʻauwai*, houselot with two houses
4362	Kaahui	n/a	?			not awarded	
4364	Kukaumiumi	1294	2	1.50	Ap. 1: mouth of Punaluʻu Stream; Ap. 2: coast		
4365	Kuolulu	1288	1	2.4	mouth of Punaluʻu Stream		
4371	Kahopukahi	n/a	?			not awarded	
4400	Kahau	1285	1	4.0	middle valley		*loʻi*, *ʻauwai*, watercourse along NW boundary
4423	Kaiwinui	none	1	3.45	middle valley		*loʻi*, *pāhale*, watercourse on S boundary
4430	Kauhaa	1291	1	3.096	Hanawao cluster		
4435	Keopohaku	1287	2	4.07	Ap. 1: lower valley; Ap. 2: coast (south)	only Ap. 1 in project area	*loʻi*, *kula*, *ʻauwai* on S boundary (Ap. 1); enclosed houselot with two houses (Ap. 2)
4445	Kalakoa	1532	2	2.639	Ap. 1: Hanawao cluster; Ap. 2: coast (south)		*loʻi*, *kula*, *ʻauwai* on S boundary (Ap. 1); pāhale and two loʻi (Ap. 2)
5808	Kiamanu	6705	1	5.0	upper valley		
5812	Kaiwi	n/a	?			not awarded	
5813	Kaha	2047	2	3.55	Waihee Valley (Podmore 1923)		
5850	Kahiakua	n/a	?			not awarded	
5851	Kaipuea	n/a	?			not awarded	

Table 2. Land Commission Awards in Punaluʻu Ahupuaʻa, including Claims Not Awarded (continued).

LCA No.	Awardee/ Claimant	RP No.	No. of *ʻĀpana* *	Acre *	Geographic Location	Notes	Land Use Within Project Area **
5884	Keohoena	1290	2	2.11	Ap. 1: lower valley; Ap. 2: coast (Maipuna Stream)		*loʻi*, *ʻauwai* on N boundary (Ap. 1); unenclosed houselot with two houses (Ap. 2)
5897	Poomahoe	n/a	?			not awarded	
5948	Puahi	n/a	?			not awarded	
6046	Oopa	n/a	?			not awarded	
6081	Hio	7908	2	2.22	upper valley	Indices (1929:376) says total acreage is 2.22 acres in two parcels	
6951	Kaniho	none	2	0.58	Ap. 1: Hanawao cluster; Ap. 2: coast (central)	only Ap. 2 in project area	*loʻi* (Ap. 1); houselot (Ap. 2)
6952	Kumauna	913	1	5.25	upper valley		
6953	Kaiawa	n/a	?			not awarded	
6956	Kaialiilii	1289	1	1.96	lower valley		*loʻi*, *kula*, *pāhale*
6962	Kukeawe	1283	1	1.1	north end of coast		
7102	Toinui	n/a	?			not awarded	
7433	Kalaaukahi and Kekaula	n/a	?			not awarded	
7533	Kaiwi	97	1	3.5	unknown	listed in Indices (1929) but not shown on historical maps	
7694	Kahaleaahu	3959	2	8.15	middle valley		*loʻi*, watercourse on NW boundary (Ap. 1); watermelon, sweet potato (Ap. 2)
8172	Hama (Hahia?)	5504	1	1.0	lower valley	another parcel in Makaua	*loʻi*

Table 2. Land Commission Awards in Punalu‘u Ahupua‘a, including Claims Not Awarded (continued).

LCA No.	Awardee/ Claimant	RP No.	No. of *‘Āpana* *	Acre *	Geographic Location	Notes	Land Use Within Project Area **
8435	Kuheleloa	1437	3	0.87	Ap. 1: Hanawao cluster; Ap. 2: “location unknown” (Podmore 1923 inset); Ap. 3: coast (central)	only Ap. 3 in project area	*lo‘i* (Ap. 1); houselot enclosed by stone wall (Ap. 3)
9962	Lima	n/a	?			not awarded	
9971	W.M. Leleiohōkū	7804	--	4,215	Ap. 25: *ahupua‘a*		
10209	Manuela	n/a	?			not awarded	
10212	Molea	5133/ 5310	1	6.7	upper valley		
10226	Maliko	1284	2	2.834	Ap. 1: Hanawao cluster; Ap. 2: coast (central)		
10912	Kauli	3858	2	1.35	Ap. 1: Hanawao cluster; Ap. 2: coast (central)		

Shading indicates LCAs that are wholly or partially within or have *‘āpana* within the project area. Data on unawarded claims are from Indices (1929) and Maly and Maly (2005a); locations within the valley and numbers of *‘āpana* are not listed because descriptions are only by place name and/or by reference to adjacent claims (i.e., unawarded claims are not mapped).

* Taken from Indices (1929).

** Compiled from Land Commission records (Native Register, Foreign Testimony, and Award), reproduced in Maly and Maly (2005a), with additional notes from Office of Hawaiian Affairs (OHA) Papakilo Database.

Table 3. Land Commission Awards in Makaua Ahupua‘a.*

LCA No.	Awardee/ Claimant	RP No.	No. of *‘Āpana* *	Acreage *	Geographic Location (Based on Alexander 1905)
4447	Kanehue	5296	2	5.92	Ap. 1: coastal plain; Ap. 2: north of Nāhiku
5809	Kaoaoa	none	2	2.6	Ap. 1: just east of Nāhiku; Ap. 2: unknown
6950	Kaehukukona	2931/912	1	8.36	coastal plain
6958	Kukae	6427	2	5.31	Ap. 1: just east of Nāhiku; Ap. 2: unknown
8146-E	Nailieha	4043	2	4.16	Ap. 1: coastal plain; Ap. 2: unknown
8164-E	Kamalii	none	2	6.095	Ap. 1: north of Nāhiku; Ap. 2: coastal plain
8172	Hama (Hahia?)	5504	1	0.25	coastal plain; another parcel in lower Punalu‘u Valley
8308	Kekaha	7985	2	113.17	slope above coastal plain
10715	Peahi	6122	3	12.37	Ap. 1: coastal plain; locations of Ap. 2 and 3 unknown

* Taken from Indices (1929).

Table 4. Land Commission Awards in Wai‘ono Ahupua‘a.*

LCA No.	Awardee/ Claimant	RP No.	No. of *‘Āpana* *	Acreage *	Geographic Location (Based on Alexander 1905)
3717	Mauele	6578	1	2.62	coastal plain
3752	Ukeke	4939	2	1.92	Ap. 4: base of ridge; Ap. 5: coastal plain; three other *‘āpana* in Punalu‘u and Kapano
3874	Paia	none	3	3.85	Ap. 1: coast; Ap. 2: coastal Makaua; Ap. 3: coastal plain
3878	Puuwaawaa	7359	2	2.58	Ap. 1: coastal plain; Ap. 2: slope above coastal plain
4347	Kuaiwa	none	1	1.44	coastal plain
4352	Koo	none	1	0.67	coastal plain
4353	Kawai	3922	2	2.71	Ap. 1: coast; Ap. 2: coastal plain
4370	Kekipi	none	5	2.747	Ap. 1 and 2: slope above coastal plain; Ap. 3: coast; Ap. 4 and 5: coastal plain
4372	Kaluhiai	7864	2	1.8	Ap. 1: coastal plain; Ap. 2: slope above coastal plain
4375	Kealoha	none	2	1.2	coastal plain
4436	Kalolohe	3096/3517	1	2.3	slope above coastal plain; another ‘āpana may be in Pūhe‘emiki
5243	Kaikaina	4850	1	1.3	coast

* Taken from Indices (1929).

In Makaua Ahupuaʻa, eight LCAs were awarded, including the large Mahele award to Kekaha that encompassed the *ʻili* of Nāhiku (LCA 8308). None of the awards are within or have *ʻāpana* within the present project area. The LCAs inland of the project area are on the rising slope to the base of the vertical cliff. In Waiʻono Ahupuaʻa, 12 LCAs were awarded, none of which are within the project area. All of the awards lie on the coastal plain.

The majority of LCA parcels were developed in taro *loʻi* (pondfields), with some parcels specifically describing *ʻauwai* (ditch) sources for irrigation (see following section). Some claims and testimonies note the total number of pondfields, and specifically describe the number of active fields and *loʻi nahelehele* (fallow or overgrown fields) (see, e.g., LCA 3716, Maly and Maly 2005a:39). Dryland gardens included sweet potato, bitter gourd, banana, and watermelon (Maly and Maly 2005a:Table 3). Many of the LCA claims/awards described forest resources, including breadfruit, pandanus, *wauke*, *kukui*, *koa*, *kou*, *olona*, *awa*, and guava, that were located in detached upland areas away from the claimed parcels.

Houselot parcels were scattered along the shoreline, including four small parcels on the narrow coastal plain south of Maipuna Stream; the southernmost parcel (LCA 4445:2) also included two *loʻi* and a *kula* area. With one exception (LCA 2869), all of the coastal parcels were part of awards that included other *ʻāpana* around Hanawao Heiau (n = 4), in the lower valley (n = 1), and in the cluster at the mouth of Punaluʻu Stream (n = 2); none of the middle and upper valley LCAs had *ʻāpana* at the coast.

Some of the parcels included rights to fisheries: for example, LCAs 3957 and 4430 to unnamed fisheries (Maly and Maly 2005a:63 and 89); and LCA 4371 to a *heʻe* (octopus) fishery and an *uhu* (parrotfish) fishery (Maly and Maly 2005a:82). Maly and Maly (2005a:Table 2) lists 18 *kai* and *muliwai* (translated as ocean and estuarine fisheries, respectively) and 19 *kahawai ʻoʻopu* (stream fisheries for goby fish).

The Origin of Irrigation Ditches

There are four major irrigation ditches that are illustrated on late 19th and early 20th century maps of Punaluʻu (Bishop 1885a, 1885b; Alexander 1905, 1907; Podmore 1923). These maps were surveyed and drawn after the beginning of rice cultivation in the valley, which raises the question of their antiquity: were they part of the traditional Hawaiian *loʻi* irrigation system; or were they constructed specifically for irrigating rice fields?

Bishop's 1885 maps of the area from Punaluʻu to Kaluanui (Bishop 1885a, 1885b) [7] are the earliest renderings that show ditches, presumably for irrigation agriculture. There are two major ditches, both tapping Punaluʻu Stream in the middle valley. One ditch (labeled "Ditch" on the maps, and herein called the "south ditch") extends seaward along the south-southeast edge of the valley to the rice mill, from which it continues to the coast, wrapping around the low hill on which Hanawao Heiau (Site 293) is situated and then extending

7 There are two versions of Bishop's 1885 map that were used in the present study; each shows slightly different information. Bishop (1885a) is a black and white rendering with a hand-written notation under the title block that states: "Tracing from S.E.B.'s working sheet by H.Em. Alexander July 1889. For details of work see the aforesaid sheet and F.B.s of Mr. B." Bishop (1885b) is a color rendering of the same map with emphasis on the cultivatable bottom lands in Punaluʻu Valley.

southeast above the coastal plain (Bishop 1885b). A second ditch (labeled "watercourse" on the maps, and herein called the "north ditch") follows the base of the northwestern valley slope and then turns north above the coastal plain in Makaua and Waiʻono, ending at the Pūheʻemiki boundary (Bishop 1885a); this ditch likely continues across all six of the small coastal *ahupuaʻa*.

Subsequent maps show two more major ditches in Punaluʻu Valley. One ditch originates on the north side of Punaluʻu Stream, just below the intake for the north ditch and follows the southeastern Punaluʻu-Nāhiku boundary, and terminates at LCA 5809:1; this ditch is herein called the "Punaluʻu-Nāhiku ditch" (Alexander 1905, 1907; Podmore 1923). A second ditch originates at the rice mill and extends seaward along the south side of Punaluʻu Stream to the cluster of LCA parcels at the mouth of Punaluʻu Stream (Podmore 1923; this ditch could be on the Bishop 1885b map but if so, is unlabeled and ambiguously drawn); this ditch is herein called the "central ditch."

Many of the Land Commission records refer to watercourses as boundary descriptors and therefore, place a rough temporal context for the historical ditches. The antiquity of the north and south ditches (i.e., constructed and used prior to the development of the rice industry in the region) is validated by Land Commission records. Documentation for LCAs 4423, 4435, and 4445 along the south edge of lower Punaluʻu Valley references "watercourse," "stream," and "auwai" (respectively) along the route of the 1885 ditch. Records for LCAs 7694, 4358, and 4440 in Punaluʻu, LCAs 8164-E and 10715 in Makaua, and LCA 4347 in Waiʻono similarly refer to *ʻauwai* and watercourses along the route of the north ditch. The only possible Land Commission reference to the Punaluʻu-Nāhiku ditch is a description of a "stream" along the Kāneʻohe side of LCA 5809 (Foreign Testimony 10:89). Similarly, the central ditch has only one possible reference in Land Commission records: LCA 5884 on the south side of the stream in the lower valley is described as being bounded "on the Hauʻula side by a watercourse," which would roughly align with the mapped central ditch.

A 1924 report by George Podmore (who produced the 1923 map of Punaluʻu that is referred to in the present report as Podmore 1923) to the Land Department of the Bernice Pauahi Bishop Estate discussed rights to water from Punaluʻu Stream, based on an earlier report by W.A. Wall in 1898 (discussed in Maly and Maly 2005a:281). Podmore stated that one half of the Punaluʻu water belonged to the adjacent lands of Makaua, Waiʻono, and Pūheʻemiki, and that although he could not substantiate this by records, he referred to the "old *auwai*" that "is mentioned in the boundary descriptions for both Punaluʻu and Makaua issued in 1886 and 1892, respectively" (he is presumably referring to the Boundary Commission determinations). In a subsequent report, Podmore (in Maly and Maly 2005a:281) writes that he has:

> read every Grant and Land Commission Award description in the lands of Makaua, Waiono, Puheemiki, Kapano, Haleaha, and Papaakoko. A great many of the Grants and L.C.A.'s consist of wet lands or taro patches, but no mention is made as to where they received their water supply. It is obvious that these several lands did not receive their water from the ahupuaa of Kaluanui, because the Kaluanui stream is dry at certain times of the year, and that their only source of supply was the Punaluu stream – a stream with flowing water the year round. Auwais getting their water from the Punaluu stream and irrigating these wet lands, to my mind, substantiate the fact that these said wet lands are entitled to water from Punaluu, but just how much I am unable to say.

PUNALUʻU IN THE LATE 19TH CENTURY

Beginning in 1861, rice became the driver of the Punaluʻu farming economy. The site of one of the first "extensive test areas of rice culture in the Islands" (Thrum 1910:133), the valley was transformed from taro to rice fields. The earliest account of rice in Punaluʻu is the lease of 200 acres for development of a rice plantation by a partnership consisting of Lot Kamehameha (the brother of Keʻelikōlani, who owned the *ahupuaʻa*), Seth P. Ford, and H.W. Severance (Maly and Maly 2005a:166, Table 4). The following year, the Hawaiian language newspaper *Ka Nupepa Kuokoa* (1862:2, quoted in McElroy and Eminger 2013:66, and translated by Maly and Maly 2005a:19) reported on the clearing of "*ka aina kanu raiki o Kauka Poka ma*":

> This is the rice plantation of Doctor Ford[8] and associates. They have built a wooden house to live in and a long house for the laborers. There are a total of 35 of them and they undertake their work without complaint. Doctor Ford and associates slaughter two cows a week for their workers to eat each week. There are between thirty to forty acres of land walled on the kula, readied for the planting of rice. The work has progressed well on this land because of the good work of the overseer with the people who labor below him.

A rice mill was constructed sometime before 1865, as indicated by an 1865 mortgage deed from Punaluu Rice Company to Luther Severance.[9] The lease notes that the "Rice Mill Buildings, Machinery, Water Wheel and appurtenances" were located on land earlier leased from Kailihiwa and identified as LCA 4423[10] (Bureau of Conveyances, Liber 19:397, in Maly and Maly 2005a:171).

In 1867, the entire *ahupuaʻa*, including its fishing rights, was leased to Punaluu Rice Company. Throughout the 1860s, H.W. and Luther Severance were acquiring LCA parcels, either through lease or purchase. Acquisitions included LCAs 3716, 3734, 3881, 4423, 6951, and 8172, in the middle and lower valleys (Maly and Maly 2005a:169-172). Three years later, in 1870, the lease was conveyed to Chulan & Co., a partnership of Wong Kwai[11], Ahlee, and Chang Hook that had been established in 1860 and had quickly become one of the largest Chinese retail/wholesale companies in the islands (Chun 1983:69; Char and Char 1988:99). Chulan & Co. also served as the factor or agent for the *wai goon* (partnerships) and family plantations in the valley as well as elsewhere along the windward coast, and extended credit to farmers.

In 1883, Chulan & Co. acquired a 15-year lease on the *ahupuaʻa*, including fishing rights but "excepting … all Kuleanas as awarded by the Land Commission, and excepting all timber trees now growing, or being, or which may hereafter grow" (Bureau of Conveyances, Liber 77:295-298, Maly and Maly 2005a:184). The lease rent was set at $1,000 annually.

---

8 Seth Porter Ford was a physician who was active in the developing rice industry in Hawaiʻi. He cultivated the first commercially viable seed-rice variety in 1860 and brought the first rice mill to the islands in 1862 (Haraguchi 1987:xiii, xiv). He died in 1866.

9 Based on records in the Bureau of Conveyances (reprinted in Maly and Maly 2005a), Henry W. Severance and Luther Severance appear to have been the primary actors in the Punaluu Rice Company. A mortgage deed dated June 19, 1865, (Bureau of Conveyances, Liber 19:397) states that Luther Severance was residing in Punaluʻu. An 1868 *Ka Nupepa Kuokoa* article (1868:3, quoted in McElroy and Eminger 2013:70) refers to Luther Severance "of the Rice Mill of Punaluʻu."

10 This Land Commission parcel is located in the middle valley, immediately west of the rice mill (Alexander 1907).

11 Alexander's 1907 map of Punaluʻu shows Wong Kwai as the owner of LCA 4423.

In 1902, the estate of Bernice Pauahi Bishop (heir of Ke‘elikōlani, who died in 1883) executed a new lease with Wong Kwai for the *ahupua‘a* that included detailed exceptions for water development rights, and land for power houses, stations, reservoirs, and electrical lines from those power stations. The lease also specified that Wong Kwai would be responsible for fencing off the inland area for a forest reserve, removing cattle, horses, and other grazing animals from the reserve, and take precautions to prevent forest fires (Bureau of Conveyances, Liber 233:71-75, in Maly and Maly 2005a:205-207).

The Landscape of Rice Farmers

By 1892, over 300 acres of Punalu‘u valley bottom were under rice cultivation (O’Hare et al. 2005:24). There was a large village along the shore and houses far up the valley. Rice fields covered the entire valley floor as well as the coastal lowlands.

The community was “almost exclusively Chinese” (Whitney 1890, quoted in Maly and Maly 2005a:22). Most of the Chinese in the Punalu‘u area came from the See Dai Doo district of Chungshan, China (Chun 1983:13), many from the village of Nam Long (Kam 2007). By the turn-of-the-century, there were about 500 Nam Long people living and farming in 13 communities on the windward coast of O‘ahu (Kam 2007).

The Chinese farms were run by families or by partnerships (called *wai goon*). The family-run farms were generally 10 to 15 acres in size, with labor done by fathers and sons with the help of perhaps one or two hired hands (Chun 1983:13). *Wai goon*, on the other hand, were larger operations covering 40 to 50 acres, requiring over a dozen workers and often double that during planting and harvesting (Chun 1983:14-15). They could be run like a cooperative with shared expenses or losses among farmers, or they could be run by the landlord or plantation company with hired laborers. The rice companies were often retail/wholesale companies based in Honolulu that extended credit to farmers.

Farmers also grew vegetables, taro, peanuts, and bananas, and raised pigs and poultry (Char and Char 1988:95). Dennis Chong, a fifth-generation descendant of one of the original Chinese farmers in Punalu‘u, described a culture of sharing (quoted in Kam 2007):

> Everyone raised pigs, so once a week somebody would slaughter a pig. They’d go in cycles, and everyone knew whose turn it was, so they’d go over to that person's house to pick up their share of pork. It was the same way with fish. My great-grandfather used to tell the family about hiking to the top of a hill when there was a big catch and lighting a bonfire to signal others to come and get fish. They really helped each other.

Transportation at the Turn-of-the-Century

Successful commerce had to overcome the tribulations of transporting goods and receiving supplies between the remote windward O‘ahu coast and the commercial hub of Honolulu, a distance of 26 miles measured from the Honolulu Post Office (Lydgate 1886:15). Transportation outside of the valley was limited to a dirt road that edged the coastline south to Kāne‘ohe, and a short distance north to Hau‘ula (Chun 1983:4, 8). Beyond Hau‘ula, the route followed the sand beach. On foot, by horse-drawn vehicles, or by horseback were the only ways to travel along the windward coast. Getting to Honolulu was accomplished most easily, albeit at a cost, by sea.

Chun (1983:17, brackets added) describes the regular arrival of the steamship, *John Cummings*, a ship of the Inter-Island Steam Navigation Company,[12] that brought in heavy equipment for the rice business in the valley, and hauled off finished rice to Honolulu:

> It was quite a day when the "John Carmen" [the Chinese name for the *John Cummings*] steamed into Punaluu, resembling, on a smaller scale, the steamer day of Matson Liners in Honolulu departing for and arriving from the West Coast. Idle residents gathered on the road to watch the loading and unloading. This process was done through small row-boats as the water at the end of the pier was still not deep enough, even for the little "John Carmen".
>
> Some Punaluu people, especially the foot-bound Chinese women who could not get to town in any other way, took the "John Carmen" to Honolulu, suffering almost certain seasickness as the vessel bobbed and buckled, dipped and pitched on the waves along the north and east shores of the island. The boat sometimes anchored at Waikane and Kaalaea to pick up more rice.

Small rowboats ferried finished rice bound for Honolulu, incoming goods, and passengers between the pier and the ship. The pier and warehouses are shown on Alexander's 1907 map at the seaward end of the "road to rice mill." The *Evening Bulletin* (1897:8, brackets added) reported on the route of another ship that provides a glimpse of the inter-island circuit:

> The steamer Kaala … docked at Fort street wharf [Honolulu] at 8 o'clock last evening from Punaluu. Purser CK Spencer reports landing a roller at Waialua last Saturday, thence to Punaluu, thence to Lahaina where the Kaala was busy all Sunday, leaving that port for Koolau Sunday evening. Monday and Tuesday was consumed at windward Oahu ports. Fine weather throughout. Wong Kwai's rice mill has stopped on account of shortage of sacks. Paddy cutting is progressing at Punaluu and Laie.

The End of the Rice Industry

The rice industry in Hawai'i collapsed in the first decades of the 20th century, a victim of competition from more efficient plantations on the U.S. mainland, labor shortage, and a blight caused by a stem-borer that affected young plants (Chun 1983:94). One of the last Punalu'u rice farmers was Choy Hong Lai, who moved his family from its Mānoa taro farm to the windward side in 1920, hoping for a comeback in the rice industry (Chun 1983:56). When this failed, he switched back to taro cultivation in the late 1920s. He died in Punalu'u in 1953, leaving his name on the road that led from the coast to the old rice mill and then inland to the Inaura residence (labeled "Hong Lai Road" on Thoene's 1953 map; also in Maly and Maly 2005b:).

---

[12] The Inter-Island Steam Navigation Company was founded by Thomas R. Foster. His part-Hawaiian wife, Mary Elizabeth Mikahala Robinson Foster, was the daughter of an English expatriate and a descendant of Maui chiefs (Karpiel 1996:178); her brother Mark Robinson was a prominent Honolulu businessman, a member of Queen Lili'uokalani's cabinet, and the owner in 1886 of much of Wai'ono Ahupua'a (Boundary Commission records, in Maly and Maly 2005:148). Mary Foster had extensive land-holdings, including most of Kahana Valley to the south of Punalu'u; her Honolulu home was bequeathed to the City and County of Honolulu at her death in 1930 and became Foster Botanical Garden. She acquired two LCA parcels in lower Punalu'u (LCAs 4435 and 6956) (Alexander 1907).

THE FIRST HALF OF THE 20TH CENTURY

A major figure in Punaluʻu land use history entered the picture at the beginning of the 20th century. In 1905, James B. Castle purchased the *lele* of Nāhiku from the John ʻIʻi Estate[13] (Bureau of Conveyances, Liber 432:234-235; in Maly and Maly 2005a:210). In 1906, he acquired the lease for Punaluʻu Valley, taking over from the Chinese *hui* directed by Wong Kwai (Maly and Maly 2005a:Table 4). Along with purchases and leases for other lands in the windward area, Castle established the symbiotic corporations of Koolau Agricultural Company and Koolau Railroad Company, and developed the Punaluʻu Ditch.

As written by Dorrance and Morgan (2000, quoted in Maly and Maly 2005a:283), Castle had a "grand vision for the development of the Windward side of Oʻahu:"

> His dream of industrial transport included extending the O.R.&L. railroad from its terminus at Kahuku with his own railroad heading south, down the eastern coast of Oʻahu to Kaneʻohe, then back through the Koʻolau range to Honolulu, where it would join his Honolulu Rapid Transit railway. He planned to revitalize the Heeia Agricultural Company plantation at the railroad's southern end, and establish new agricultural enterprises along the way between Kahuku and Heʻeia.

Koolau Agricultural Company

James B. Castle established Koolau Agricultural Company in 1909 on Koʻolauloa lands stretching from Lāʻie to Kahana Bay. Lands in Punaluʻu and adjacent Kaluanui were leased from the Bishop Estate for a term ending in 1956 (Maly and Maly 2005a:219-221, 246). Other smaller parcels (former LCAs and grants) were acquired through purchase. A 1910 *Hawaiian Star* article described Castle's plans for 6,500 acres on the windward coast, essentially consolidating Castle's lands in Kailua, Kāneʻohe, Heʻeia, and Koʻolauloa, with other privately held lands in Kahana, Kualoa, and Waikāne, into one large commercial venture. Plans included a mill that would be built in Kāneʻohe (Timmons 1910:5).

By 1910, sugarcane was flourishing in Punaluʻu. Thrum (1910:132) describes the view from the Koolau Railroad:

> One fails to grasp the extent of agricultural effort put forth by glimpses from a passing train, but an idea may be had from the fact that in addition to rice growing cane fields are ripening and new tracts are being cleared for planting.

Castle died in 1918, and his lease with the Bishop Estate was transferred to the Koolau Agricultural Company (Bureau of Conveyances, Liber 526:60-63, in Maly and Maly 2005a:246). In 1926, Koolau Agricultural Company, including leases on the land and fishing rights of Punaluʻu, was acquired by Zion's Securities of Lāʻie. The holdings were subsequently incorporated into Kahuku Plantation Company in 1931 (Maly and Maly 2005a:5).

---

13 Barrère (1994:75) notes that John ʻIʻi's widow, Maraea Kamaunauikea Kapuahi, "gives to daughter Airene her kuleana in … Makaua, Koolauloa." Presumably, this is the origin of the John ʻIʻi Estate's ownership of the *lele* of Nāhiku, but the connection between Maraea Kapuahi and the Mahele awardee, Kekaha, is not known.

At the time of its acquisition by Zion's Securities, Koolau Agricultural Company was cultivating around 200 acres of sugarcane in Punaluʻu (Maly and Maly 2005a:281). The fields in the upper valley were watered by rainfall; the fields in the lower valley, and in Makaua, Waiʻono, and north to Kaluanui, were watered by a combination of the Punaluʻu Ditch system (see below) and modified taro/rice *ʻauwai*. Podmore's 1923 map of the valley shows cane also growing on the coastal plain south of the valley, cultivated in a narrow strip on both sides of the railroad track.[14]

Sugarcane continued to cover lower Punaluʻu Valley until the 1970s when Kahuku Plantation closed. The fields on the coastal plain south of the valley, however, do not appear on the Thoene (1953) map and were apparently taken out of production sometime in the 1930s or 1940s.

Koolau Railroad Company

In 1905, the Territory of Hawaii issued a charter for the Koolau Railway Company, Ltd., the brainchild of James B. Castle (Condè and Best 1973:308; Livingston n.d.). It was planned to service the windward coast, running from Kahuku Plantation in the north to Kāneʻohe, with a connection to Honolulu by way of a tunnel through the Koʻolau Mountains. Once in Honolulu, the system would join with Castle's Honolulu Rapid Transit railway (Dorrance and Morgan 2000, quoted in Maly and Maly 2005a:283).

Ultimately, only 11 of the projected 35 miles of rail were constructed, connecting Kahuku and Kahana Valley. In the section between Hauʻula and Punaluʻu, surveyors and road builders had to "cut through miles of dense hau forest, the surveyors in running their preliminary lines having to practically tunnel their way"; 2,000 cords of *hau* wood was shipped to Kahuku Plantation during the course of railroad construction (Matheson 1908:1, 8). Instead of the planned route over the Koʻolau Range to Honolulu, the connection to the city was via the more circuitous route of the Oahu Rail and Land Company (OR&L) line along the north and western shores of the island. Harvested cane from the Koolau Agricultural Company fields was transported by the 36-inch narrow gauge railroad to the sugar mill at Kahuku (Dorrance and Morgan 2000, in Maly and Maly 2005a:283).

A front-page article in the January 7, 1908, *Hawaiian Gazette* announced the completion of the first 11 miles of the railroad (Matheson 1908:1):

> The completion of the first eleven miles of the new Koolau railroad has already had a wonderfully stimulating effect on the agricultural activity of the windward side of Oahu and when the line is continued from Kahana, the present terminus, to Heeia, that entire section will be brought into a state of agricultural possibility as healthy as any portion of the islands. This completion is promised by the end of the present year, at which time automobile stages will be put on between Heeia and Honolulu and tourists and others will be brought within easy reach of the most picturesque part of Oahu and enabled to make a comfortable and cheap one day trip around the island.
>
> What the building of this railroad is going to mean for the Koolau district is shown to a certain extent at present, plans being well under way for the opening of thousands of acres of land for cane planting, for the cultivation of rubber trees, for the planting of pineapples on a large scale, for the planting of experimental

[14] The source of water for these fields is uncertain. The ditch that originates above the rice mill and wraps around the hill on which Hanawao Heiau sits lies below these fields and does not appear to be a likely irrigation source.

> patches of cotton, for the transplanting of thousands of cocoanut palms for the manufacture of copra, for putting in of upland rice, for the raising of manioca for starch and for the cultivation of the lesser branches of the possible diversified farming industries … The big item in connection with the development of the district is to be the reopening on a large scale of the Heeia plantation, the building and equipping of a modern mill and the infusion of new life into the pretty plantation town of Heeia.

The article continued with a description of the railroad operations (Matheson 1908:1):

> From here [Kahuku] two trains run daily, connecting with the noon train from Honolulu and the one reaching Kahuku in the late afternoon. Passengers and freight are carried as far as Kahana and the traffic so far developed has been such as to encourage the promoters. The trip over the line is an interesting one and the fare is five cents a mile.

In 1920, the Territorial Planning Board reported that Koolau Railroad Company still had only 11 miles of rail, and with one locomotive, two passenger cars, and 21 freight cars, it was carrying 1,056 passengers and 31,152 tons of freight (Condè and Best 1973:309). The railroad company ordered a second locomotive. In 1930, passenger service had dropped to only 50 passengers, but freight had risen to 50,811 tons.

The railroad, along with Koolau Agricultural Company, was absorbed by Zion's Securities in 1926, and was subsequently leased to Kahuku Plantation Company in 1931 (Maly and Maly 2005a:280). Kahuku Plantation continued to operate the railroad as an extension of its plantation system until 1954 (Livingston n.d.). When the sugar plantation closed, all remains of the railroad were removed (R. Albert interview, in O'Hare et al. 2013:99). The route through Punalu'u Valley is still extant as a graded road.

Punalu'u Ditch

The Punalu'u Ditch was constructed by James B. Castle in the first decade of the 20th century, as part of his efforts to establish commercial sugar production on the windward coast. The ditch consisted of 12 tunnels and connecting flumes and ditches in the back of Punalu'u Valley. It drew water directly from Punalu'u Stream at an intake located about 3.2 km (2 miles) inland from the coast. The gravity-fed tunnel/flume section wrapped around the western slopes of the valley (roughly following the 61 m (200 foot) elevation), and then extended north about 6.4 km (4 miles) to Hau'ula (Maly and Maly 2005a:5). It supplied water to sugarcane fields on the coastal plain in Punalu'u, Makaua, Wai'ono, and north to Kaluanui (Maly and Maly 2005a:281).

The Alexander 1907 map of Punalu'u shows "proposed power house site" near the entrance to Tunnel 3, at the inland end of a road labeled "new road" (presumably built to access the proposed power house). There is no indication that the power house was ever constructed, but the road, in various near alignments, is the present Punalu'u Valley Road.

A 1908 Hawaiian Gazette article describes the proposed power plant as producing "between five and six thousand horse power … and it is well within the possibilities that this power will be used later on to develop electricity and supplant steam as a motive power on the railroad" (Matheson 1908:8).

Concrete-lined irrigation channels were added to the ditch system in 1922 to transport water (Townscape 2010:16).

After its acquisition of the cane lands of the former Koolau Agricultural Company, Kahuku Plantation maintained the ditch, using a crew of "*hana wai*" men who were responsible for the plantation irrigation system as well as the ditch (J. Primacio interview, Maly and Maly 2005b:71):

> The *hana wai* men had, when they weren't irrigating, they had the responsibility of maintaining the irrigation system. Part of the irrigation system was the ditch. They cut the root system that protrudes into the water.
>
> … When it came off season, when the plantation wasn't producing sugar cane, there was a lot of labor. That's when they took us and brought us into Punaluʻu to clean. Go through the tunnels take out all the rocks, the mud, do repair work, that kind of stuff.

In 1927, the plantation installed a pipeline from the south valley *ʻauwai* intake at about the 58 m (190 foot) elevation (F. Trotter interview, Maly and Maly 2005b:161). The pipeline ran along the south edge of the valley and took water to a 25,000 gallon water tank that supplied water to the houses along the highway.

During the time of the modern Koolau Agricultural Company (post-1970), a pipe was installed between Tunnels 9 and 10 to divert water from the ditch system (J. Primacio interview, Maly and Maly 2005b:77). In 2009, a Kamehameha Schools diversion improvement project modernized the ditch irrigation system with installation of a more efficient and reliable pipe delivery system (City and County of Honolulu, Board of Water Supply, http://www.boardofwatersupply.com/cssweb/display.cfm?sid=2141).

Other Farming Activity

Farming in Punaluʻu in the first half of the 20th century was not limited to sugar and rice. A 1912 mortgage between Sensuke Hiramoto and Libby McNeill & Libby recorded in the Bureau of Conveyances (Liber 377:225-228, in Maly and Maly 2005a:225) states that Hiramoto was leasing 28.7 acres from Koolau Agricultural Company for the cultivation of pineapples. The mortgage with Libby McNeill & Libby specified that the company would purchase pineapple that Hiramoto delivered to its Kahaluu cannery, at a specified price and for an advance of $150 per month for seven months, with a final advance of $500 on June 30, 1913. Similar agreements were made with other farmers, including Sakichi Noda who had almost 154 acres leased from Koolau Agricultural Company (Bureau of Conveyances, Liber 377:231-233, in Maly and Maly 2005a:226). Noda subsequently sub-leased land to nine other Japanese farmers (Maly and Maly 2005a:227). In a report on the prospective creation of the Hauula Forest Reserve, Judd (1918, quoted in Maly and Maly 2005a:286) notes that "in Kaluanui, Punaluu and Kahana, pineapples have been raised in the past near the forest boundary, but cultivation of this crop here has recently been given up."

One of the pineapple farmers was a Japanese man named Inaura, who with his family, were still remembered by a Punaluʻu resident who was interviewed in 2004 (J. Primacio interview, Maly and Maly 2005b:8; Maly and Maly 2005a:13). The Inauras leased the land inland of the rice mill.

Wah Chan Ching[15] (interview, Maly and Maly 2005b:21) remembered that pineapple farmers would bring the pineapple "down to the highway and then they used to truck it to Libby Cannery … in Kahaluʻu." The coastal road was paved in concrete around 1926 or 1927 (W.C. Ching interview, Maly and Maly 2005b:26). Prior to that time, the primary means of getting around the island was via the railroad to Kahuku, the dirt road to Kāneʻohe, or by ship from the pier at Punaluʻu (near the south end of the present Punaluʻu Beach Park).

Taro was also being cultivated. In addition to pineapples, the Inauras grew taro, and are remembered as having "maintained *loʻi* with *ʻauwai*, everything must have come off the stream all through here" (J. Primacio interview, Maly and Maly 2005b:63). A 1914 agreement between two Japanese farmers in Punaluʻu and a Chinese firm in Honolulu detailed an arrangement for purchase of 800 bags of taro to be shipped via the Koolau Railway to Kahuku and then by OR&L from Kahuku to Honolulu (Bureau of Conveyances, Liber 406:56, in Maly and Maly 2005a:228-229). The farmers would send 15 bags every Monday, Wednesday, and Friday. A 1923 agreement between Wong Nin and S. Yonenaka[16] stipulated that the former would purchase "all marketable taro" raised in the 40 patches tended by the latter, and that the latter would not sell his taro to anyone else (Bureau of Conveyances, Liber 693:374-375, in Maly and Maly 2005a:255-256).

Maly and Maly (2005b:205) interviewed Gentaro Ota, who was born in Punaluʻu Valley in 1925 and lived with his parents on an upland taro farm until he was eight or nine years old:

> The Ota family lived far back in the valley, along the Punaluʻu River, on *kuleana* land in which Kupau and McCandless shared an interest (L.C.A. 10212, originally awarded to Molea).[17]
>
> Both his father and mother planted taro on the land. There were two *loʻi* on one side of the stream, and one *loʻi* on the other side of the stream. There was also a dam in the stream that diverted water to the *ʻauwai* for the *loʻi*. The taro was bagged in 100 pound sacks, hauled out of the valley on a horse drawn wagon, and delivered to the Haleʻiwa and Waiāhole Poi Factories.

Hauula Forest Reserve

With a precedent in the Hawaiian government's 1876 "Act for the Protection and Preservation of Woods and Forests," which recognized that the destruction of the Hawaiian forest had an impact on the water supply (reprinted in Planters' Monthy 1887), the new Territorial government in 1903 established a Division of Forestry that oversaw the Hawaiʻi forest reserve system (Cuddihy and Stone 1990:49). The Kaipapau Forest Reserve (north of Punaluʻu) was one of the first forest reserves established (in 1904), and was followed in 1918 with the Hauula Forest Reserve. Together, the two reserves protected the upland forest of Koʻolauloa (Judd 1918, quoted in the Maly and Maly 2005a:285-286):

15 Wah Chan Ching is a descendent of one of the first Chinese settlers in Punaluʻu (Maly and Maly 2005b:8).

16 Yonenaka is mentioned by oral history interviewees as one of the Japanese pineapple farmers in Punaluʻu (Maly and Maly 2005b:8).

17 LCA 10212 to Molea is located just inland of the present project area.

> The area includes land which supports a “water-bearing forest” composed of the usual native trees such as koa, ohia, kukui, hala, hau and their plant associates of ferns, vines and undergrowth, which combine to make up the ideal ground cover for conserving the water run-off. This forest in general is in a very healthy condition with very few dead trees.
>
> Many industries are dependent on the water emanating from this forest, viz: the sugar in lower Kaluanui, Punaluu and Kahana valleys, the rice in Punaluu Valley, and from the headwaters of the main Kahana Stream, at an elevation of about 750 feet, water is taken by tunnel south along the mountain, then through the main Waiahole tunnel to far distant cane fields in the upper Ewa basin. The importance of protecting and maintaining the forest on this area for the conservation of water is therefore apparent.

The Hauula Forest Reserve alone covered 9,193 acres of government and private lands in Makao, Kaluanui, Waiʻono, Makaua, Punaluʻu, and Kahana (Judd 1918, in the Maly and Maly 2005a:286). The estate of Bernice Pauahi Bishop contributed 2,950 acres in Punaluʻu, as well as 1,033 acres in Kaluanui. Various owners of former LCA parcels added another 28 acres in Punaluʻu. The forest reserve boundary in Punaluʻu lies just inland of the present project area.

World War II

With the onset of World War II, the Hawaiian Islands were the front line in the Pacific theater. The military acquired lands across Oʻahu for training, including Punaluʻu and neighboring Kahana Valleys, which became part of the Pacific Jungle Combat Training Center (CTC). The training area originally consisted of 2,267 acres of several non-contiguous parcels in Kahana and Punaluʻu Valleys (Parsons 2008:2-4). Approximately 1,782 acres in Punaluʻu Valley were acquired by leases, licenses, and informal agreements between October 1943 and March 1947.

The training complex began operations in September 1943 and served for unit level training to supplement Department Ranger and Combat School Training. The Center was divided into three courses, Red, Blue, and Green; Punaluʻu was the site of the Green course, where advanced jungle warfare training as well as the Instructor Jungle Training School were conducted. Basic jungle warfare was conducted in Kahana Valley in the Red and Blue courses. Training during one-week courses included jungle first aid and evacuation, hand-to-hand combat, construction and passage of wire entanglements, booby traps and demolitions, patrolling and ambushing, hip shooting and infiltration, stream crossing expedients, assault with bayonets, assault of Japanese-fortified areas, combat reaction proficiency, and jungle living (Parsons 2008:2-4). Live ammunition was used during training exercises and unexploded ordnance has been found in CTC areas.

Japanese villages and pillboxes with pop up dummies were reportedly constructed for training (U.S. Army Engineer District 1993:Findings of Fact). A Japanese tank was placed in the central valley as a visual aid for soldiers (O’Hare et al. 2013:99); the tank was still in place in 1993, located on TMK (1) 5-3-011:005 (U.S. Army Engineer District 1993:January 22, 1993 site visit). Earthen and concrete bunkers were constructed in the upper valley (U.S. Army Engineer District 1993:January 22, 1993 site visit). In addition, temporary barracks, a bachelor officers’ quarters (BOQ), mess hall, bakery, and shower facilities were built (U.S. Army Engineer District 1993:January 22, 1993 site visit; O’Hare et al. 2013:99). The road to the upper valley was paved with coral base (U.S. Army Engineer District 1993:attachment to February 16, 1993 letter) and it became known during the war as Green Valley Road (O’Hare et al. 2013:99).

By early 1944, as the war moved to the western Pacific, advanced training on the Green course was discontinued as the need for basic jungle warfare training gained priority.

In the immediate post-war years, the military closed its training centers, but retained Punaluʻu. It gradually removed equipment and abandoned remaining structures. On April 1, 1946, it quickly reactivated the training center to serve as an emergency shelter for displaced residents in the aftermath of a devastating tsunami (U.S. Army Engineer District 1993:Findings of Fact). Leases and licenses for parcels in Punaluʻu Valley were officially terminated between April 1945 and November 1950.

PUNALUʻU IN THE SECOND HALF OF THE 20TH CENTURY

Kahuku Plantation Company held the lease on Punaluʻu lands until 1971, when the original lease to James Castle expired. A new lease was issued to Kaluanui Ventures, Inc., from 1975 to 1984. Subsequently, Koolau Agriculture Company acquired the lease, which ran until 2000, when Kamehameha Schools took over day-to-day management of Punaluʻu.

PREVIOUS ARCHAEOLOGICAL INVESTIGATIONS

There have been numerous archaeological studies adjacent to the present project, with two investigations overlapping the stream restoration area (Table 5; Figs. 6 and 7). However, as a whole, fundamental aspects of Punaluʻu's pre-Contact history are poorly defined. The absolute settlement chronology for the *ahupuaʻa* is based on five[18] radiocarbon determinations, which makes for a less than robust estimate. Artifact collections—critical for identifying past activities—are also small in number, largely due to the limited amount of controlled subsurface testing that has been completed, particularly in the valley proper. Faunal collections are limited for the same reason, and therefore, an analysis of subsistence patterns and possible changes in those patterns over time is not possible.

What has been accomplished moderately well by the studies overlapping the current project area is identifying surface features along the southern valley bottom and lower to mid-elevation slopes (Denison 1975; McElroy and Eminger 2013). These data, though, require a critical evaluation because of the extensive land modifications completed throughout this area during the 19th and 20th centuries for rice, sugarcane, and pineapple plantation agriculture, as well as more recent alterations (e.g., straightening of Punaluʻu Stream). Another aspect of the archaeological record that has been well-documented is the prevalence of traditional[19]

---

18 A total of six radiocarbon determinations have been obtained; however, the standard error for one of the ages is not reported, thus the date cannot be calibrated. In addition, two other determinations are reported as measured radiocarbon ages, rather than isotopically corrected conventional radiocarbon age, which therefore adds a degree of uncertainty to the calibrated dates.

19 The term "traditional" is used to refer to pre-Contact and early post-Contact Hawaiian culture and material culture that was not influenced by Western ideas or goods. Activities and material culture from the early decades of the post-Contact period (AD 1778- ~1830, or later for certain activities/items) often exhibited little to no dissimilarities with older pre-Contact technologies and practices. The timing of changes, however, varied between activities (e.g., the practice of hula) and materials (e.g., stone adze production and use); see Bayman (2003, 2007, 2009) for summaries of this issue.

burial along the calcareous sand coastal margin (Jourdane 1995a, 1995b; Hammatt et al. 2013; LaChance et al. 2014b; O'Hare et al. 2007, 2008a; Perzinski and Hammatt 2004). In contrast to the rather bleak state of archaeological knowledge of the area, this windward location with perennial stream flow, a large alluvial valley bottom, a nearshore marine ecosystem protected by a fringing reef, and reef passages, would have provided ideal environmental parameters for early and sustained occupation throughout the pre-Contact period. Some of the radiocarbon ages point to an early settlement date, but additional research is needed to test this hypothesis.

SURFACE ARCHAEOLOGY IN PUNALU'U VALLEY

Two archaeological surveys previously covered the project area, wholly or in part. Denison (1975) conducted a reconnaissance-level survey of approximately 200 acres along the southern and back portions of the valley, approximately 4.5 acres of which overlaps with the project area. He did not record any sites in this overlapping acreage, but did document 25 sites across his larger survey area. Two sites (Sites 292 [possible *heiau*] and 293 [Hanawao Heiau]) had been previously recorded by McAllister (1933) and two other sites (Sites 1040 [historic residential/agricultural complex] and 1041 [pre- and post-Contact dryland agricultural complex]) had been listed on the Hawaii Register of Historic Places prior to his survey. Most of the features Denison recorded he identified as pre-Contact agricultural and/or habitation complexes, comprised variously of terraces, mounds, and walls. Features identified as post-Contact structures included walls, mounds, a residential complex, and an *'auwai*. Based on historical research undertaken for the present project, it is possible that at least some of the agricultural complexes Denison classified as pre-Contact may be more recent structures (or at least represent post-Contact use of older structures).

Following upon a reconnaissance-level survey (McElroy et al. 2011), McElroy and Eminger's (2013) survey of 433 acres encompassed the majority of the mid- and lower valley. They recorded, or re-recorded, 44 sites, that include traditional residential, agricultural, and religious structures; plantation infrastructure and associated structures; and, early 20th century military structures. These include sites originally documented by McAllister (1933) and Denison (1975), some of which were assigned new, duplicate SIHP numbers[20] at the request of McElroy and Eminger (see Table 5). Two of the sites recorded by McElroy and Eminger (2013) extended into (Site 7223, Feature 1e) or abut (Site 7236) the Punalu'u Valley Component of the stream restoration project area.

Site 7223, Feature 1e, is described as a 1,642-meter long historic irrigation ditch and road (McElroy and Eminger 2013:114). The ditch is unlined, extending approximately 90 m into the Punalu'u Valley Component and along the slope contour over 1,500 m to the south. Two subfeatures, A and B, were also recorded. Subfeature A is a pair of 2.3-meter long concrete walls interpreted as water control features. Subfeature B is a secondary spur ditch with a concrete sluice gate.

---

20 This duplicate numbering needs to be rectified with the SHPD. IARII is completing a separate inventory survey of Punalu'u Valley for KS, which encompasses the sites recorded by Denison (1975) and McElroy and Eminger (2013). As part of the reporting for that project, IARII will address the duplicate numbering with the SHPD.

Table 5. Previous Archaeological Work Within and Adjacent to the Project Area.

Author & Year	Location	Ahupua‘a	Work Completed	Findings (50-80-06-)
McAllister (1933)	O‘ahu Island	multiple	Site recording	Site 292, possible *heiau*; Site 293, Hanawao Heiau; Site 294, Kaluaolohe fishpond; Site 295, Kaumaka‘ula‘ula Heiau; Site 296, *heiau* (unknown name). [Not depicted in Fig. 6.]
Denison (1975)	200 acres along Punalu‘u Stream	Punalu‘u	Reconnaissance	Re-located Site 292, possible *heiau*, Site 293, Hanawao Heiau, Site 1040, residential/agricultural complex, and Site 1041, dryland agricultural complex (that may subsume Site 292); newly recorded: Site 2924, wall; Site 2925, mound complex; Site 2926, wall; Site 2927, dryland agricultural complex; Site 2928, mound, Site 2929, dryland agricultural terraces; Site 2930, irrigated agricultural complex; Site 2931, residential terrace; Site 2932, irrigated agricultural complex; Site 2933, dryland agricultural complex; Site 2934, irrigated agricultural complex; Site 2935, irrigated agricultural complex; Site 2936, retaining walls.
Barrera (1984)	Well sites	Punalu‘u	Reconnaissance	None.
Bath and Smith (1988)	Pat’s at Punalu‘u	Papa‘akoko	Field inspection	Site 3970; field inspection prompted by a possible burial determined that the bones were nonhuman but a buried cultural deposit with pit features was noted. [Not depicted in Figs. 6 and 7.]
Medical Examiner (1988)	53-183 Kamehameha Highway	Punalu‘u	Inadvertent burial documentation	Site 3764; apparent in situ, intact burial disturbed and fragmented during trenching for power line; investigation conducted by the Medical Examiner and Honolulu Police Department (no SHPD involvement); undisturbed remains left in place. The burial was misplotted on maps included in the Medical Examiner’s report as being on the *mauka* side of the highway at the intersection with Punalu‘u Valley Road (Green Valley Road).
Smith et al. (1988)	53-368 Kamehameha Highway	Wai‘ono	Inadvertent burial documentation	Site 3977; three human burials (pre-Contact and historic), one dog burial; historic trash pit with late 19th century bottles, firepit. [Not depicted in Figs. 6 and 7.]
Kawachi and Smith (1989); Pietrusewsky (1989)	Unimproved road along the base of the south slope of Punalu‘u Valley	Punalu‘u	Inadvertent burial documentation	Site 4145; secondary burial pit with the incomplete remains of at least six individuals, including subadults and at least one adult male.

Table 5. Previous Archaeological Work Within and Adjacent to the Project Area (continued).

Author & Year	Location	Ahupua‘a	Work Completed	Findings (50-80-06-)
Kennedy (1992)	Well sites (TMK [1] 5-3-001:041; [1] 5-3-003:001)	Punalu‘u	Reconnaissance	Four mounds, an *‘auwai*, and terraces; no State site numbers assigned. No map of the survey locations is included in the letter report. [Not depicted in Fig. 6.]
Hammatt (1994)	Well site on Punalu‘u Valley Road (Green Valley Road) (TMK [1] 5-3-007:014)	Makaua	Reconnaissance	None; area had been previously graded. Barrera (1984) had previously surveyed this parcel.
Jourdane (1995a)	Former Paniolo Café; *mauka* side of Kamehameha Highway (TMK 5-3-01:052)	Punalu‘u	Inadvertent burial documentation	Site 5132; two human burials and a cultural layer.
Jourdane (1995b)	53-504 Kamehameha Highway (TMK [1] 5-3-006:029)	Hale‘aha	Inadvertent burial documentation	Site 5308; human remains. [Not depicted in Figs. 6 and 7.]
Colin and Hammatt (2000)	Former Paniolo Café; *mauka* side of Kamehameha Highway (TMK [1] 5-3-001:052)	Punalu‘u	Inadvertent burial documentation	Site 5132, two previously disturbed human burials and an intermittent cultural deposit; no skeletal inventories (both completely disinterred) and no controlled testing of the cultural layer. Follow-up to Jourdane (1995a).
Perzinski and Hammatt (2004)	Kamehameha Highway	Punalu‘u, Makaua, Wai‘ono, Puhe‘emiki, Kapano, Hale‘aha	Monitoring	Sites 6574 to 6588, 6695 to 6697; pre-Contact and historic period human burials and three areas of cultural deposits.
O’Hare et al. (2005)	Hanawao Heiau	Punalu‘u	Archaeological Inventory Survey	Site 293, Hanawao Heiau: four features, including a pavement, retaining walls, a boundary wall, and a historical cemetery.
Tulchin and Hammatt (2006)	Hanawao Heiau	Punalu‘u	Survey	A set of rock alignments; no SIHP number assigned.
Kennedy (2006)	South and west sides of the valley	Punalu‘u	Field check	One terrace (no SIHP number assigned).
Tulchin et al. (2007)	North of Punalu‘u Stream mouth	Kapano, Puhe‘emiki	Field check	Historic drainage pipe.
O’Hare et al. (2007)	Punalu‘u Beach Lots 1, 15, 17, 20, 21, 27, 28	Punalu‘u	Survey	Site 6938, one human burial at Lot 15.
O‘Hare et al. (2008a)	Punalu‘u Beach Lots 12 and 19	Punalu‘u	Survey	Site 6939, one human burial at Lot 19; Site 6947, human skeletal remains at Lot 12.

Table 5. Previous Archaeological Work Within and Adjacent to the Project Area (continued).

Author & Year	Location	Ahupua‘a	Work Completed	Findings (50-80-06-)
O’Hare et al. (2008b)	Punalu‘u Beach Lots 4, 6, 25, 36	Punalu‘u	Survey	No findings.
Paolello et al. (2012)	Punalu‘u Beach Lot 8	Punalu‘u	Archaeological Inventory Survey	No findings.
McElroy and Eminger (2013) (preceded by McElroy e tal. 2011)	Punalu‘u Valley	Punalu‘u	Archaeological Inventory Survey	Documentation or re-recording of 44 archaeological sites: Site 7223, historical ditch system and road; Site 7224, possible habitation terrace; Site 7225, enclosure and wall; Site 7226, C-shape; Site 7227, mound; Site 7228, wall and mound; Site 7229, historical ditch; Site 7230, concrete monument; Site 7231, alignment and walls; Site 7232, *lo‘i* complex (re-recording of Site 2936); Site 7233, terrace complex; Site 7234, terrace complex; Site 7235, historical ditch; Site 7236, historical ditch; Site 7237, boulder monument with Chinese inscription; Site 7238, three walls and a terrace; Site 7239, terrace; Site 7240, terrace complex; Site 7241, concrete water tank foundations; Site 7242, mound and traditional artifact/midden scatter; Site 7243, mound complex; Site 7244, two terraces; Site 7245, two mounds (re-recording of Site 1041); Site 7246, nine concrete bunkers and four gun emplacements; Site 7247, mound; Site 7248, mound, terrace, wall, and enclosure (re-recording of Site 2927); Site 7249, pit; Site 7250, terrace complex; Site 7251, mound; site 7252, mound complex (re-recording of Site 1041); Site 7253, Chinese memorial; Site 7254, historical cemetery; Site 7255, wall and terrace complex (re-recording of Site 1040); Site 7256, terrace and mound complex (re-recording of Site 2933); Site 7257, feature complex interpreted as a possible *heiau* (re-recording of Site 292/1041); Site 7258, terrace and mounds interpreted as a *heiau*; Site 7259, feature complex interpreted as a *heiau* (re-recording of Site 296); Site 7300, two mounds and a pit; Site 7301, feature complex; Site 7302, feature complex; Site 7303, terrace; Site 7304, two terraces and two walls; Site 7305, C-shape and mound; Site 7306, terrace

Table 5. Previous Archaeological Work Within and Adjacent to the Project Area (continued).

Author & Year	Location	Ahupua‘a	Work Completed	Findings (50-80-06-)
LaChance et al. (2014a)	Punalu‘u Beach Lot 23	Punalu‘u	Archaeological Inventory Survey	Single basalt flake and some fire-cracked rock collected, but no intact cultural deposit; no SIHP number assigned
LaChance et al. (2014b)	Punalu‘u Beach Lot 29	Punalu‘u	Archaeological Inventory Survey	Site 7476, buried pre-Contact cultural layer; Site 7480, pre-Contact burial
LaChance et al. (2014c)	Punalu‘u Beach Lot 31	Punalu‘u	Archaeological Inventory Survey	Site 7476, buried pre-Contact cultural layer with two pit features
Mierzejewski et al. (2014)	Punalu‘u Beach Park	Punalu‘u	Archaeological Monitoring	No findings

Shading indicates archaeological projects that include, at least in part, the present project area.

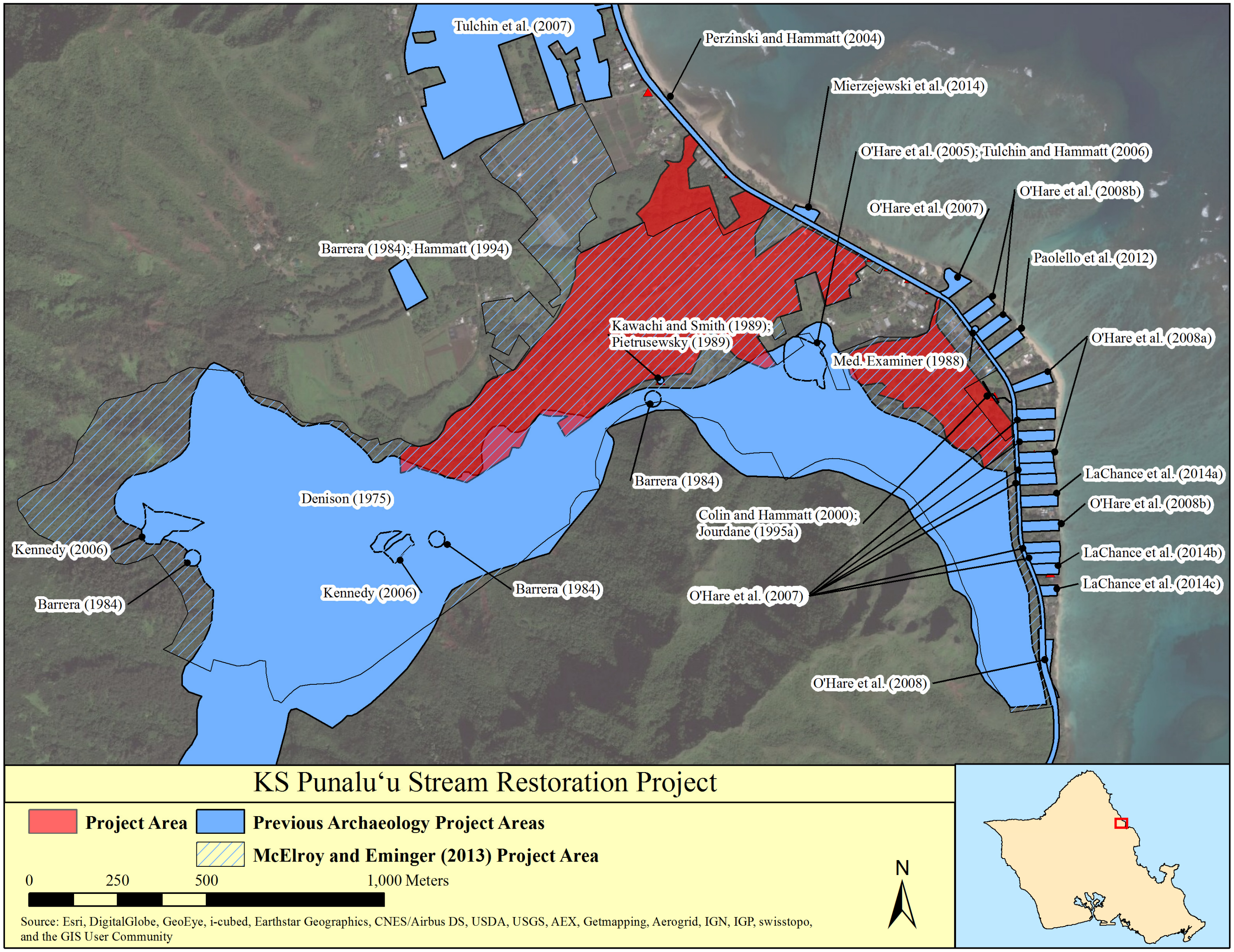


Figure 6. Previous archaeological investigations in and around the stream restoration project area.

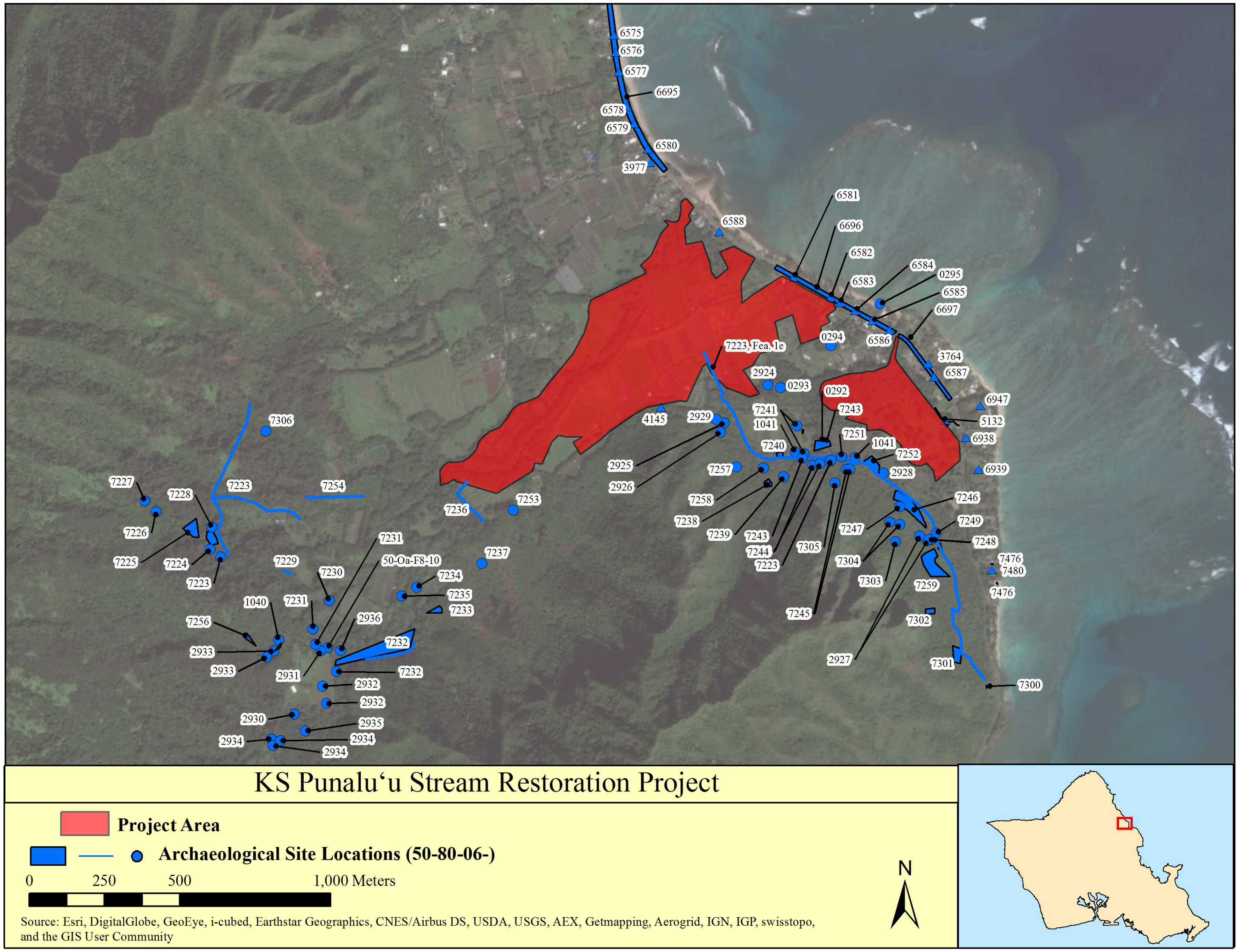


Figure 7. Previously identified archaeological sites in and around the stream restoration project area.

Site 7236 is a L-shaped, unlined irrigation ditch at the northern end of the stream restoration area. The northeastern end of the irrigation ditch adjoins Punaluʻu Stream, which is the water source for the ditch. The ditch runs to the southwest before making a nearly right-angle turn to the southeast, with a total length of approximately 150 m (McElroy and Eminger 2013:163). Three modern dams lined with black plastic sheeting were noted within the ditch, and the land to the east is currently cultivated by the University of Hawaiʻi-Mānoa.

SUBSURFACE ARCHAEOLOGICAL DEPOSITS

A nearly continuous buried cultural deposit was recorded along Kamehameha Highway by Perzinski and Hammatt (2004). This buried A horizon soil, which was designated as Sites 6695 to 6697, is approximately 30 to 45 centimeters below the surface (cm bs) and ranges from 10 to 40 cm in thickness. It is an organically enriched, black sand soil with charcoal, midden, and artifacts. The extensive burial series Perzinski and Hammatt documented is associated with these deposits. No controlled sampling of any of the deposits was undertaken. Remnants of similar buried A horizon soils have been noted along other areas of the coast, but with more limited horizontal distributions: Site 3970 (Bath and Smith 1988), Site 5132 (Colin and Hammatt 2000), and Site 7476 (LaChance et al. 2014b, 2014c). Of these sites, only limited sampling of Site 7476 was undertaken and reported.

Site 5132 is of particular relevance to the current project as it sits along the *makai* boundary of the Kahana Component. This is a dark grayish brown to dark brown sandy loam located 10 to 100 cm bs, with a thickness of 20 to 60 cm. Colin and Hammatt (2000:7) note that multiple pit features are present and that these and the cultural stratum contains "sparse" marine shell, charcoal, and water rounded stones. The skeletal remains of two individuals were also recovered from this deposit.

COASTAL AND INLAND BURIAL PATTERNS

The skeletal remains of at least 75 individuals have been found along the coast (within 20 to180 m of the shore), many of these being intact, primary interments (Colin and Hammatt 2000; Jourdane 1995a, 1995b; LaChance et al. 2014b; Medical Examiner 1988; O'Hare et al. 2007, 2008a; Perzinski and Hammatt 2004; Smith et al. 1988). In contrast, a single secondary burial consisting of the incomplete remains of at least six individuals has been found within Punaluʻu Valley in terrigenous soil (Kawachi and Smith 1989; Pietrusewsky 1989).[21]

Sixty-four individuals were encountered during monitoring of the water main upgrade along Kamehameha Highway, and this study provides the most comprehensive analysis of coastal burial patterns for Punaluʻu (Perzinski and Hammatt 2004). Radiocarbon dates from the associated cultural deposits indicate occupation may have begun sometime during the 14th to 15th centuries, however, how this relates to the chronology for the burial series is uncertain. A few burials have early 19th century artifacts, indicating a continuation of traditional interment practices for several decades after initial Western contact. Although a

[21] The historical cemetery at Hanawao Heiau (O'Hare et al. 2005) is a more recent burial pattern that is not considered in this discussion of traditional burial patterns.

few isolated burials were encountered, most burials formed clusters of two to nine individuals. The skeletons of three infants, 13 juveniles (<15 years of age), 32 individuals aged 15-40, and nine adults over the age of 40 were documented. Nineteen of the individuals were identified as male, 12 as female, and the sex could not be determined for the remaining 33 individuals. Thirty-two of the individuals in this series were found in a flexed position, six were in an extended position, one adult was in a "crouched and cross-legged" position (Perzinski and Hammatt 2004:324), while 25 individuals were too disturbed to identify the burial orientation. Two individuals were interred with *lei niho palaoa* (ivory pendant) with others having shell or glass beads. A basalt adze, adze fragments, a grinding stone, volcanic glass debitage, an early 19th century brandy bottle, and a pig tooth were other artifacts recovered with burials. Two individuals had associated dog (*Canis familiaris*) interments. Most burials, however, lacked associated grave goods.

Although differential preservation and varying amounts of excavation work between coastal and inland areas should be kept in mind, geographical patterning in burial practices is evident with the data at hand. Interment in coastal, calcareous Jaucas sands was the dominant burial setting. All intact and moderately disturbed burials along the coast are primary interments with the only known secondary burial for the *ahupua'a* from a mid-valley location. Burial clustering is common, suggesting burial of family members in groups. Flexed burial orientations are the most common, although other orientations have been documented. Grave goods, including *ali'i* ornamentation, are infrequently found.

TRADITIONAL ARTIFACT AND MIDDEN COLLECTIONS

Table 6 lists the artifacts and midden that have been recovered during archaeological projects in the greater Punalu'u area. Only general observations about the presence of certain traditional artifact forms and their broad relations to particular activities can be evaluated because of the rather meager collection. Five adze fragments have been recovered from coastal and inland locations, representing wood carving or vegetation clearing. Basalt and volcanic glass debitage documenting flake tool manufacture and use has been collected in small numbers. Other lithic artifacts include two grinding stones, a basalt pounder, basalt chopper, a hammerstone, and a discoidal groundstone (either an abrader or *'ulu maika* [gaming stone]). These artifacts may relate to several economic and domestic activities, such as flake tool production and food preparation. Traditional non-lithic artifacts are limited to two *lei niho palaoa*—*ali'i* ornaments found with burials—and a sea urchin spine abrader, which could have been used for fine finishing or shaping work for fishhooks or wood carvings.

Historic artifacts include a surface grab sample of ceramic and glass fragments and containers from an inland residential/agricultural complex and glass bottles from two coastal locations (including one burial).

Aside from multiple dog burials from the coast, which do not represent midden, vertebrate and invertebrate food remains have only been recovered from a single cultural deposit along the coast. Multiple invertebrate marine taxa were present while the vertebrate remains went unanalyzed.

It must be pointed out that only one artifact has been recovered from a controlled excavation unit that was explicitly laid out to sample archaeological deposits, albeit this was a small (less than 50 x 50 cm) test pit. Many research questions cannot be addressed until systematic, controlled excavation is consistently completed as part of archaeological investigations in Punalu'u.

Table 6. Artifacts and Midden Recovered During Archaeological Investigations in Punalu‘u and Adjacent Ahupua‘a.

Site (50-80-06-)	**Location**	**Recovery Method**	**Artifacts**	**Midden**	**Reference**
1040	Punalu‘u, inland	Surface, grab sample	Ceramic sherds, glass bottle, glass lens, teapot	--	Denison (1975)
2930	Punalu‘u, inland	Surface, grab sample	Basalt debitage	--	Denison (1975)
2932	Punalu‘u, inland	Surface, grab sample	Basalt pounder, bifacial grinding stone	--	Denison (1975)
3977	Wai‘ono, coastal	Noted, no controlled excavation	Historical glass bottles	--	Smith et al. (1988)
6575	Kapano, coastal	Burial excavation	Grinding stone (grave good)	--	Perzinski and Hammatt (2004)
6579	Puhe‘emiki/Wai‘ono, coastal	Burial excavation	Basalt adze, two adze fragments, volcanic glass debitage, *lei niho palaoa* (grave goods)	--	Perzinski and Hammatt (2004)
6582	Punalu‘u, coastal	Burial excavation	Volcanic glass flake (presumed grave goods)	--	Perzinski and Hammatt (2004)
6584	Punalu‘u, coastal	Burial excavation	*Lei niho palaoa*, glass brandy bottle (grave goods)	--	Perzinski and Hammatt (2004)
6585	Punalu‘u, coastal	Burial excavation	Glass beads (two necklaces)	--	Perzinski and Hammatt (2004)
7242	Punalu‘u, inland	Surface	Adze (two fragments)	--	McElroy and Eminger (2013)
7248	Punalu‘u, inland	45 x 40 cm test pit, 1/4-inch mesh	Volcanic glass flake	--	McElroy and Eminger (2013)
7301	Punalu‘u, inland	Surface	Basalt chopper	--	McElroy and Eminger (2013)
7476	Punalu‘u, coastal	Screening (unspecified mesh) of 5-, 4-, and 1.5-gallon sediment samples	Discoidal hammerstone	21.5 g of marine invertebrates, 153.2 g of unidentified vertebrate	LaChance et al. (2014b, 2014c)

Table 6. Artifacts and Midden Recovered During Archaeological Investigations in Punalu‘u and Adjacent Ahupua‘a (continued).

Site (50-80-06-)	**Location**	**Recovery Method**	**Artifacts**	**Midden**	**Reference**
--	Punalu‘u, coastal	Surface and backhoe excavation	Discoidal groundstone (abrader or *‘ulu maika* [gaming stone]), adze fragment, sea urchin spine abrader	--	Paolello et al. (2012)
--	Punalu‘u, coastal	Collected from backhoe trench sidewall	Basalt flake	--	LaChance et al. (2014a)

PUNALU‘U’S SETTLEMENT CHRONOLOGY

Table 7 presents the radiocarbon determinations obtained from previous investigations in Punalu‘u Valley. As noted above, three of these determinations are measured radiocarbon ages, which can be calibrated, but may produce inaccurate dates. Relying solely on the three conventional radiocarbon ages for the valley, settlement began during the late 13th to late 14th centuries continuing to the 19th century. In light of Athens et al.’s (2014) estimate that Polynesian colonization of the Hawaiian island occurred between AD 940-1130 (95% highest posterior density), settlement of Punalu‘u was approximately 150 to 450 years later.

Table 7. Radiocarbon Determinations from Previous Archaeological Investigations in Punalu‘u.

Site (50-80-06-)	**Provenience**	**Event Dated**	**Sample**	**Lab. No.**	**CRA (BP)**	**$^{13}C/^{12}C$ Ratio (‰)**	**Reference**
6579	Burial pit, L. IV, 90 cm bs	General cultural activity (unknown burning event) preceding burial	unidentified charcoal	not given	[+]500±50	not given	Perzinski and Hammatt (2004)
	Burial pit, L. V, 100 cm bs	General cultural activity (unknown burning event) preceding burial	unidentified charcoal	not given	[+]230±*	not given	Perzinski and Hammatt (2004)
6695	Midden concentration, L. III, 70 cm bs	General cultural activity (unknown burning event)	unidentified charcoal	not given	[+]170±70	not given	Perzinski and Hammatt (2004)
7239	TP 1, terrace soil	General cultural activity (unknown burning event)	*Cordyline fruticosa* (*kī*)	Beta-322445	90±30	-23.9	McElroy and Eminger (2013)
7248	TP 1, terrace soil	General cultural activity (unknown burning event)	*Osteomeles anthyllidifolia* (‘*ūlei*)	Beta-322446	260±30	-25.8	McElroy and Eminger (2013)
7476	Test Exc. 2, Fea. A (pit)	General cultural activity (unknown burning event)	*Hibiscus tiliaceus* (*hau*)	Beta-348681	670±30	-22.4	LaChance et al. (2014b)

CRA = Conventional radiocarbon age

[+] Measured radiocarbon age

* The standard error is not presented in the original report.

ARCHAEOLOGICAL EXPECTATIONS

Considering that much of the project area is under cultivation and was subject to plantation agriculture for nearly a century, most surface archaeology is expected to relate to relate to historic agriculture. The two irrigation ditches recorded within and adjacent to the Punaluʻu Valley Component by McElroy and Eminger (2013) support this expectation. A review of historic maps of the valley suggests that additional ditch segments may be present. Some of these features may be historical adaptations or re-use of older agricultural infrastructure (e.g., terraces, irrigation ditches). In addition, there is the possibility of older, buried cultural deposits and features within the Punaluʻu Valley Component.

The possibility that subsurface cultural deposits and human burials may be encountered within the Kahana Component is assessed to be greater than the Punaluʻu Valley area based on previous findings in the vicinity. Site 5132 is along the *makai* boundary of this component and additional burials have been discovered 30 m to 130 m to the east across Kamehameha Highway.

PREVIOUS ORAL HISTORICAL STUDIES

Maly and Maly (2005b) conducted extensive oral history interviews with 25 long-time residents of Punaluʻu, including some who are descendants of the early Chinese settlers in the valley. In discussing their methodology, Maly and Maly (2005a:292) write:

> In selecting interviewees, we followed several standard criteria for selection of those who might be most knowledgeable about the study area. Among the criteria were:
>
> 1. The interviewee's genealogical ties to early residents of lands within or adjoining the study area;
>
> 2. Age. The older the informant, the greater the likelihood that the individual had personal communications or first-hand experiences with even older, now deceased Hawaiians and area residents; and
>
> 3. An individuals' identity in the community as being someone possessing specific knowledge of lore or historical wisdom pertaining to the lands, families, practices, and land use and subsistence activities in the study area.
>
> Readers are asked to keep in mind that while this component of the study records a depth of cultural and historical knowledge of Punaluʻu and vicinity, the documentation is incomplete. In the process of conducting oral history interviews, it is impossible to record all the knowledge or information that the interviewees possess. Thus, the records provide readers with only glimpses into the stories being told, and of the lives of the interview participants.

As part of an archaeological inventory survey of Hanawao Heiau and the historic cemetery on the *heiau* site, O'Hare et al. (2005) interviewed six individuals, five of whom had also been interviewed by Maly and Maly (2005b). The focus of these interviews was the history of the cemetery, which existed at this location since at least 1907

O'Hare et al. (2013) interviewed Robert Albert and Genevieve Ululani Oberle Albert as part of a FUDS remediation investigation/feasibility study. Mr. Albert was stationed in Hawaiʻi in the early post-

World War II period, and in 1949, was head of the security in charge of protecting the Combat Training Areas at Punaluʻu, Kahana, and Kualoa. Mrs. Albert lived in Punaluʻu on family *kuleana* land during the war.

Most recently, Monahan and Evans (2014) completed a draft Cultural Impact Assessment for the stream restoration project. They interviewed six individuals, three of whom had also been interviewed by Maly and Maly (2005b). The aim of this study was the documentation of cultural resources and customary and traditional practices within and near the project area.

III. RESEARCH METHODS

This section presents the project research problems, fieldwork methods, and laboratory analyses.

RESEARCH QUESTIONS

Five general research questions guided the field and laboratory investigations.

1) Are traditional Hawaiian surface features present? If so, what activities are represented? Due to the extent of late 19th century and 20th century plantation agriculture in the stream restoration areas expectations that traditional Hawaiian surface features are present is low. There is the possibility that certain extant features, such as terraces and irrigation ditches, however, are historical iterations of older features. Construction attributes will be considered to assess the potential for the re-use of traditional structures.

2) Are historical surface features present? If so, what activities are represented? McElroy and Eminger (2013) recorded two historical irrigation ditches (Sites 7223 [Feature 1e] and 7236) that cross into or abut the Punaluʻu Valley Component. Thoene's (1953) map of the valley depicts numerous additional ditch segments tying in to Site 7223, as well as, apparent structures within the Kahana Component.

3) Are traditional Hawaiian cultural deposits present? If so, what activities are represented? Within the valley, if cultural deposits are encountered it is more likely that they will be buried agricultural soils rather than residential or midden deposits. This assumes that residential and most other non-agricultural activities occurred on the adjacent lower slopes and along the coast. The *makai* margins of the project areas, particularly those locations that have Jaucas sand deposits, may be more productive locations for encountering habitation deposits. Site 5132 attests to this. Sampling of these deposits has been negligible, so any additional data generated for artifact and midden assemblages should be valuable. A single radiocarbon assay from a nearby coastal deposit indicates occupation possibly as early as the 13th-14th centuries.

4) Are historical period cultural deposits present? If so, what activities are represented? Multiple LCA were granted in and around the project area. In addition, historical artifacts have been found on the surface at one inland complex (Site 1040), while glass bottles and beads have been found with burials along the coast (Sites 6584 and 6585).

5) Are human skeletal remains present? Human skeletal remains have been recovered in areas immediately adjacent to the present project area (Sites 4145 and 5132), as well as, at numerous locations along the Punaluʻu coastline.

SURVEY METHODS

Keala Pono had completed an inventory survey of 108.7 acres of the 119.8-acre stream restoration area. The remaining 11 acres is densely covered with a *hau* thicket and was not surveyed during their investigation. Three survey methods were employed during the current project to ensure appropriate coverage of the entire 119.8-acre area (Fig. 8).

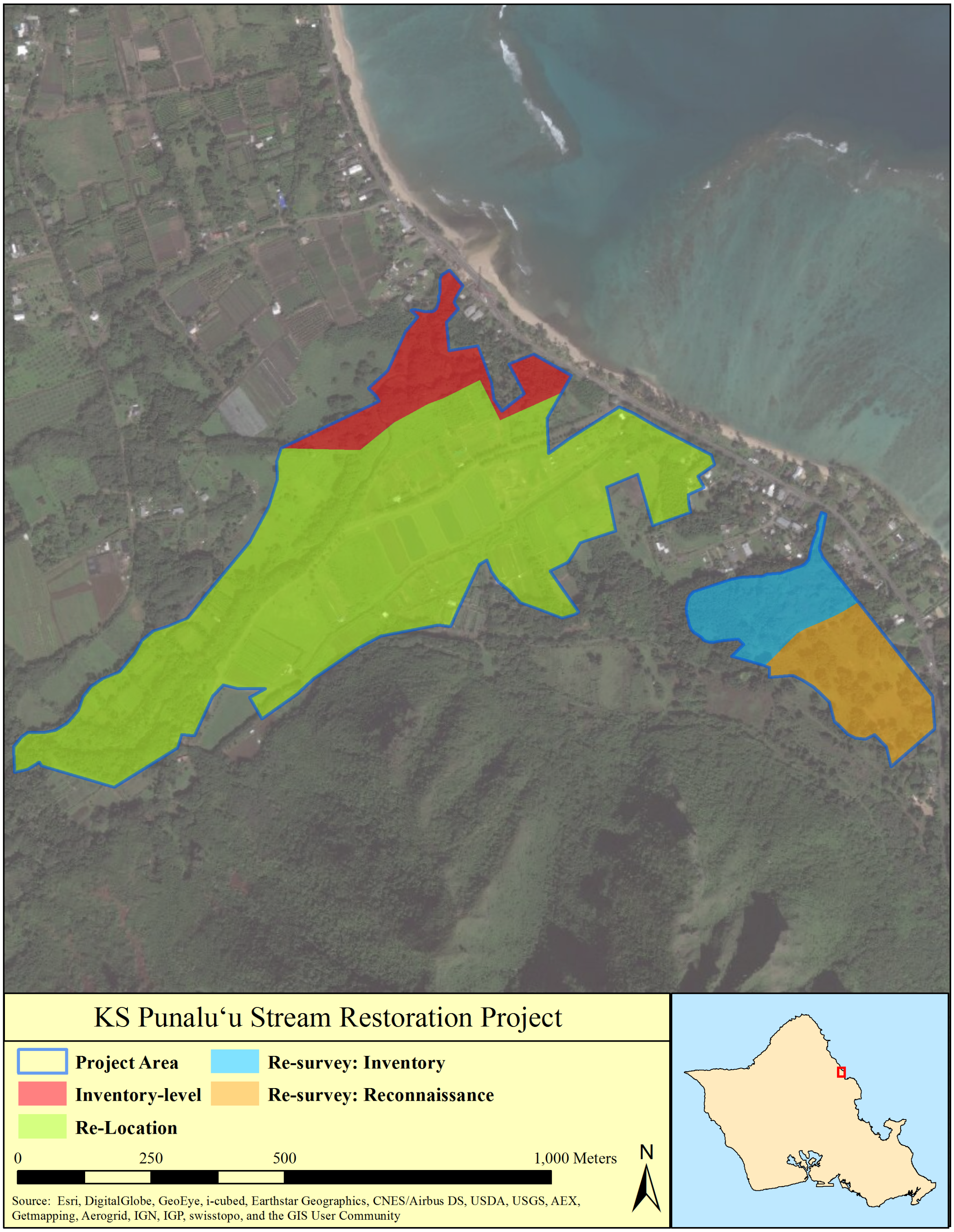


Figure 8. Survey methods employed within the project area.

SITE RE-LOCATION SURVEY

Keala Pono's Global Positioning System (GPS) data and irrigation ditch locations obtained from historic maps were used to navigate to the two archaeological sites Keala Pono had recorded as well as other possible extant ditches within or adjacent to the stream restoration area. We re-recorded the site locations with improved accuracy and precision using a professional-grade Trimble Geo7X GPS unit. The locations of the newly recorded irrigation ditches were also recorded with a Trimble Geo7X GPS unit. Spatial data were collected using the North American Datum of 1983 (NAD 83) in Universal Transverse Mercator Zone 4 North (UTM 4N); data were differentially corrected.

Samsung Galaxy Note 8 tablet computers were used for feature and site recording. Keala Pono's feature and site descriptions and maps were loaded onto the computers, along with our standardized recording forms. The archaeologists assessed the existing descriptions with field observations and made the appropriate notations and updates to the forms. Nonmetric feature and site recording included descriptions of features, construction materials and techniques, observations on inferred age, interpretations of function, and notes on the surrounding topography, soils, and environment. Length, width, and height or depth were recorded, as well. Digital photographs were taken of all features.

RE-SURVEY OF PREVIOUSLY SURVEYED AREAS

Reconnaissance-level survey transects were completed within the previously surveyed areas in the Punalu‘u and Kahana project components. These areas had been identified by Keala Pono as being devoid of archaeological features during their inventory survey, and the reconnaissance transects aimed to test their conclusions. Surveyors were spaced approximately 10 m apart on these transect sweeps. Across the northernmost portion of the Kahana Component, archaeological features were identified and survey methods were adjusted to inventory-level. This entailed decreasing the transect spacing to approximately 3 m and completing systematic pedestrian coverage of these areas. The new features were recorded following the same procedures outlined above.

INVENTORY-LEVEL SURVEY OF PREVIOUSLY UNSURVEYED ACREAGE

The unsurveyed, *hau*-covered 11-acre area at the mouth of Punalu‘u Stream was subject to systematic, inventory-level survey (see Fig. 8). Transect lines were closely spaced (2-4 m) due to the density of the *hau* thicket. Vegetation clearance was minimal, and was employed to clear survey access and to expose possible surface features. As would be expected for such a heavily vegetated area, ground visibility was often low.

SUBSURFACE TESTING METHODS

Backhoe trenching was employed for subsurface testing across the habitat bank and stream restoration areas in Punalu‘u Valley and the Kahana Project Component. Historic period agriculture, specifically 20th century sugarcane cultivation, presumably removed most of the earlier traditional agricultural surface infrastructure (terraces, irrigation ditches, etc.) along the valley bottom. However, there is the potential that older agricultural deposits and other cultural layers (e.g., habitation and midden deposits) could be present below the depth of historic cultivation. These deposits could include older terrace construction phases and other subsurface features. By excavating long trenches oriented generally parallel to the stream we aimed to intersect any older pondfield soils and field divisions, if they still exist. The trenches also allowed the opportunity to document the process of valley infilling caused by pre- and post-Contact agricultural activities on surrounding slopes and the larger Punalu‘u catchment. Lengthy, continuous scaled stratigraphic profiles were recorded. In one instance, a controlled excavation unit was placed extending from a trench edge to expose a bisected feature.

Scaled profile drawings were completed for at least one of the long sidewalls in each trench. Soils were described, and trench sidewalls and locations were photographed. Stratigraphic profiles and soil descriptions were described using a fresh vertical face. The soil characteristics recorded included the following at a minimum: color, including moisture condition (wet, moist, dry) when color read; texture; structural grade, size, and form (or absence of structure); dry or moist consistence; wet consistence (stickiness, plasticity); root frequency and size; presence of charcoal or other cultural materials; and lower boundary distinctness and topography (Munsell Color 2000; U.S. Department of Agriculture Soil Survey Staff 1951, 1962). Each deposit was also examined for signs of sedimentary structures such as bedding, and for any other information (e.g., evidence for basaltic or coralline origin) that can help to clarify depositional and soil forming history.

The locations of all trenches were recorded using a professional-grade Trimble Geo7X GPS unit using the North American Datum of 1983 (NAD 83) in Universal Transverse Mercator Zone 4 North (UTM 4N). Data were differentially corrected.

Twenty-five trenches ranging from 23-40 m long (0.8 m wide) were placed in fields and open areas along the north and south sides of Punalu‘u Stream and in the the Kahana project portion. The Punalu‘u Valley trenches were generally staggered along northeast-southwest axes to provide stratigraphic investigations along the lower ~1 km of the stream. The placement of these trenches takes into account accessibility for a backhoe, proximity to the stream, current field layouts, and historical land plots.

The single controlled excavation unit, 1 m x 1 m, was excavated along the north side of Trench 14 to sample a buried *imu* (underground oven) designated Site 50-80-06-7727. The backhoe removed the upper 40 cm of overburden, exposing the *imu* in plan view. Excavation proceeded from the exposed surface by trowel in 10 cm levels and continued into the sterile matrix below the feature. The *imu* was excavated and screened separately. All material was screened with 1/8" mesh and examined for any cultural objects, including fire-affected basalt and charcoal, which were collected and labeled with the proper provenience. Charcoal encountered during excavation was collected with locational provenience recorded.

LABORATORY METHODS

No artifacts, with the exception of fire-cracked rock, were encountered during the course of fieldwork. Laboratory analyses consisted of taxonomic identification of wood charcoal samples and accelerator mass spectrometry (AMS) radiocarbon dating.

Gail Murakami, B.A., IARII Wood Identification Laboratory, analyzed the wood charcoal samples for taxonomic identification. This analysis was undertaken to 1) characterize the plant taxa that were used as fuel; 2) to select short-lived taxa or plant parts for radiocarbon dating (e.g., Allen and Huebert 2014; Rieth and Athens 2013); and, 3) alternatively, to identify any historically introduced plant taxa that would obviate obtaining a radiocarbon date for a particular feature. Identifications were done under magnification of a dissecting microscope comparing the anatomical features seen in the freshly fractured transverse and tangential facets of the charcoal pieces with those of known woods from the Pacific Islands Wood Collection at the Department of Botany, University of Hawaiʻi-Mānoa and CSIRO Atlas of Hardwoods (Ilic 1991).

Beta Analytic, Inc., conducted the AMS radiocarbon dating.

CURATION

Field and laboratory notes, forms, and other records and materials will be temporarily curated at the IARII Honolulu office, which has been approved by the SHPD as a temporary curation facility. Upon completion of the project and acceptance of the report by the SHPD, these records and materials will be submitted to Kamehameha Schools for permanent curation.

IV. RESULTS

This section presents the survey, subsurface testing, and laboratory results. Six archaeological sites were documented: Site 7236, a network of historic irrigation ditches (we have subsumed McElroy and Eminger's [2013] Site 7223, Feature 1e into Site 7236); Site 7718, a complex of concrete foundations and a stone-lined pond; Site 7727, a buried *imu*; Site 7728, a buried terrace; Site 7733, a buried *lo'i* soil; and Site 7734, a buried *lo'i* soil. The surey areas have been heavily impacted by modern agricultural activities, particularly sugar during the 20th century. Approximately 81 acres (67.6%) of the project area is currently under agriculture or some other present use (Fig. 9). Table 8 presents the characteristics of these sites, and their locations are depicted in Figure 10.

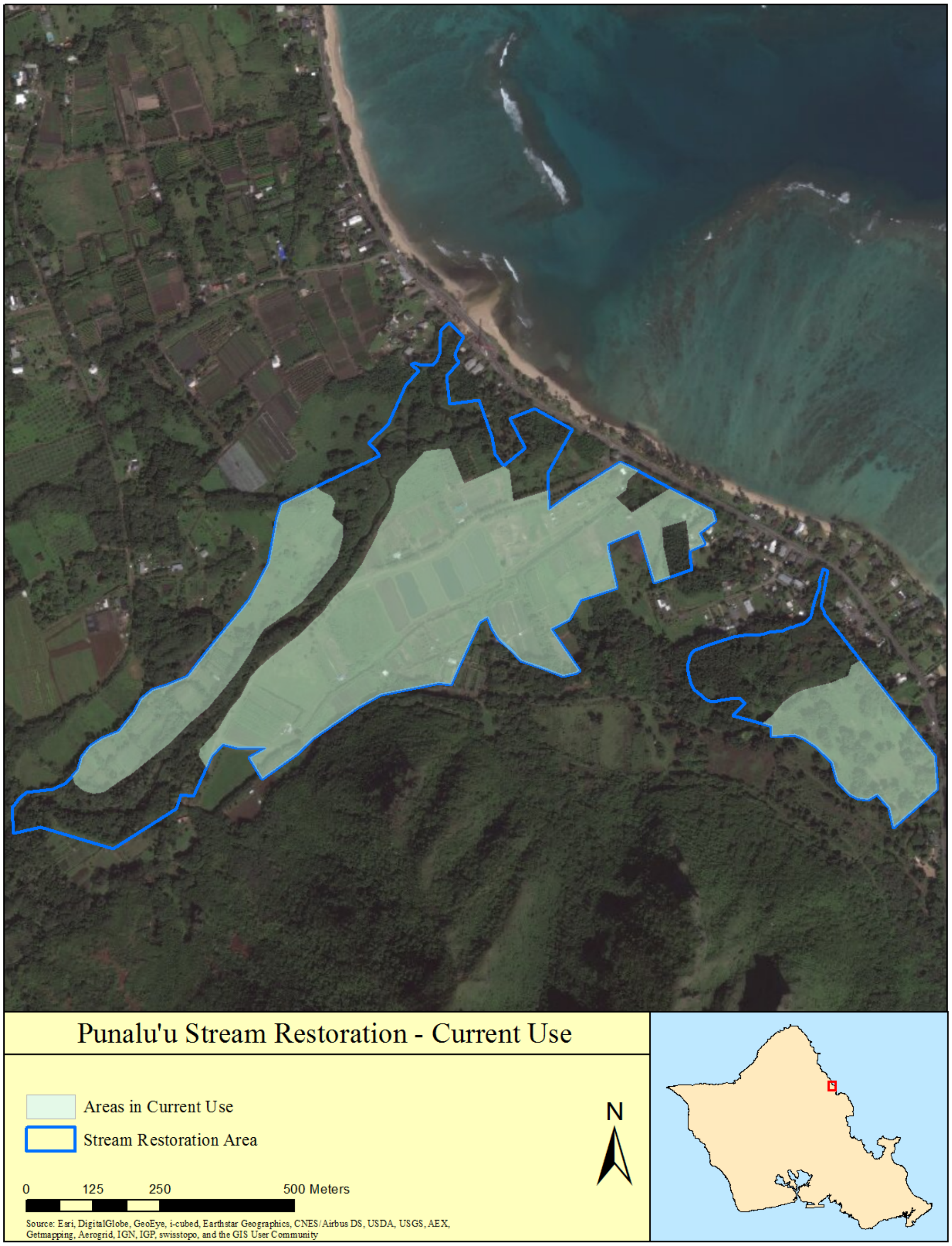


Figure 9. Portions of the project area currently in agriculture.

Table 8. Attributes of Sites Recorded During the Stream Restoration Inventory Survey.

Site No. (50-80-06-)	**Form**	**Dimensions (Site Area)**	**Inferred Function**	**Age**
7236	Ditch Network	2,344 m (total length)	Agriculture	Early to Mid 20th Century
7718	Foundation/Pond Complex	2.03 acres	Habitation	Mid 20th Century
7727	Subsurface Fire Feature	90 x 90 x 16 cm	Habitation	Late pre-Contact or early post-Contact (200±30 BP)
7728	Buried Pondfield Wall	90 x 85 cm	Agriculture	Unknown
7733	Buried *lo‘i* soil	39 m (minimum length)	Agriculture	*Terminus ante quem* of 1848 based on Pahakae’s testimony for LCA 3881
7734	Buried *lo‘i* soil	40 m (minimum length)	Agriculture	*Terminus ante quem* of 1848 based on Hahia’s testimony for LCA 8172

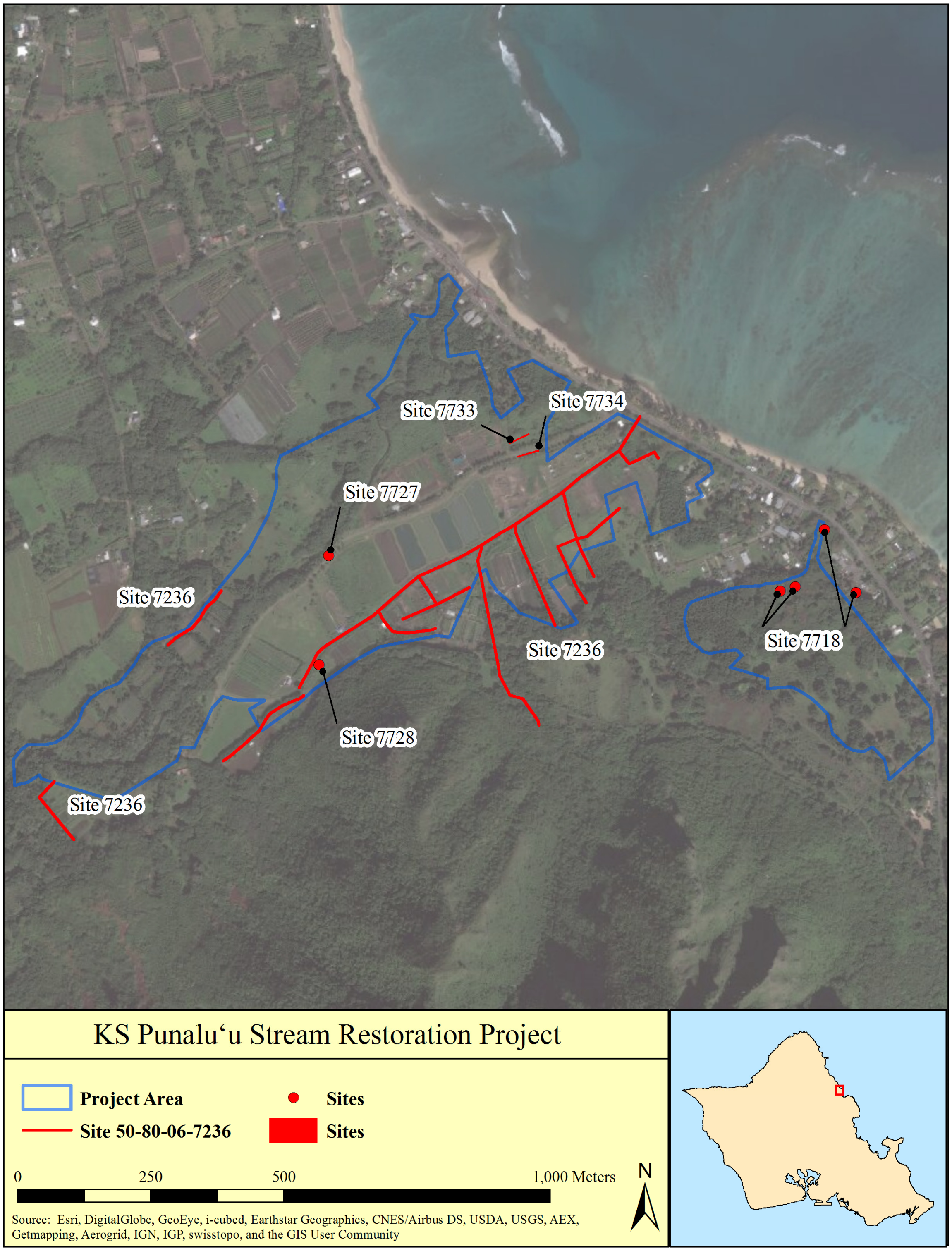


Figure 10. The locations of sites recorded during the stream restoration inventory survey.

SITE 50-80-06-7236

Site 50-80-06-7236 is a network of valley-bottom irrigation ditches (Photos 3-5) running at least 2,344 m in total length. The network is within the valley and is fed principally from Punaluʻu Stream, though it appears to have previously been fed by another major ditch (Site 7223; outside of the current project area). The earthen ditches typically include soil berms on either side without any stone or concrete lining. They vary in width from 0.5-2.0 m and in depth from 0.5-1.0 m. Recently constructed stone dams and metal culverts as well as steel culverts, are found at various locations throughout the network. Three stone dams 2.2-2.5 m long, 0.8-1.4 m wide, and 0.4-0.9 m high were recorded. The dams are recent constructions, being built with stacked basalt rocks atop plastic lining. Four steel culverts measuring 0.3-0.9 m in diameter were recorded at locations where roads crossed over the ditches. Much of the ditch network is still in use, with other recent modifications including diversion ditches and pipes.

Photo 3. Typical Site 7236 ditch; view to the southeast.

Photo 4. Culvert, part of the Site 7236 ditch network; view to the west.

Photo 5. Stone dam, part of the Site 7236 ditch network; view to the east.

Examination of historical maps and aerial photographs indicates that the network was constructed in phases between at least 1907 and 1993 (Fig. 11); the dates listed in Figure 11 are *termini ante quem* (dates before which a particular ditch was constructed). By 1953, major components of the ditch network had tied earlier, shorter segments together (Thoene 1953). A segment of ditch appears on Alexander's 1907 map at the head of a large area labeled "Rice Land". Its position indicates it served as drainage for the ricefields, and also suggests other ditches were present further into the valley, which were not represented on the map. Three of ditches are found on Podmore's (1923) map, either extending from another ditch (Site 7223, the long, major ditch arteries for the valley [beyond the current project area]) or from Punaluʻu Stream. Two ditch segments are visible on a 1928 aerial photo and one in an aerial from 1963. It is likely that most of these ditches were constructed to facilitate the intensification of sugarcane agriculture in the valley bottom during this period, though some probably served pondfields growing rice and taro. Three ditches recorded during this survey do not appear until 1977 or later. These ditches were not included as part of Site 7236.

The site is in good condition and is evaluated as significant per Hawaii Administrative Rule (HAR) §13-284-6 under Criteria a and d. Site 7236 is a local (Punaluʻu Valley) example of the 20th century agricultural infrastructure that was engineered across vast swaths of the islands as part of the archipelago-wide plantation agricultural economy (Criterion a). Plantation agriculture during the 19th and 20th centuries had wide-ranging and dramatic effects on the landscape, food and agricultural commodity production, larger economy, politics, and demography. The layout and orientation of the Site 7236 ditches provides important information pertaining to individual agricultural plots, the integration of these plots into a larger irrigated planting system, and the types of plants that could have been grown (Criterion d).

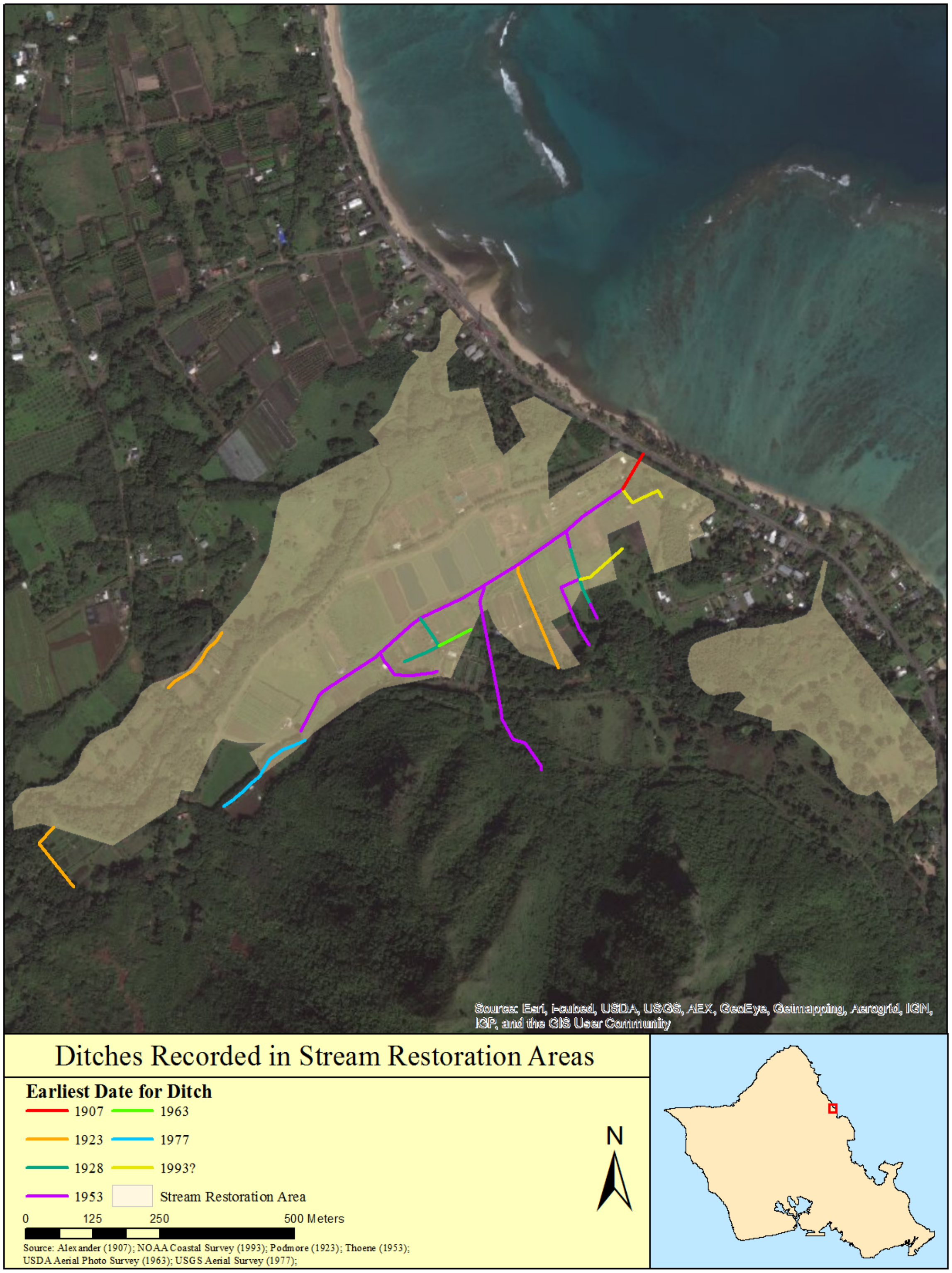


Figure 11. Ditches recorded during inventory survey; dates are *termini ante quem* estimates based on the earliest map depiction of a particular ditch.

SITE 50-80-06-7718

Site 50-80-06-7718 is a complex of historic features consisting of three concrete slab foundations and one stone-lined pond. Two of the site's features (Features A and B) are located along the northern boundary of the Kahana parcel while the other two (Features C and D) are immediately beyond the northeastern boundary of the Kahana area (Figs. 12-14). The latter two features, although beyond the project area (but still within KS-owned property), were recorded due to their proximity to the other features of Site 7718 and their presumed contemporaneity. The features are spread across a 2-acre area with the most distant features separated by approximately 140 m. The two smaller concrete slabs (Features A and B) are interpreted as foundations for ancillary residential or agricultural structures, which fits with the suggestion by community members consulted as part of this project that these may have been rice threshing areas used by Chinese farmers. The larger concrete slab (Feature D) may be the foundation for a residence, although no internal divisions or remnant utilities are present; community members suggested that this foundation may too have been a rice threshing area. An inscription in one of the smaller slabs dates the construction of that feature to 1953, while the pond (Feature C) is depicted on Thoene's (1953) map. The ages for the other features are less certain, but their proximity and general similarity in construction suggests a mid-20th century date. Based on Thoene's (1953) map it seems that the features represent generally contemporaneous structures, but that they do not relate to a single residence or parcel.

The area is largely covered in vegetation, though some areas were recently cleared at the time of the survey (Photo 6).

Photo 6. Recently cleared area near Site 7718; view to the west.

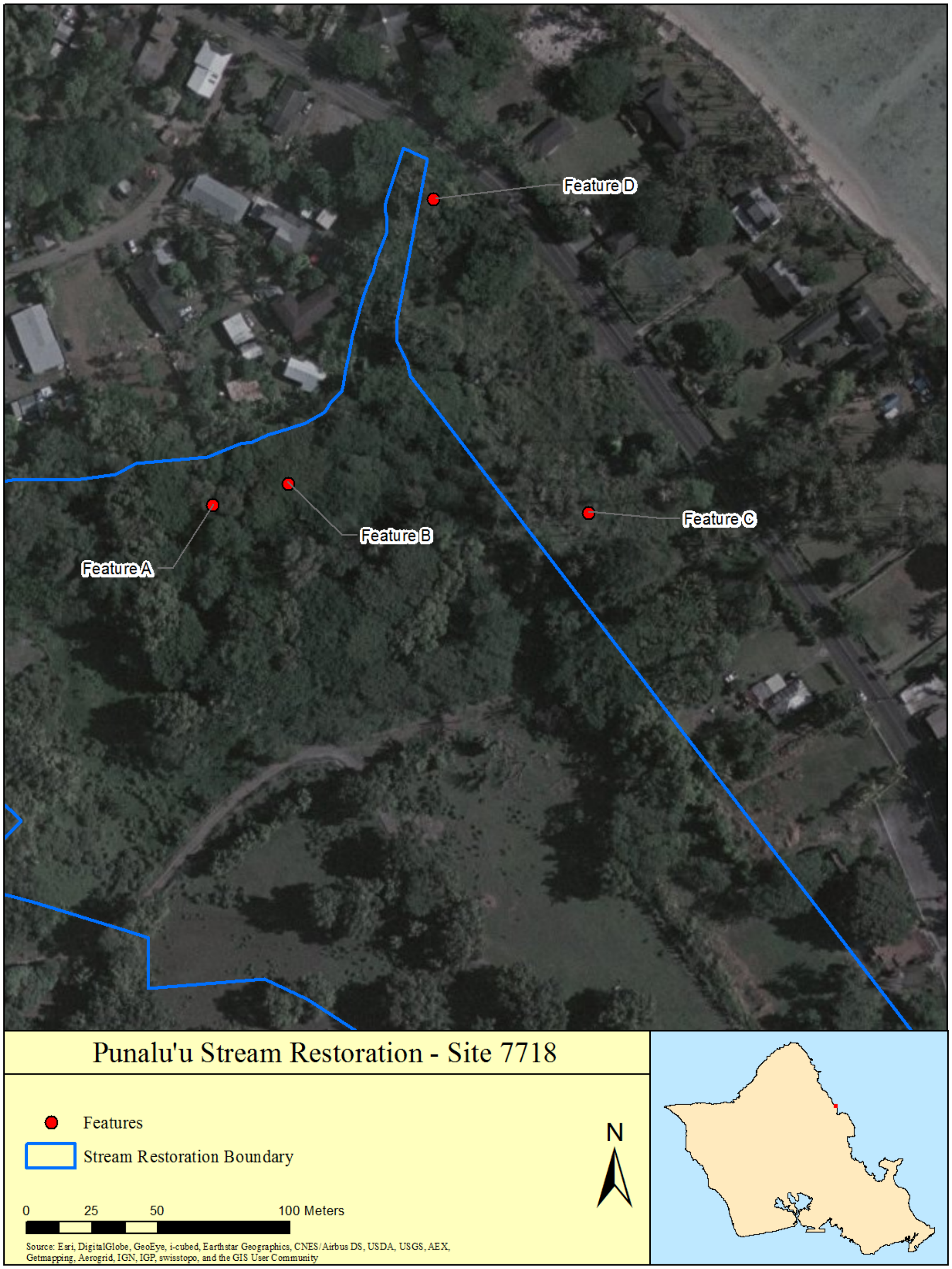


Figure 12. Site 7718, showing the locations of each feature.

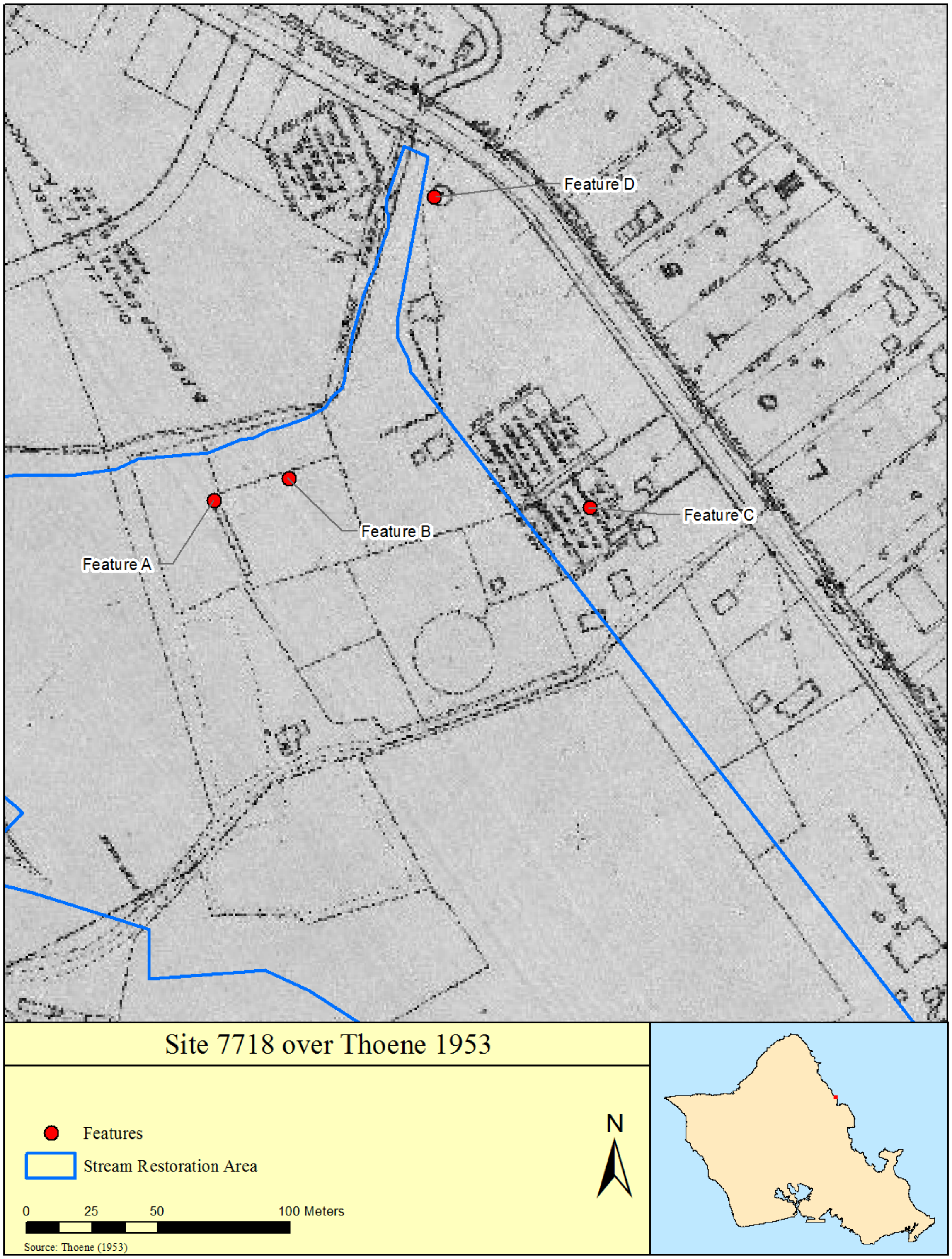


Figure 13. Features in Site 7718 overlaid on Thoene's 1953 map of Punalu‘u Valley.

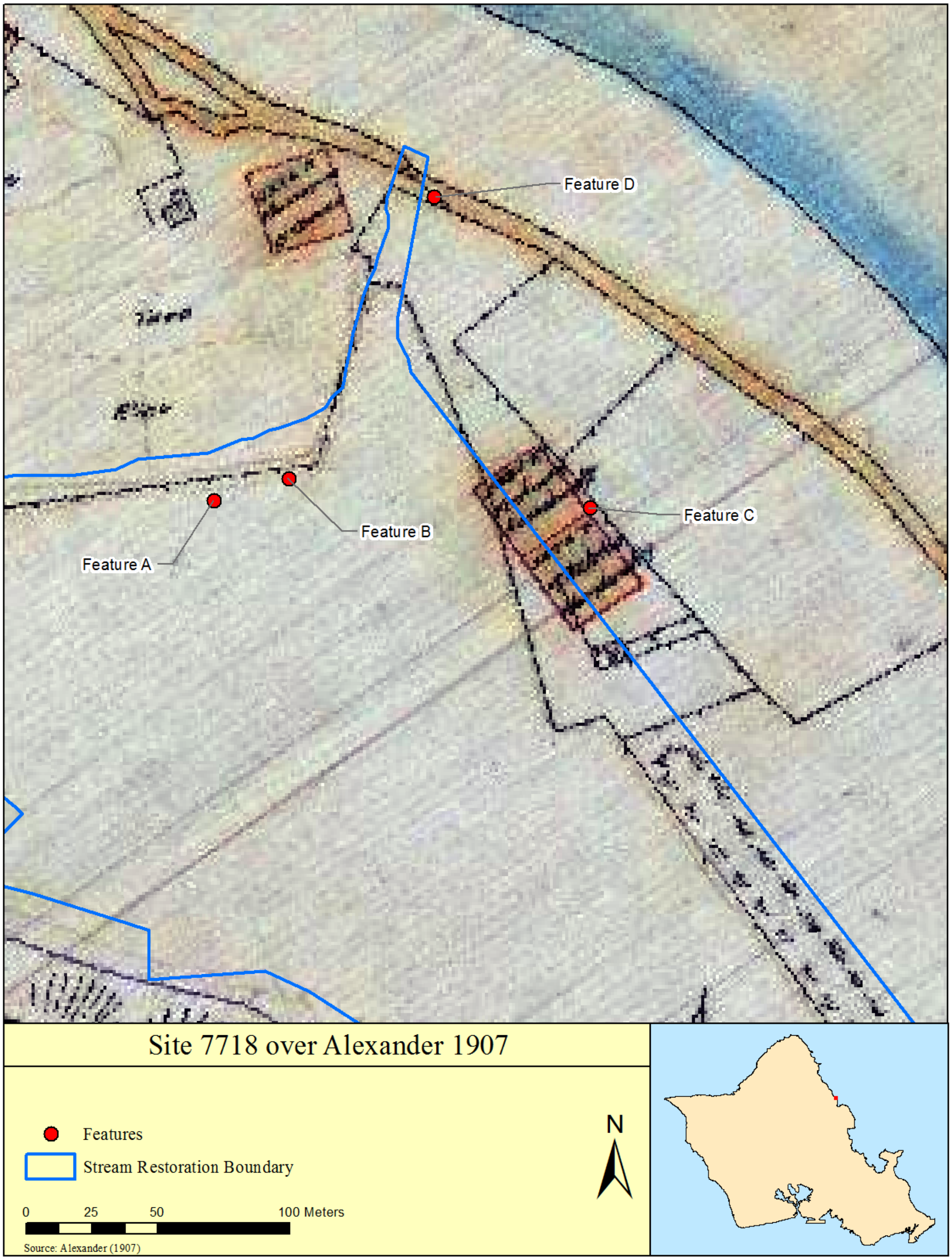


Figure 14. Features in Site 7718 overlaid on Alexander's 1907 map.

Feature A is a square concrete pad with corners oriented roughly to compass points. The foundation is 3.15 m by 3.0 m and 0.25 m in height (Fig. 15; Photo 7). The concrete pad was poured over a layer of subrounded basalt cobbles. In the south corner is a disarticulated section of a metal pipe and a power outlet box. A date inscribed in the concrete at the north corner indicates that the structure was built on September 11, 1953 (Photo 8). The concrete pad is in fair condition. Feature A is interpreted as a building foundation, presumably for an outbuilding since it is smaller than a typical mid-20th century primary residence.

Feature A plots along the boundary of an agricultural field on Alexander's (1907) and Thoene's (1953) maps (see Figs. 13and 14).

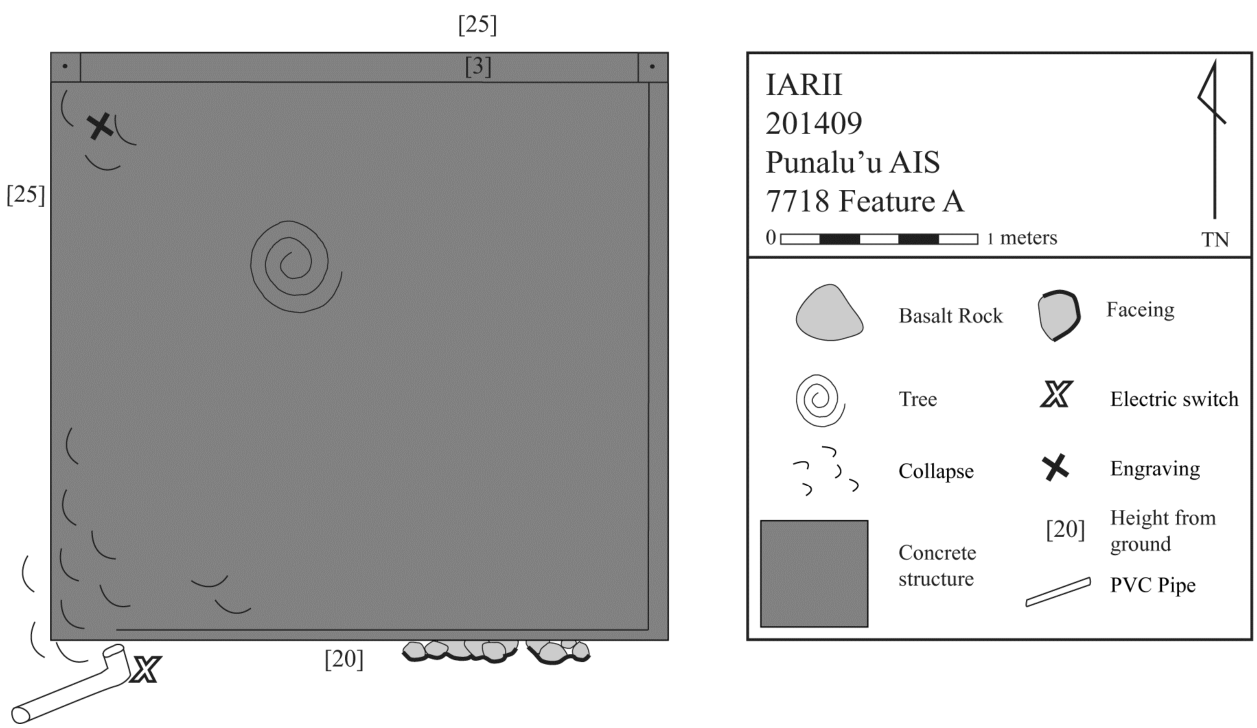


Figure 15. Scaled plan view map of Feature A, Site 7718.

Photo 7. Feature A; view to the west.

Photo 8. Inscribed date “9/11/53” in the north corner of Feature A.

Feature B is a rectangular concrete pad with the partial remains of a concrete block and mortar superstructure still standing in places (Fig. 16; Photo 9). The feature is located 30 m north northeast of Feature A. The foundation is 3.1 m by 1.1 m and 0.15-0.3 m in height. The standing wall is constructed of concrete masonry units and measures 1.45 m by 0.2 m and 0.85 m in height. Unlike Feature A, the concrete slab foundation does not appear to overlay basalt cobbles, but rests directly on the soil. The feature is in fair condition. As with Feature A, based on its size Feature B is interpreted as an ancillary residential or agricultural structure although its specific function is unclear.

Feature B plots along the boundary of an agricultural field on Alexander's (1907) and Thoene's (1953) maps (see Figs. 13and 14).

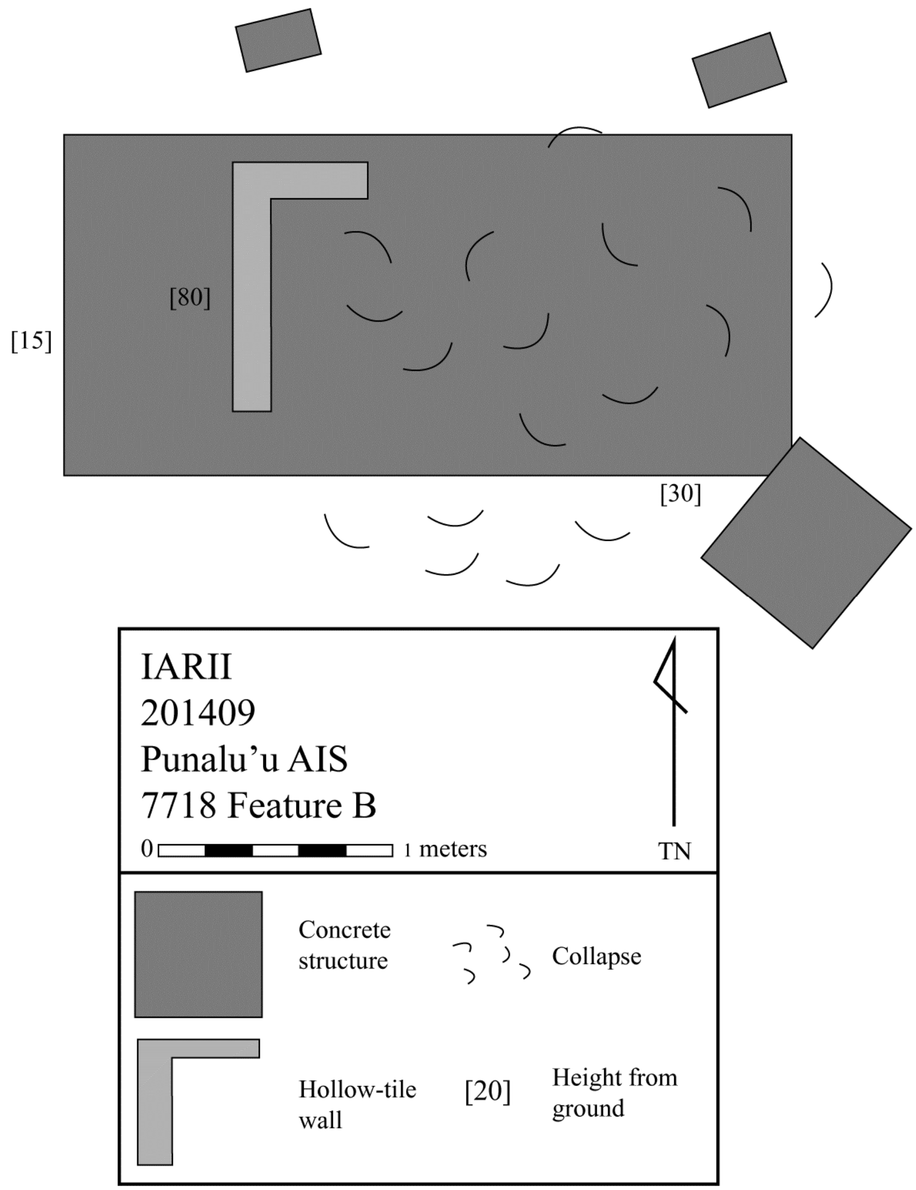


Figure 16. Scaled plan view map of Feature B, Site 7718.

Photo 9. Feature B, showing intact standing wall segment; view to the east.

Feature C is a concrete slab foundation located 115 m east of Feature B, outside of the current project area. The foundation is 6.1 m by 6.1 m and 0.2 m in height (Fig. 17; Photo 10). The slab is bare, with no discernable internal features. Feature C is the foundation for the largest structure within Site 7718, yet the lack of internal divisions or remnant utilities (e.g., plumbing drain pipe) suggests that it was not the foundation for a primary residence. This does not, however, exclude the possibility that it was the foundation for a house lacking plumbing (a possibility for a mid-20th century, rural family). Therefore, the function of this feature is unclear. Feature C is in good condition.

Feature C is not present on Thoene's (1953) map, falling along the eastern edge of LCA 8435:3, a houselot awarded to Kuheleloa (see Fig. 13). Several structures are depicted on Thoene's map approximately 10-15 m to the east and south. Alexander's (1907) map of Punaluʻu indicates that Kuheleloa's houselot was abandoned (see Fig. 14).

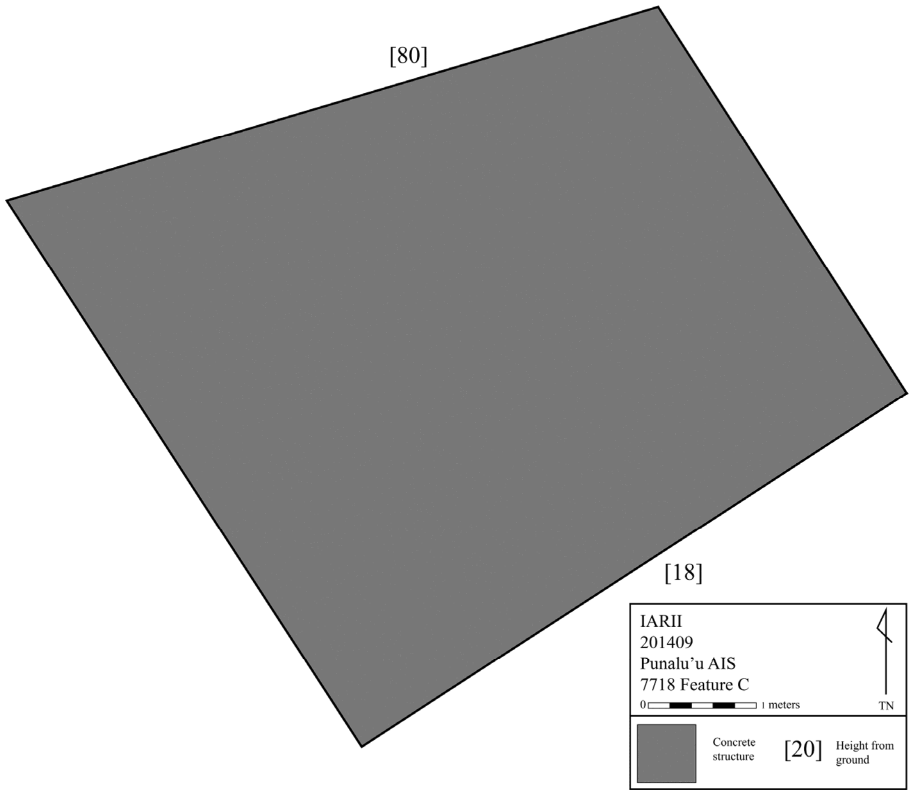


Figure 17. Scaled plan view map of Feature C, Site 7718.

Photo 10. Feature C; view to the west.

Feature D is a stone-lined pond located along the highway 130 northwest of Feature C, outside of the current project area (Fig. 18; Photo 11). The pond measures 12 m in diameter and is partially lined with dry-stacked basalt cobbles and boulders with some limestone facing; it was holding water at the time of the survey and the depth was not determined. The perimeter of the pond is bounded with an embankment 0.4-0.55 m in height. A small islet 1.75 m in diameter and 0.4 m above the water line is present at the center of the pond. The islet is faced with basalt and limestone cobbles and contains a single tree. The pond is in good condition. A circle interpreted as the pond is depicted on Thoene's (1953) map (see Fig. 13).

Site 7718 is evaluated as significant per HAR §13-284-6 under Criterion d. The distribution and construction characteristics of the foundations and pond provide information about mid-20th century agricultural and/or residential activities in this area.

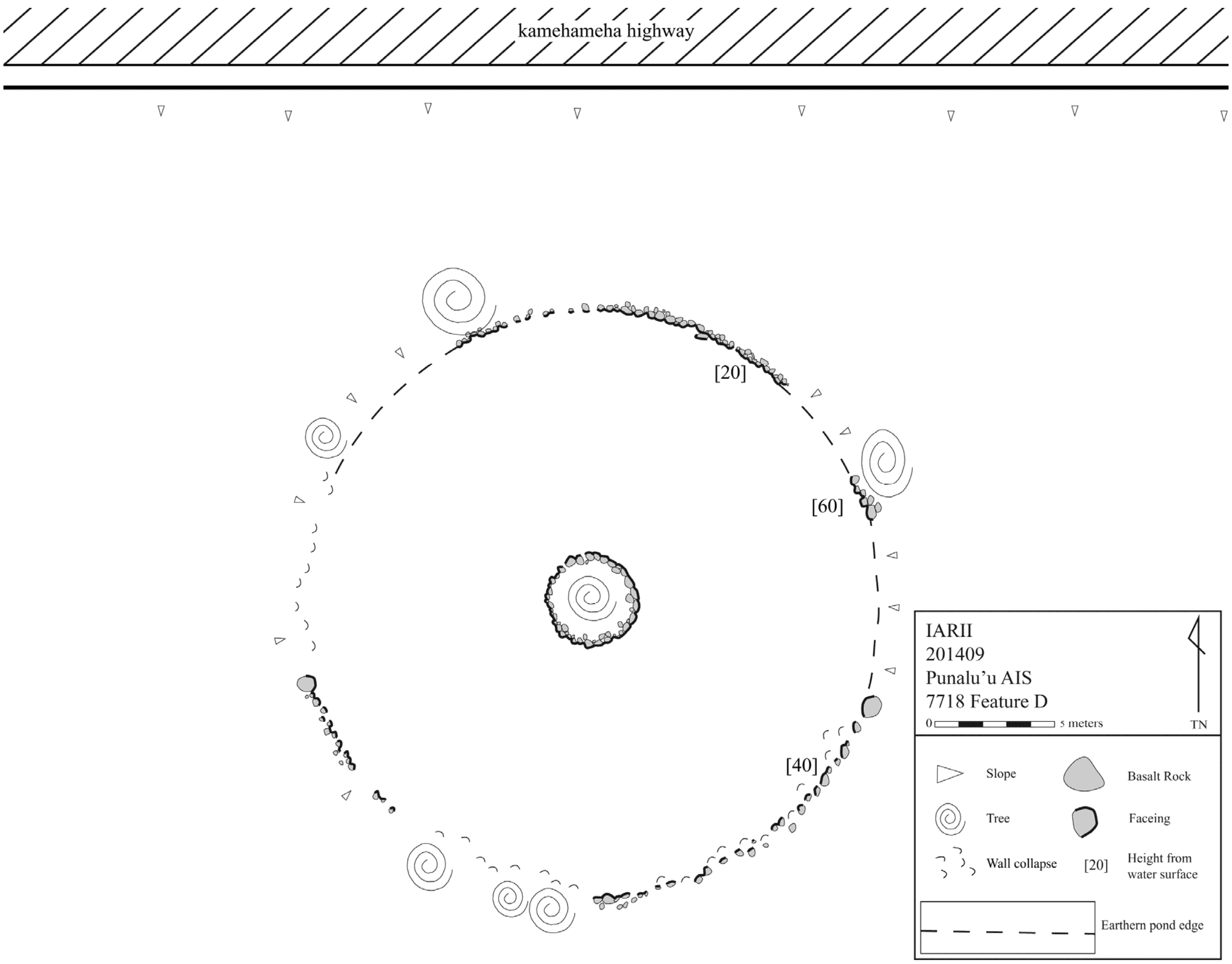


Figure 18. Scaled plan view map of Feature D, Site 7718.

Photo 11. Feature D, showing the islet at the center of the pond; view to the north.

SITE 50-80-06-7727

Site 50-80-06-7727 is a buried *imu* encountered during excavation of Trench 14, located along Punaluʻu Valley Road (Green Valley Road) approximately 600 m from the highway (Figure 19; Photo 12). The feature was bisected during trenching and the remainder was investigated with the excavation of a controlled test unit. The feature extended from 59-75 cm below surface (bs) and measured 95 cm in diameter. There was no associated cultural deposit present and the stratigraphy documented in the trench indicates that the feature was likely placed in or adjacent to a former stream channel; Punaluʻu Stream is currently approximately 10 m to the northwest. Significant amounts of basalt and charcoal were present within the feature. No other cultural materials were encountered. Charcoal of *alaheʻe* (cf. *Psydrax odorata*) and an unknown woody taxon was recovered from the base of the feature; no historic species were identified in the sample. The *alaheʻe* charcoal provided a conventional radiocarbon age of 200±30 BP (Beta-396329).

Site 50-80-06-7727 was destroyed by the excavations and therefore is not significant under HAR §13-284-6. Data collected from the site—site location, contents, and radiocarbon dating—do provide valuable information about traditional settlement in the valley.

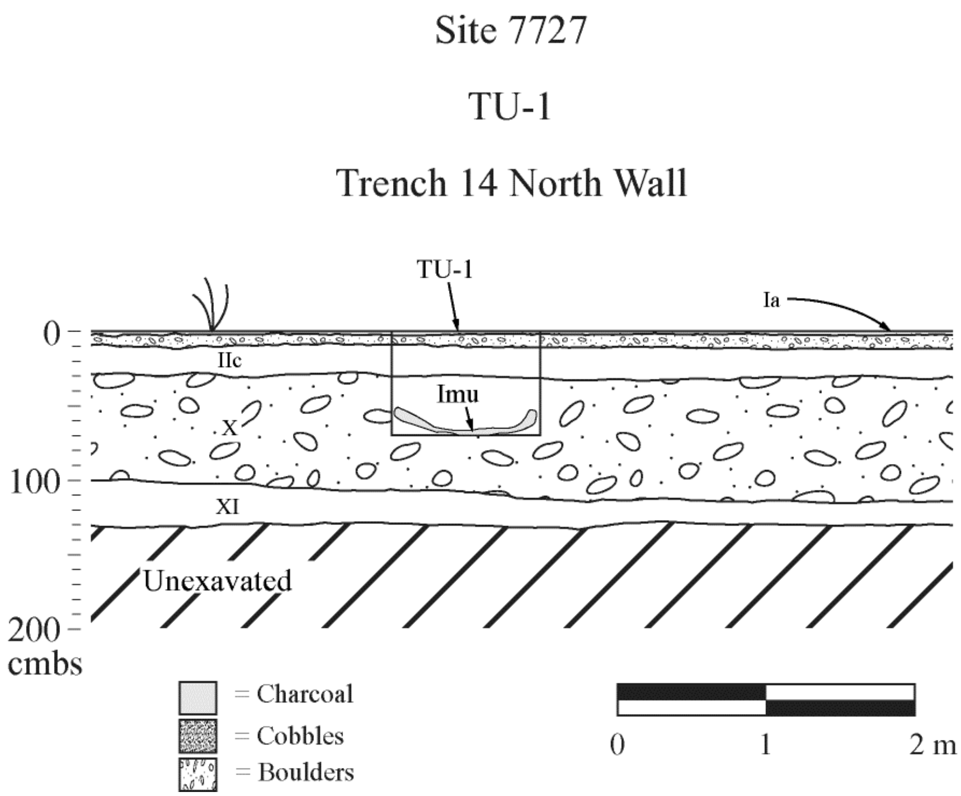


Figure 19. Portion of Trench 14 north wall profile, showing *imu* before test unit excavation.

Photo 12. Closeup of the north wall of the trench, with the *imu* highlighted by the dashed line.

SITE 50-80-06-7728

Site 50-80-06-7728 is a possible buried terrace retaining wall and associated agricultural soil, which was encountered during excavation of Trench 18 along the southern edge of the valley (Fig. 20; Photo 13). Trenching exposed a concentration of basalt cobbles and small boulders, visible in both sidewalls of the trench. The stones were roughly arranged in 2-4 dry-stacked courses, 10-35 cm tall. In order to examine feature construction, a second backhoe trench, extending from the northwest side of the trench, was excavated parallel to the downslope (northeast) side of the wall. Additionally, the southeast side of the trench was manually excavated around the feature (Photo 14). Integrity of the wall rapidly diminished on both sides and it was no longer intact at 1.2 m from Trench 18. The lack of a well-defined edge or corner suggests that the retaining face was previously damaged, leaving ony this small section intact. Although the structural evidence is ambiguous, the presence of a gley agricultural layer (see Fig. 20) in association with the feature supports its interpretation as a pondfield wall. Furthermore, historic maps indicate the area where the wall is located was under rice cultivation in 1907 (Fig. 21) and sugarcane by 1923 (Fig. 22); neither map shows internal terracing of these fields. Charcoal samples were collected from below the wall and between wall stones; however, both samples were too small and degraded for taxonomic identification and therefore were not submitted for radiocarbon dating. No other cultural material was encountered in the trench.

Soils recorded at Site 7728 consist of the current A horizon (Layer Ia) extending from the surface to 20 cm bs. Layer IVb, a dark brown silty clay, is present from 20-80 cm bs, and contains modern materials such as plastic. A dark greenish gray gley soil (Layer IX) underlies Layer IVb, and is thicker on the upslope side of the wall. This gley layer is interpreted as the agricultural soil deposited during pondfield cultivation.

Site 7728 is in fair to poor condition based on the current observations. The site is evaluated as significant per HAR §13-284-6 under Criterion d. The terrace and pondfield soil are remnants of early 20th century, or earlier, irrigated agriculture in the valley. Much of this agricultural infrastructure, particularly pre- and early post-Contact features, was apparently destroyed by later agricultural activities.

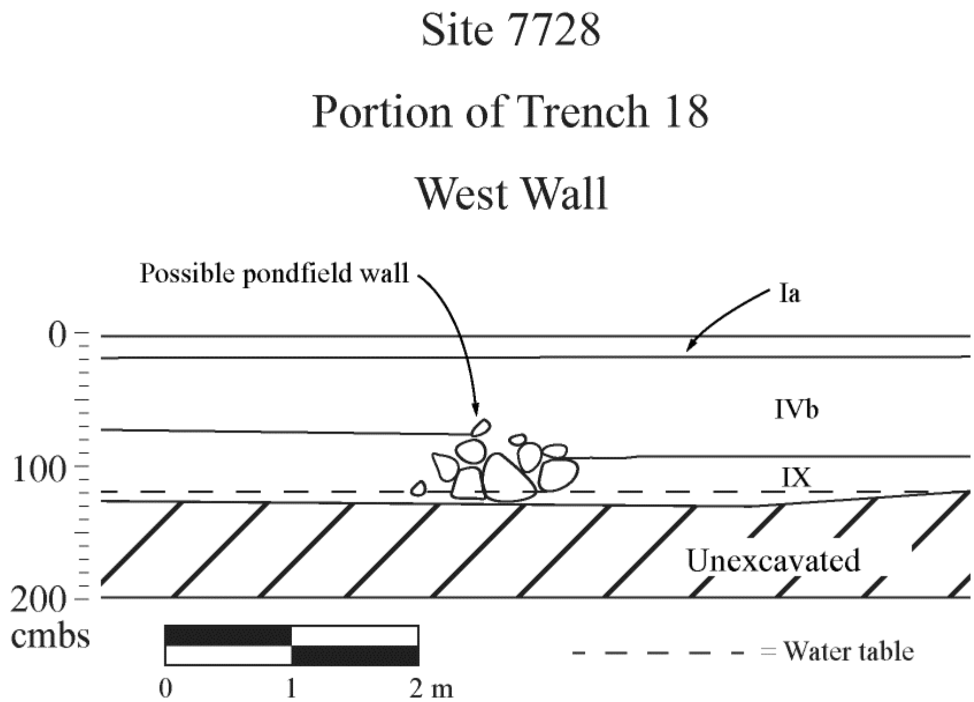


Figure 20. Portion of Trench 18 northwest wall profile, showing the terrace wall; note the thicker deposition of agricultural soil on the upslope (left) side.

Photo 13. Close up of the southeast wall of Trench 18, showing the buried terrace wall.

Photo 14. Possible buried wall after manual excavation on southeast side of Trench 18.

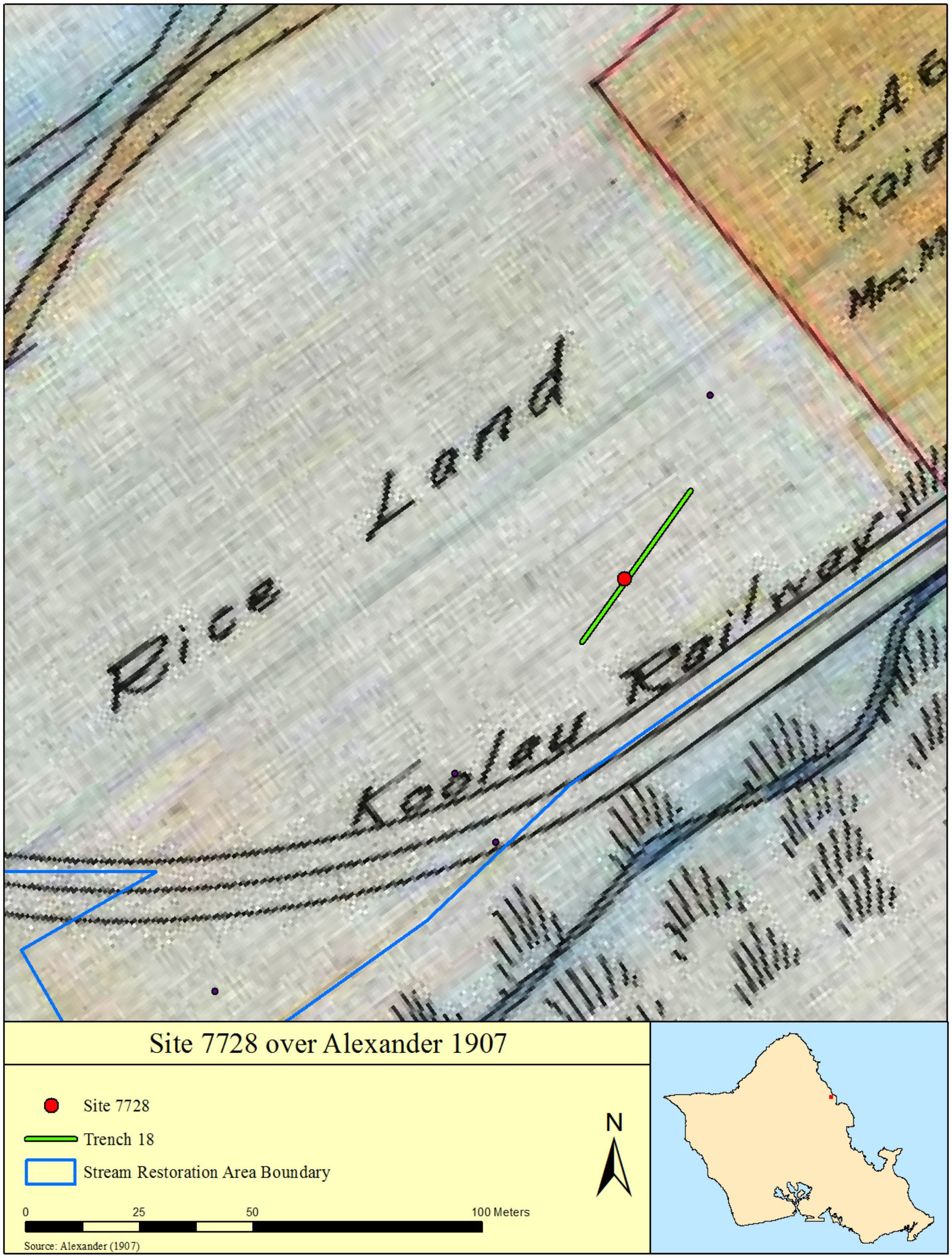


Figure 21. Site 7728 overlayed on Alexander's 1907 map.

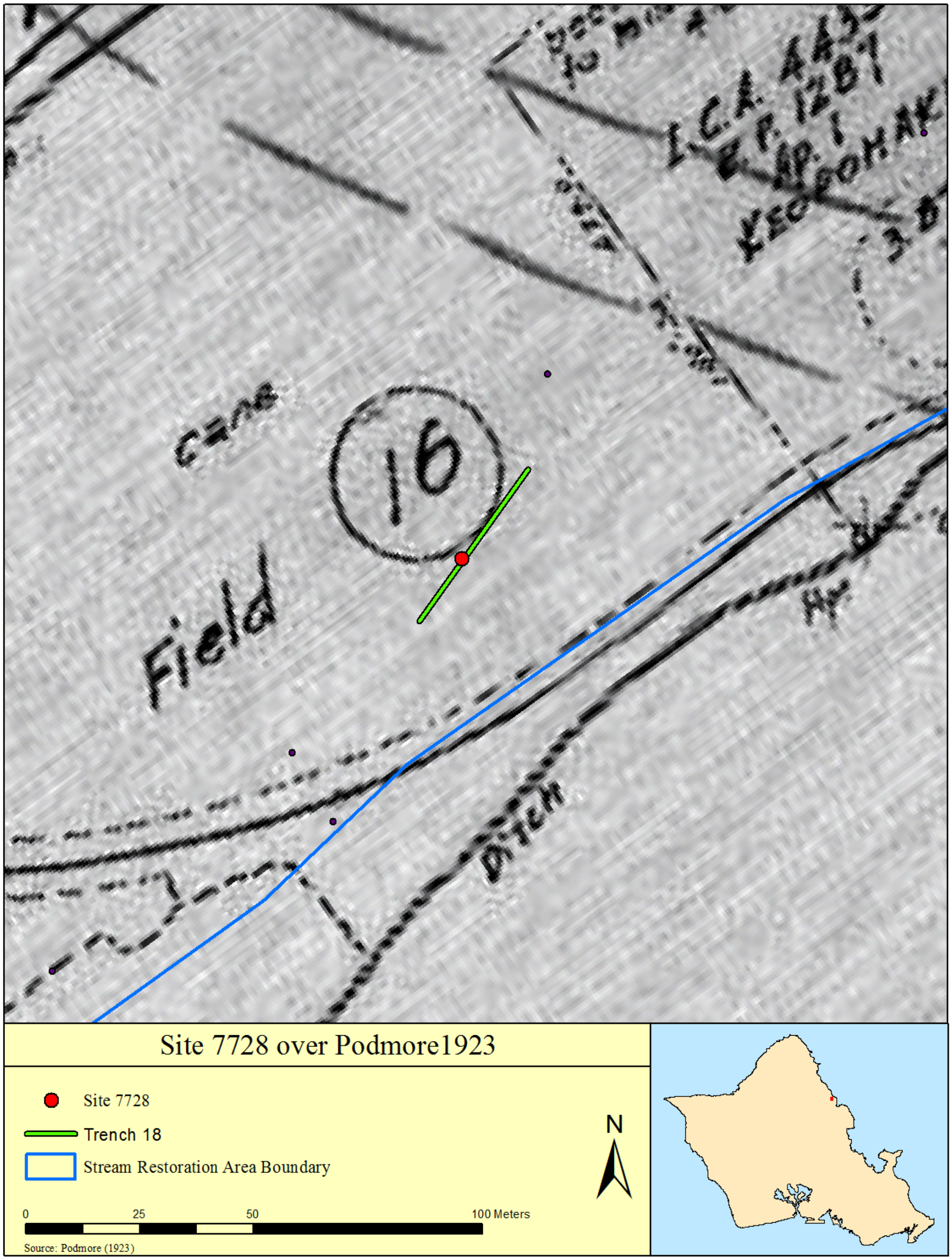


Figure 22. Site 7728 overlayed on Podmore’s 1923 map.

SITE 50-80-06-7733

Site 7733 is a buried gleyed agricultural soil (Layer IX, Trench 10), extending 60-120+ cm bs, that correlates with LCA 3881 awarded to Pahakae. Pahakae provided the following testimony for his claim on January 8, 1848 (Native Register Volume 4:185, translation from Maly and Maly 2005:61):

> To the people who Quiet Land Titles, Greeting to you. I, Pahakae, hereby tell you of my property, 3 loi kalo. N., Makaiwa. East, Halepapai. South, Kionaole [sic, Keonaole]. West, Paepae. There is 1 kula parcel at Holu, adjoining Halepapai ili land on the West, there at Meheiwi. My right is from the grandparents.

Kuolulu and Ikeole provided testimony in support of Pahakae's claim (Foreign Testimony Volume 10:34, translation from Maly and Maly 2005:62):

> Kuolulu, sworn, says he knows the kalo land of Pohakae [Pahakae] in Punaluu. It consists of 3 patches, in one piece. Bounded on Hauula side by Kukeawe's land. Makai by Kuheleloa's land. Kaneohe side by Hihia's land. Mauka by Paupau's land. Claimant and his relations have held the land for over ten years.
>
> Ikeole, sworn, says he knows Pahakae's land. There are three patches as set forth by the last witness.
>
> Kawana, the Konohiki had no objection to this claim.

As depicted in Figure 23, Trench 10 cut across the eastern (*makai*) boundary of LCA 3881, extending approximately 14 m into the parcel. The very dark gray clay agricultural soil, which we are correlating with Pahakae's *lo'i*, is present along the length of the trench (Fig. 24). No field boundary (e.g., stone facing or vertical break in the stratigraphy) was visible in the trench sidewalls, suggesting additional *lo'i* to the east (on Kuheleloa's land [Kuheleloa, however, did not receive an award in this area.]). No charcoal or artifacts were observed in the soil.

Site 7733 is in good condition and is evaluated as significant per HAR §13-284-6 under Criterion d. The agricultural soil relates to *lo'i* in production during the first half of the 19th century, and as such documents the last stage of traditional agriculture in the valley before the significant changes initiated by commercial agriculture.

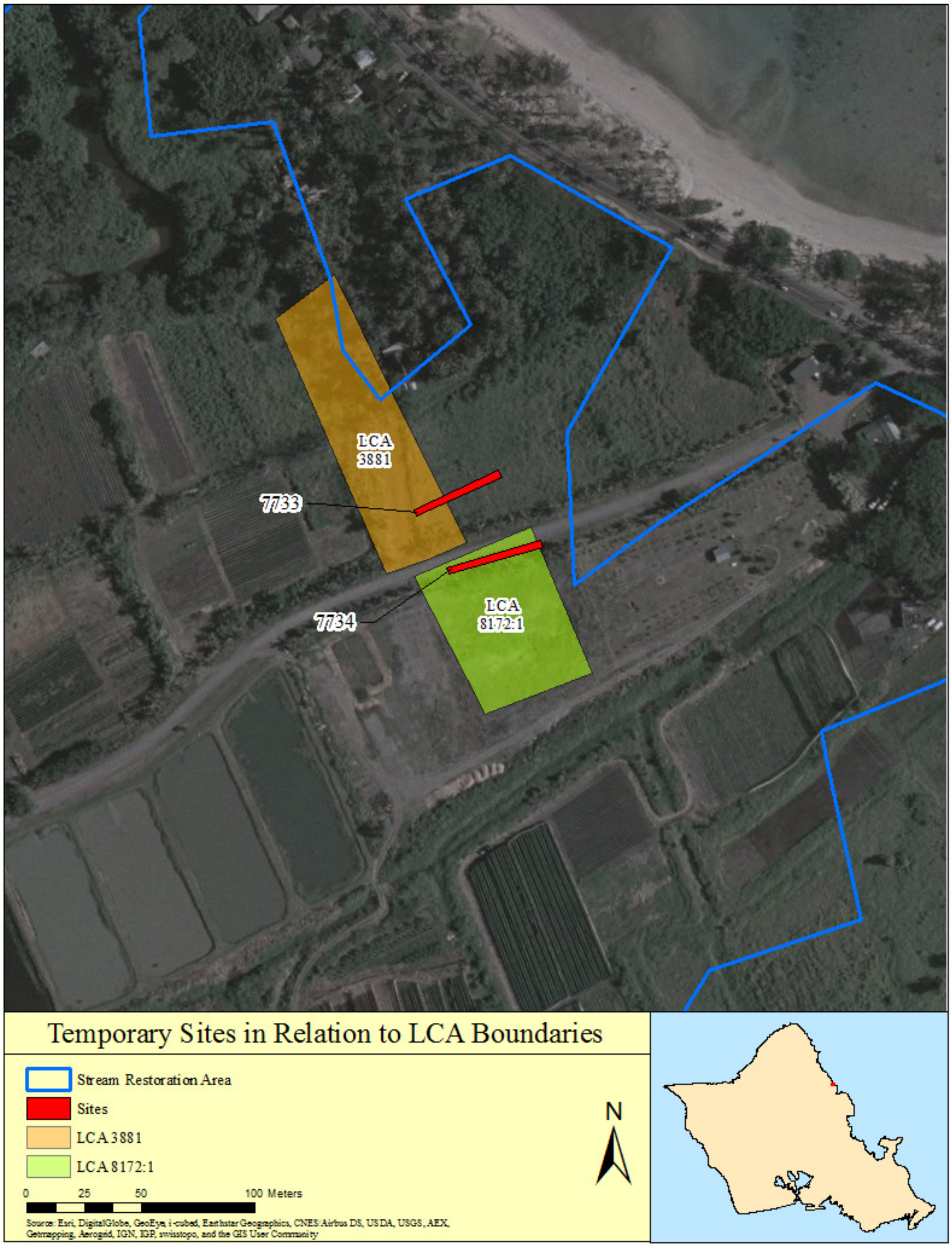


Figure 23. LCA 3881 and 8172:1 with Sites 7733 and 7734.

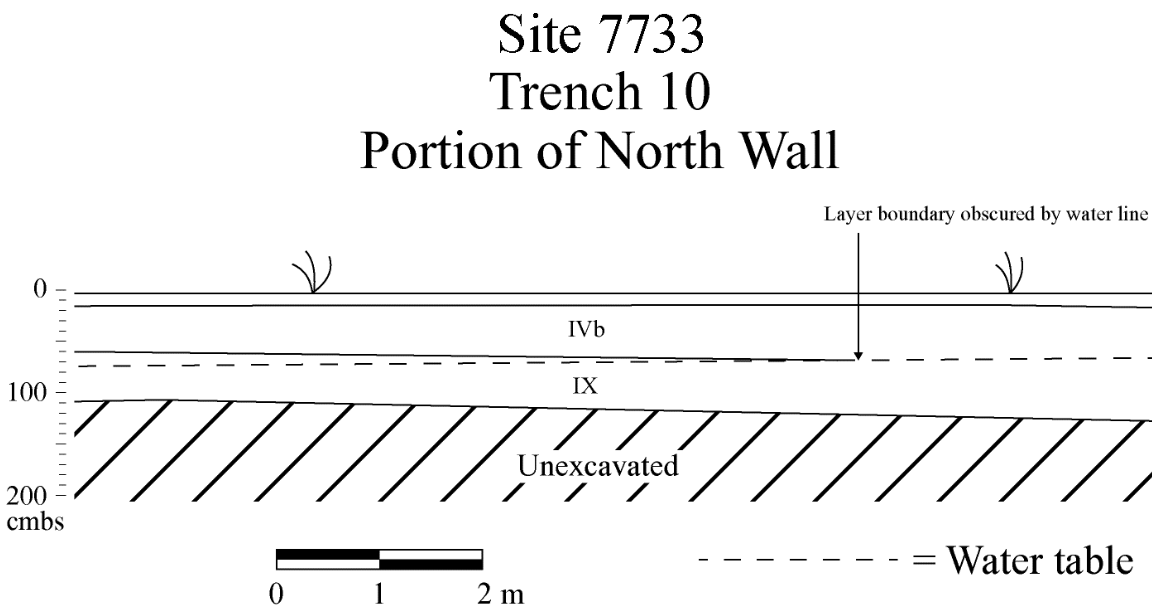


Figure 24. Scaled stratigraphic profile of a portion of the north wall of Trench 10. Layer IX is the Site 7733 agricultural soil correlated with Pahakae's *lo'i* (LCA 3381).

SITE 50-80-06-7734

Site 7734 is a buried gleyed agricultural soil (Layer IX, Trench 17), extending 125-140+ cm bs and throughout the length of the trench to the westernmost 6 m, that correlates with LCA 8172:1 awarded to Hahia. Hahia provided the following testimony for his land claim on January 7, 1848 (Native Register Volume 5:498, translation from Maly and Maly 2005:133):

> To the Commissioners who Quiet Land Titles. Aloha to all of you. I hereby tell you of my land claim in the ili land of Halepapai, Ahupuaa of Punaluu, District 5, Division 3, Island of Oahu. 3 taro loi; 3 fallo loi; 1 kula parcel; 1 house. Also, adjoining the ili of Paepae is 1 wauke patch. There is also adjoining another one, on the Ahupuaa of Makaua, 1 sweet potato patch. It is a true right from the Konohiki, in the time of Kamehameha III. That is my application on this 7th day of January, 1848. At Punaluu, Koolauloa. By me, Hahia X.

Pahakae and Oopa provided supporting testimony (Foreign Testimony Volume 10:61, translation from Maly and Maly 2005:134-135):

> Pahakae, sworn, says he knows the land of Hahia in Punaluu. It consists of 6 kalo patches, forming one piece. Bounded makai by the land of Kauli. On Kaneohe side by Kaahui's land. Mauka by Paupau's land. Hauula side by witness' land.
>
> Clt. [Claimant] has a House lot in Makaua. It is fenced in, and bounded: East by a stream. South by kalo land of Kamalii. West by Kauhi's land. North by Kaehukukona's land.
>
> Clt. has a piece of kula land also in cultivation. It is not enclosed and contains perhaps 3/4 of an acre of land. It is planted with potatoes and melons. Clt. has held these lands for six years.

Oopa, sworn, says he knows the land of the Clt. The kula land is in full cultivation. The House Lot is as set forth by the last witness.

The Konohiki had no objections to make to this claim.

As depicted in Figure 23, Trench 17 is completely within LCA 8172:1, at the northeast corner. The dark greenish gray clay agricultural soil, which we are correlating with Hahia's *lo'i*, is present along the length of the trench (Fig. 25). No charcoal or artifacts were observed in the soil.

Site 7734 is in good condition and is evaluated as significant per HAR §13-284-6 under Criterion d. The agricultural soil relates to *lo'i* in production during the first half of the 19th century, and as such documents the last stage of traditional agriculture in the valley before the significant changes initiated by commercial agriculture.

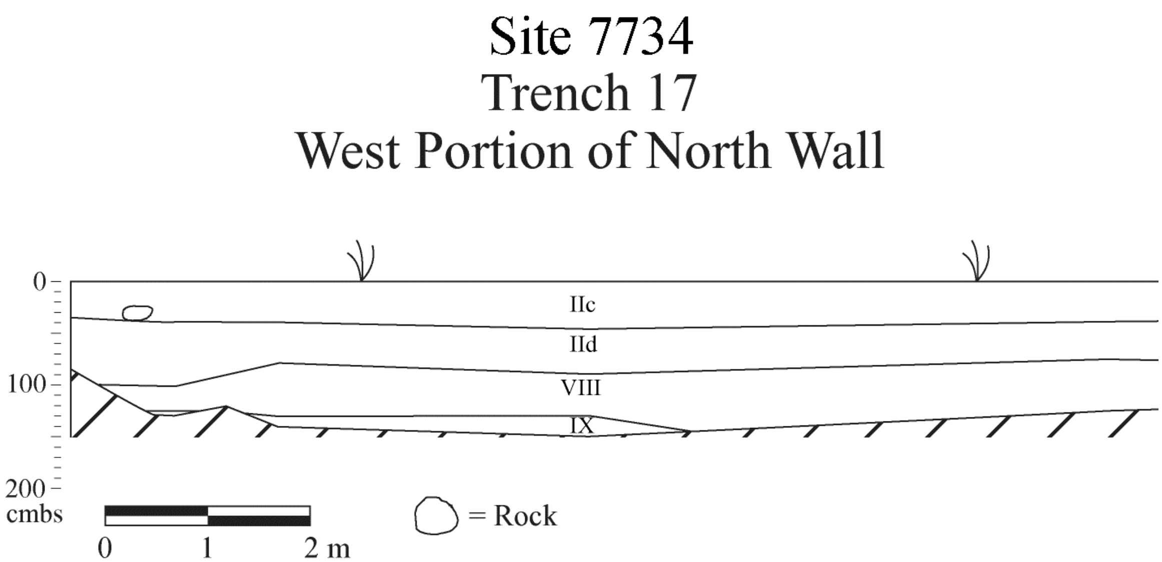


Figure 25. Scaled stratigraphic profile of a portion of the north wall of Trench 17. Layer IX is the Site 7734 agricultural soil correlated with Hahia's *lo'i* (LCA 8172:1).

RESULTS OF SUBSURFACE TESTING AND STRATIGRAPHIC INTERPRETATIONS

Twenty-five backhoe trenches were excavated at locations distributed across the project area (Fig. 26). Trenches were excavated to test for the presence of non-agricultural and agricultural cultural deposits and to determine the stratigraphy of the area. With one exception, trenches within the Punalu'u Component were oriented along the long axis of the valley in hopes of encountering any buried pondfield walls (which would have largely been oriented perpendicular to the stream). A single trench (Trench 8) was oriented to examine the possible presence of a buried irrigation ditch, shown on Podmore's (1923) map of the valley. Appendix A provides individual trench descriptions.

Four sites were recorded during subsurface excavation (Sites 50-80-06-7727, 7728, 7733, and 7734; see above). Site 7727 was a buried *imu* encountered during excavation of Trench 14. The feature was documented in the wall of the trench and subsequently recorded in further detail through controlled excavation. Site 7728 is a buried pondfield wall and soil encountered during excavation of Trench 18. A second trench was opened adjacent to the downslope side of the wall in order to document its construction and increase the chance of obtaining datable material from beneath its base. Sites 7733 and 7734 are buried agricultural soils correlated with 19th century LCA that were *lo'i*.

Strata were correlated across the project area, with fourteen primary layers (I-XIV) documented. Table 9 presents the descriptions of these layers and interpretations about their deposition, followed by text descriptions. General consistencies in stratigraphy were documented across the project area, although certain sediment types tend to group together in specific areas. Appendix B provides profile drawings of each trench. The profiles included here (Figs. 16-19) are characteristic of the distribution of soils across the project area.

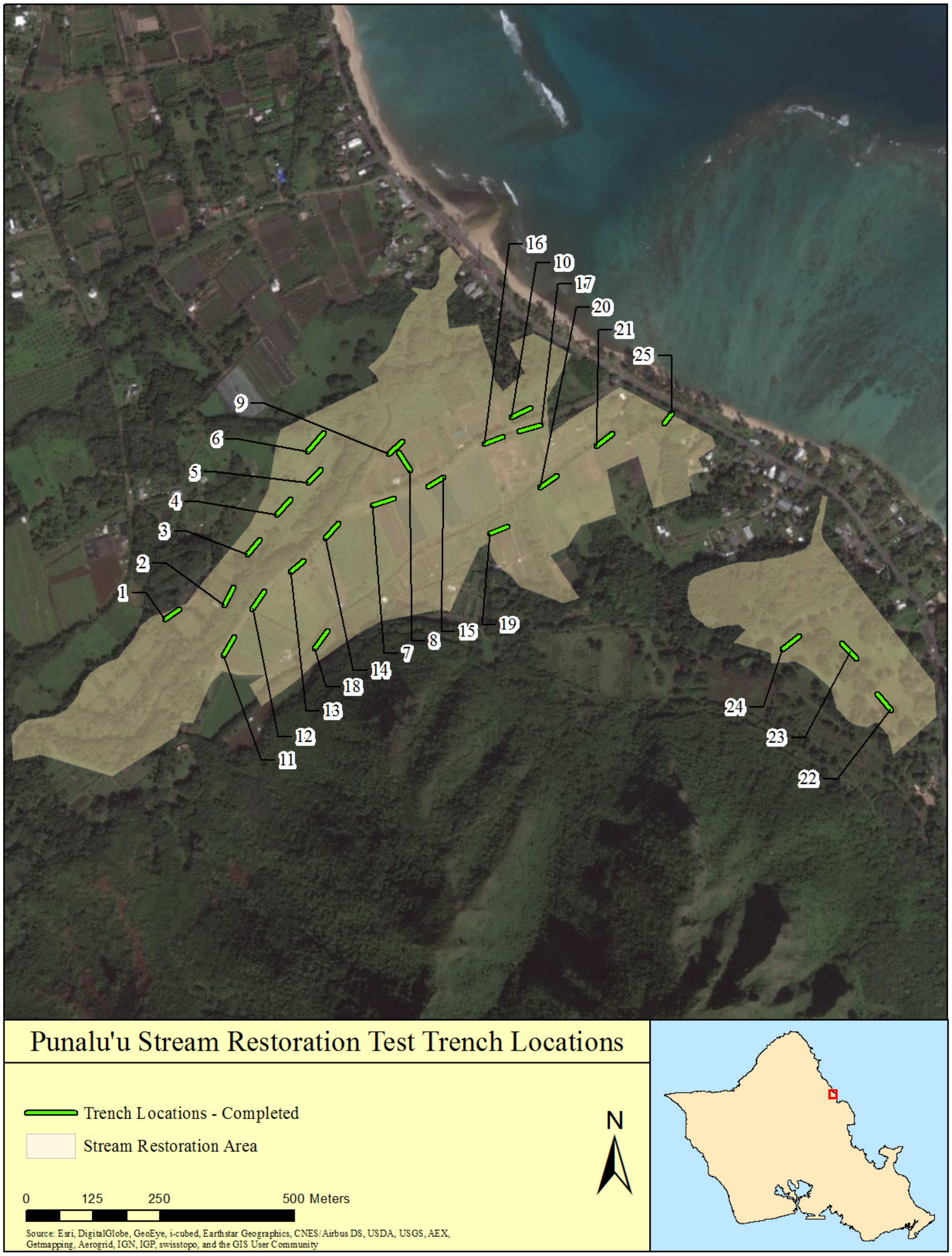


Figure 26. Locations of test trenches and sites recorded during subsurface survey.

Table 9. Soils Documented Across the Project Area.

Layer	Interpretation	Description	Trenches	Notes
Ia	Current A horizon	Very dark grayish brown (10YR 3/2), dark brown (10YR 3/3), dark grayish brown (10YR 4/2), black (10YR 2/1), silty clay to silty clay loam to loam; weak to medium structure, subangular blocky peds; moist consistence: friable to very friable, wet consistence: non to slightly sticky, non to slightly plastic; fine to coarse roots common; abrupt to clear smooth lower boundary	1-6, 11-14, 16, 18	Developed in terrigenous matrix
Ib	Current A horizon	Black (5YR 2.5/1) sandy loam; moderate, medium, angular blocky structure; dry consistence: slightly hard; wet consistence: slightly sticky to sticky, slightly plastic to plastic; few to common, fine to coarse roots; abrupt to clear, smooth to wavy lower boundary	19, 22-25	Developed in calcareous sand matrix
IIa	Fill	Very dark brown (10YR 2/2) loam; moderate to strong coarse or thick angular blocky structure; moist consistence: firm; wet consistence: slightly sticky, plastic; 30% subrounded to subangular pebbles and cobbles; abrupt smooth lower boundary; cobble pebble path present at surface of trench	1	Pathway
IIb	Fill	Very dark grayish brown (10YR 3/2) sandy loam; moderate fine to medium angular blocky granular structure; moist consistence: firm; wet consistence: slightly sticky, slightly plastic; very fine to medium roots few to common; 5-20% subrounded to subangular pebbles and cobbles; abrupt smooth lower boundary	7, 12-16	Located along edge of existing road

Table 9. Soils Documented Across the Project Area (continued).

Layer	Interpretation	Description	Trenches	Notes
IIc	Fill	Light olive brown (2.5Y 5/4) stones and very coarse sand; structureless; moist consistence: loose; wet consistence: non sticky, non plastic; many fine to coarse roots; 0-25% subrounded to subangular pebbles and cobbles; clear smooth lower boundary	7, 13, 14, 16, 17	Likely remnant of an older road subsurface
IIIa	Lower-energy alluvial deposit	Very dark brown (7.5YR 2.5/2), very dark grayish brown (10YR 4/2) sandy loam; weak, fine, granular, crumb structure; moist consistence: loose, very friable; wet consistence: non sticky, slightly plastic; clear, wavy lower boundary	1, 25	
IIIb	Alluvial deposit	Very dark gray (10YR 3/1) to dark brown (7.5YR 3/2) silt loam; moderate medium to coarse angular blocky to granular structure; moist consistence: firm to friable; wet consistence: slightly sticky, slightly plastic to plastic; few to common, very fine to fine roots; 5-15% well rounded to rounded to sub rounded pebbles and cobbles; abrupt smooth lower boundary	10, 12, 13	
IVa	Disturbed terrigenous alluvial deposit	Dark brown (7.5YR 3/2, 3/3; 10YR 3/3), very dark grayish brown (10YR 3/2), or brown (10YR 4/3) clay to silty clay to clay loam, distinct medium strong brown (7.5YR 5/6) mottles common; moderate coarse to very coarse subangular to angular blocky structure; moist consistence: friable, firm; wet consistence: non sticky to sticky, slightly plastic to plastic; abrupt to gradual wavy lower boundary	1, 6-10, 17, 19-21	Contains modern materials

Table 9. Soils Documented Across the Project Area (continued).

Layer	Interpretation	Description	Trenches	Notes
IVb	Alluvial terrigenous flood deposit	Very dark grayish brown (10YR 3/2) or dark gray (10YR 4/1) silty clay loam; many fine distinct dark reddish brown (5 yr 3/3) mottles, strong, medium, blocky to angular blocky structure; moist consistence: friable to very friable; wet consistence: slightly sticky to sticky and plastic; common very fine to fine root; very few thin clay films on ped faces; 25-40% rounded to sub rounded to sub angular pebbles and cobbles; gradual, wavy lower boundary	3, 6, 10, 11, 14-16, 18	
Va	Terrigenous stream deposit	Very dark grayish brown (10YR 3/2) loamy sand; moderate fine angular blocky crumb structure; moist consistence: very friable to friable, wet consistence: sticky, slightly plastic; clear wavy lower boundary	1	
Vb	Medium- to high-energy alluvial deposit	Very dark grayish brown (10YR 3/2) or dark brown (10YR 3/3) sandy loam to loamy sand; moderate fine angular blocky crumb structure; moist consistence: very friable to friable, wet consistence: slightly sticky to sticky, slightly plastic to plastic; 70-80% subangular to rounded granules to cobbles	1, 6	
VIa	Flood deposit	Dark yellowish brown (10YR 3/4) silty clay; weak to moderate fine to medium single grain subangular blocky structure; moist consistence: friable; wet consistence: slightly sticky, slightly plastic; abrupt wavy lower boundary	2	

Table 9. Soils Documented Across the Project Area (continued).

Layer	Interpretation	Description	Trenches	Notes
VIb	Flood deposit	Dark yellowish brown (10YR 3/4) silty clay; weak to moderate fine to medium single grain subangular blocky structure; moist consistence: friable; wet consistence: slightly sticky slightly plastic; 70-95% rounded to subrounded pebbles and cobbles, varying in places; abrupt wavy lower boundary	2	
VIIa	Flood deposit	Dark yellowish brown (10YR 3/4) silty clay; moderate fine to medium angular blocky structure; moist consistence: very friable; wet consistence: slightly sticky, slightly plastic; abrupt wavy lower boundary	2	
VIIb	Flood deposit	Dark yellowish brown (10YR 3/4) silty clay; moderate fine to medium angular blocky structure; moist consistence: very friable; wet consistence: slightly sticky, slightly plastic; 70-95% rounded to subrounded pebbles and cobbles; abrupt wavy lower boundary	2	
VIII	Alluvial deposit	Dark brown (10YR 3/3), very dark grayish brown (10YR 3/2),or dark reddish brown (5YR 3/3) clay loam; moderate medium to very coarse granular crumb structure; moist consistence: friable; wet consistence: sticky, slightly plastic; 15% subrounded to rounded pebbles; moisture in layer increases with depth	4, 5, 7, 8, 12, 13, 16, 17	
IX	Agricultural soil	Dark gray (10YR 4/1), very dark gray (Gley1 4/N), or dark greenish gray (Gley1 3/10GY) silty clay to clay; moderate, medium, blocky structure; moist consistence: very friable to friable; wet consistence: slightly sticky to very sticky, plastic to very plastic	10, 17, 18	Pondfield (*lo'i*) deposits: Sites 7728, 7733, and 7734
X	High-energy alluvial deposit	Very dark grayish brown (10YR 3/3) sandy clay loam; moderate, fine, granular, crumb structure; moist consistence: friable; wet consistence: sticky and slightly plastic; >75% well rounded to rounded granules, pebbles, cobbles, and boulders	9, 12-14, 19-21	Former stream bed

Table 9. Soils Documented Across the Project Area (continued).

Layer	Interpretation	Description	Trenches	Notes
XI	Alluvial deposit	Dark reddish brown (5YR 3/3) clay loam; many yellowish red (5YR 4/6) fine prominent mottles; moderate, fine to medium, platy structure; moist consistence: friable; wet consistence: very sticky, very plastic; abrupt, smooth lower boundary	11, 14, 15	
XII	Beach deposit	Very pale brown (10YR7/3, 8/2) very coarse sand, coarse sand, loamy coarse sand; structureless; dry consistence: loose; wet consistence: nonsticky, nonplastic; clear, smooth lower boundary	25	
XIII	Fill or alluvial flood deposit	Brown (10YR 4/3) clay loam; weak, medium, angular blocky structure; moist consistence: friable; wet consistence: slightly sticky, slightly plastic; clear, smooth lower boundary	25	Proximity to the highway suggests this layer may be fill
XIV	Beach deposit	Very pale brown (10YR 8/2) very coarse sand, coarse sand (dry); structureless; dry consistence: loose; wet consistence: nonsticky, nonplastic	22-25	

SUMMARY OF SOIL LAYERS RECORDED ACROSS THE PROJECT AREA

As noted above, 14 layer designations have been applied to the soils documented across the project area. The majority of these soils derive from alluvium deposited by Punalu‘u Stream under different energy regimes (as indicated by particle sizes). Medium- and high-energy deposits area present at most trench locations immediately north and south of the stream, documenting a moderate degree of meandering through time. Three trenches near the main ditch of Site 7236 also revealed high-energy alluvial deposits, suggesting a much greater meandering of Punalu‘u Stream in the past. Various deposits of finer-grained alluvium blanket the valley bottom and were recorded in every trench in this area.

The three trenches excavated in the Kahana Component reveal a significantly different stratigraphic sequence. These trenches have a surface A horizon soil derived from the underlying Jaucas calcareous sand.

Layer I

The majority of the trench excavations revealed a modern A horizon soil that developed either from a silt or silty clay terrigenous matrix (Layer Ia) or calcareous sand (Layer Ib). Variation in the color and texture of Layer Ia soils relates to differences in source alluvium, but a primary characteristic of this soil in all of its exposures in the valley is that it is the surface soil.

Layer II

Layer II consists of three types of fills found in various contexts in the project area. Layer IIa is a loamy fill found only in a pathway that intersects Trench 1. Layer IIb is a sandy loam fill found in some trenches that were excavated along Punalu‘u Valley Road (Trenches 7, 12-16), and it is interpreted as relating to road construction. Layer IIc is a stony sand fill located, like Layer IIb, in several trenches excavated along Punalu‘u Valley Road (Green Valley Road) (Trenches 7, 13, 14, 16, 17). The fill is interpreted as a base course layer from an earlier surface of the road.

Layer III

Layer III is an alluvial loam or silt deposit found in areas under rice or taro cultivation in the 20th century. It is divided into two sublayer designations. Layer IIIa is a sandy loam found in Trenches 1 and 25. Layer IIIb is a silt loam present in Trenches 10, 12, and 13 that contains higher concentrations of waterworn stone.

Layer IV

Layer IV is a alluvial deposit comprised of clay, silty clay, or a silty clay loam and was predominantly documented in the central portion of the valley. Layer IV is divided into two sublayer designations. Layer IVa (Trenches 1, 6-10, 17, 19-20) has been disturbed by recent activities and often contains modern materials. Layer IVb (Trenches 3, 6, 8, 10, 11, 14-16, 18) shows no sign of disturbance.

Layer V

Layer V is a natural terrigenous sand layer located north of Punalu‘u Stream. Layer V is divided into two sublayer designations. Layer Va is a loamy sand encountered in Trench 1. Layer Vb is a sandy loam to loamy sand recorded in Trenches 1 and 6.

Layer VI

Layer VI is a layer of silty clay found only in Trench 2 and is interpreted as a flood deposit. The lower component of this layer (Layer VIb) has a considerably higher amount of waterworn pebbles and cobbles than the upper portion (Layer VIa). This vertical organization of particle sizes is consistent with the variable rates at which different size classes settle out of suspension.

Layer VII

Layer VII is also found only in Trench 2 and is also a likely flood deposit. Layers VIIa and VIIb exhibit the same particle size differentiation that characterizes Layer VI.

Layer VIII

Layer VIII is a clay loam that is a low-energy alluvial deposit, found primarily along the stream. Layer VIII was documented in Trenches 4, 5, 7, 8, 12, 13, 16, and 17.

Layer IX

Layer IX is a dark gley silty clay or clay and is interpreted as a pondfield agricultural soil. Characteristics vary slightly between the three trenches in which it was identified (Trenches 10, 17, and 18), but it is interpreted as *lo'i* soil at all locations. The Trench 10 exposure is Site 7733, correlated with a mid-19th century *lo'i* awarded as LCA 3381 to Pahakae. The Trench 17 soil is Site 7734, which is correlated with Hahia's mid-19th century *lo'i* awarded as LCA 8172:1. The Trench 18 soil relates to Site 7728, a buried terrace.

Layer X

Layer X is a very stony, sandy clay loam predominantly found near the stream. This high-energy alluvial deposit was recorded in Trenches 9, 12, 13, 14, 19, 20, and 21.

Layer XI

Layer XI is an alluvial clay loam encountered along the south side of Punalu'u Stream in Trenches 11, 14, and 15.

Layer XII

Layer XII is a very coarse calcareous Jaucas sand deposit (a former beach deposit) found only in Trench 25.

Layer XIII

Layer XIII is a clay loam, also found only in Trench 25. Given its location, it is possible that Layer XIII is fill associated with construction of Kamehameha Highway, though alternatively it may be a flood deposit.

Layer XIV

Layer XIV is a layer of very coarse calcareous Jaucas sand found in Trenches 22, 23, 24, and 25. The layer is a former beach or coastal dune deposit.

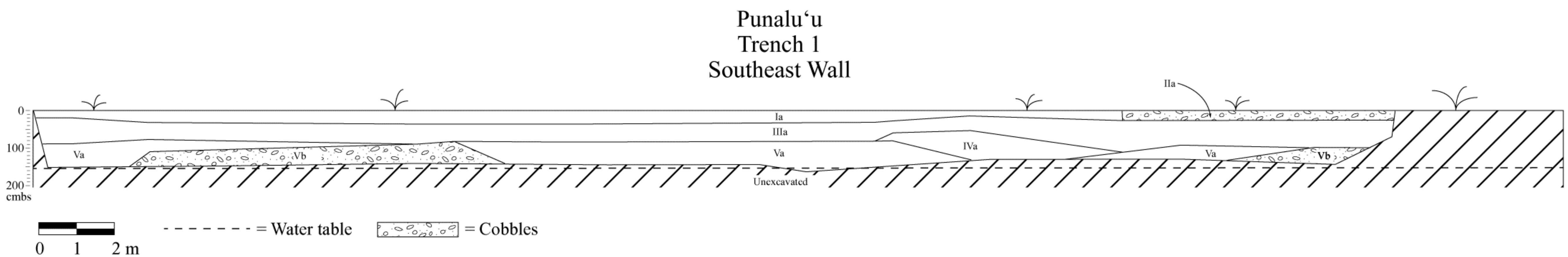


Figure 27. East wall of Trench 1.

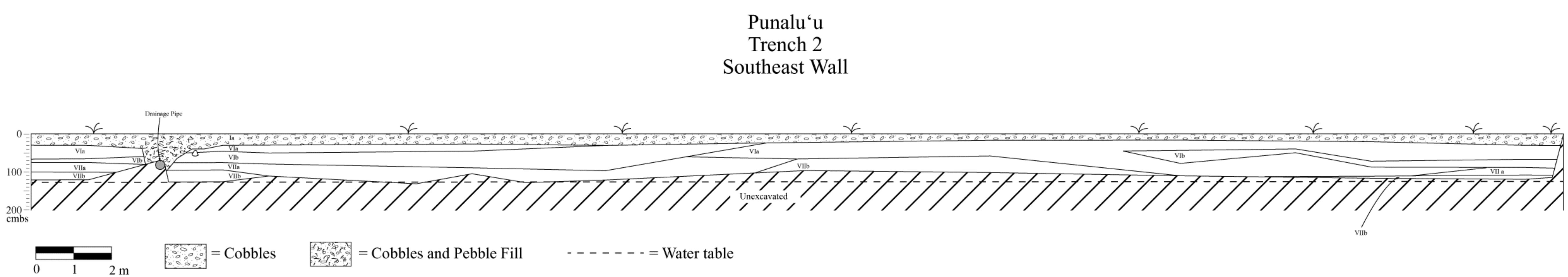


Figure 28. West wall of Trench 12.

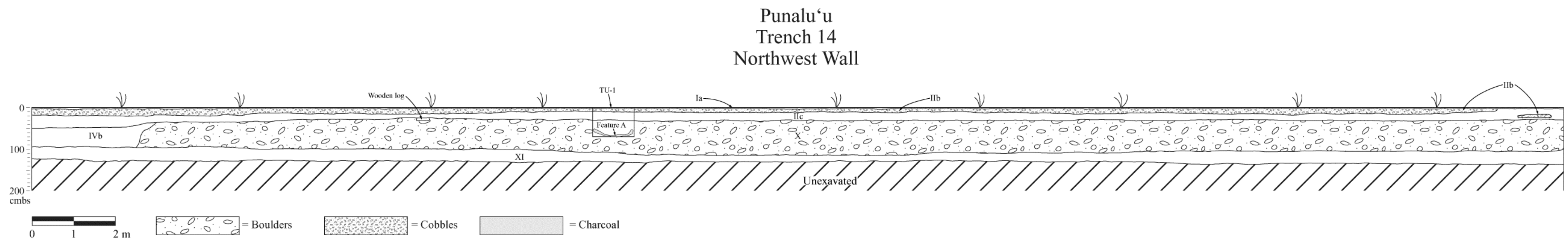


Figure 29. North wall of Trench 14, showing the location of Site 7727 (buried *imu*). Note the abrupt, nearly vertical boundary between Layers IVb and X, which is interpreted as the edge of a former stream channel (Layer X representing the high-energy stream channel deposit).

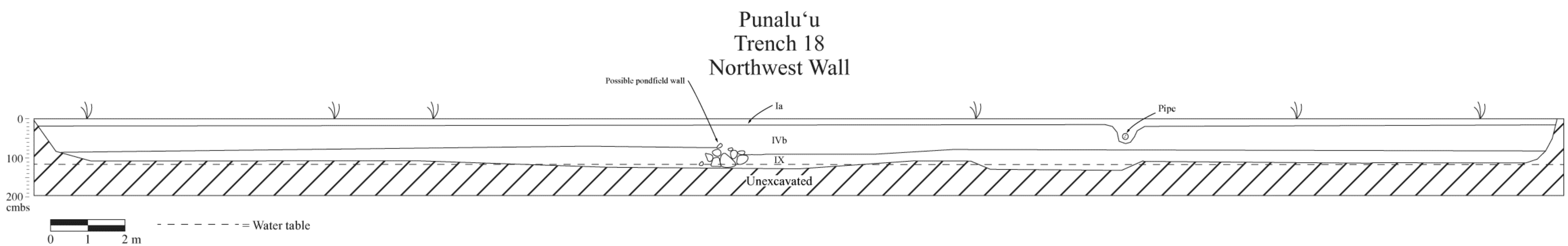


Figure 30. West wall of Trench 18, the location of Site 7728.

LABORATORY RESULTS

Wood charcoal identification and radiocarbon dating were the laboratory analyses completed for this project. Aside from 15,935 grams of fire-cracked rock collected from Site 7727, no artifacts were recovered.

WOOD CHARCOAL IDENTIFICATIONS

Within the three charcoal samples that were analyzed, one native tree (*alahe'e*) is present along with two unidentified woody taxa (Table 10). *Pysdrax odorata* (synonym: *Canthium odoratum* [G. Forster]; *alahe'e*) is an indigenous shrub or small tree, usually 3 to 6 m tall but it may be up to 15 m. It has been found in dry shrublands and dry to mesic forests at 10 to 1,160 m elevation on all of the main islands except Ni'ihau and Kaho'olawe (Wagner et al. 1990:1119). Its hard wood was once used for making *'ō'ō* digging sticks and its leaves made a black dye (Handy and Handy 1972:117; Pukui and Elbert 1986:17; Rock 1974:437).

Table 10. Summary of Taxa Identifications for Charcoal Samples from Sites 7727 and 7728.

Provenience	Taxon	Common / Hawaiian Name	Origin / Habit	Part	Count & Weight, g	WIDL	^{14}C Sample
Site 7727, Trench 14, TU-1, L. V/3; from *imu*	cf. *Psydrax odorata*	*Alahe'e*	Native/Tree	Wood	1 / 4.44	1420-1	X
	Unknown 1			Wood	9 / 0.15	1420-2, 1420-3	
Site 7728, Trench 20, 85 cm bs, from interstices of stone facing	Unknown 2			Wood	1 / 0.06	1420-4	

RADIOCARBON DATING

One AMS radiocarbon date was obtained, the sample coming from the Site 7727 *imu* (Table 11). The cf. *Psydrax odorata* charcoal provided a conventional radiocarbon age of 200±30 BP (Beta-396329). Using Oxcal v4.2.4 (Bronk Ramsey 2009) and the IntCal13 Northern Hemisphere atmospheric calibration curve (Reimer et al. 2013) the radiocarbon determination produces a multi-modal date distribution (95.4%): AD 1646-1690 (24.9%), 1728-1810 (51.2%), 1926- (19.3%; this portion of the date extends beyond the calibration range). These results are generally consistent with McElroy and Eminger's (2013) dates for late pre-Contact to early post-Contact activities in the valley.

Table 11. Radiocarbon Dating Results for Site 7727.

Provenience	Target Event	Sample Material	$^{13}C/^{12}C$ Ratio (‰)	Conventional Radiocarbon Age (BP)	Lab No.	WIDL No.
Trench 14, *imu*	Use of *imu*	cf. *Psydrax odorata*	-28.7	200±30	Beta-396329	1420-1

V. CONSULTATION

During the past nine years, Kamehameha Schools has coordinated multiple consultation sessions relating to Punalu‘u Ahupua‘a in general, archaeological findings in the area, and most recently, the stream restoration project (Table 12). Consultations have taken the form of ethnographic/oral history interviews with Punalu‘u residents—*kūpuna* (ancestor) and *kama‘aina* (native-born)—with genealogical ties to the area and group meetings to discuss project plans and archaeological results. Maly and Maly (2005a, 2005b) and Monahan and Evans' (2014) gathered significant oral history information about the valley's cultural resources and traditional practices, though nothing specific to the archaeological sites identified during the present survey. Similarly, consultation for McElroy et al.'s (2011) reconnaissance-level survey of the area resulted in no additional information.

December 11, 2014, Jason Jeremiah and Jon Tulchin of Kamahemahe Schools met with the Punalu‘u Watershed Alliance, a group comprised of many longtime residents of Punalu‘u, to discuss the stream restoration project and the results of the current archaeological inventory survey. Attendees were shown the locations of the identified historic properties and were provided summaries of the sites. Some attendees suggested that Site 7718 Features A-C, concrete pads, may have been utilized by Chinese rice farmers as rice threshing areas. Additionally, Site 7718 Feature D, a pond, was remembered by community members as being an ornamental water feature that was filled with goldfish and lilies in the 1970s. The group had no concerns about the project's potential effect on any of the historic properties. .

Table 12. Consultations Coordinated by Kamehameha Schools for Punalu‘u Ahupua‘a and the Stream Restoration Project.

Date	Consultation Group	Purpose
2005	Punalu‘u residents	Oral history interviews (Maly and Maly 2005a, 2005b)
June 7, 2011	Punalu‘u residents	Results of an archaeological reconnaissance survey within the valley (McElroy et al. 2011)
2014	Punalu‘u residents	Cultural Impact Assessment report for stream project (Monahan and Evans 2014)
December 11, 2014	Punalu‘u Watershed Alliance	Punalu‘u Stream Project and Archaeological Inventory Survey (this report)

VI. DISCUSSION

This section presents a discussion of the survey results as they pertain to the research questions guiding the project.

1) Are traditional Hawaiian surface features present? If so, what activities are represented?

No traditional Hawaiian surface features were identified. It is possible that some of the extant agricultural fields that are under cultivation represent the modern re-use of older features, but there is no empirical support for this possibility. Site 7728, a buried terrace retaining face and agricultural soil, is the only possible traditional structural feature documented during the survey. Although the dates for the construction and use of this feature are unknown, the dry-stacked stone facing is representative of traditional architecture. The terrace relates to irrigated agriculture.

2) Are historical surface features present? If so, what activities are represented?

Two historical sites—Site 7236 and Site 7718—were recorded, which relate to different 20th century activities. Site 7236 is a fairly extensive irrigation ditch network of which the earliest component was constructed no later than 1907. However, the majority of the network as it is presented arranged was built between the 1920s and early 1950s. These ditches were integral infrastructure for 20th century commercial agriculture.

Site 7718, which includes three concrete foundations and one stone-lined pond, is assumed to represent residential and/or agricultural activities. A date ("9/11/53") inscribed in one of the concrete pads and the depiction of the pond on Thoene's 1953 map confirms a mid-20th century age for at least a portion of the site complex. The specific functions for the foundations are unknown.

3) Are traditional Hawaiian cultural deposits present? If so, what activities are represented?

No traditional Hawaiian cultural deposits were encountered, but an isolated *imu* was documented. This *imu* (Site 7727) was identified within a former stream deposit towards the center of the valley. Abundant fire-cracked rock and charcoal was present, but no formal artifacts or midden were identified. A radiocarbon date obtained from *alaheʻe* charcoal collected from the base of the feature provides a late pre-Contact to early post-Contact age (200±30 BP; Beta-396329) for the use of the *imu*. The *imu* represents food preparation and by extension, habitation in the vicinity.

4) Are historical period cultural deposits present? If so, what activities are represented?

Sites 7733 and 7734 are buried *loʻi* soils correlated with land claim petitions submitted in 1848 (LCA 3881 and 8172:1, respectively). Per the testimony offered in support of the claims, Site 7733 was under taro cultivation as early as 1838 with cultivation at Site 7734 beginning no later than 1842. Although it is not clear if both parcels were still being used as *loʻi* in 1907, Alexander's (1907) map does not list them as abandoned like many of the other LCA in the area. These sites represent a continuation of traditional irrigated agriculture into at least the mid-19th century.

5) Are human skeletal remains present?

No human remains were encountered during the subsurface testing and no possible, or confirmed, burial features were identified on the surface.

VII. CONCLUSIONS AND RECOMMENDATIONS

International Archaeological Research Institute, Inc., completed an archaeological inventory survey of the planned Punaluʻu Habitat Bank and Stream Restoration Project encompassing 119.8 acres within Punaluʻu, Makaua, and Waiʻono Ahupuaʻa. The inventory survey included a pedestrian survey and the excavation of 25 backhoe trenches within the two projects parcels (identified as the Punaluʻu Valley and Kahana Components). Six archaeological sites were identified. These sites are a valley-bottom irrigation network dating to the early to mid-20th century (Site 50-80-06-7236), a mid-20th century complex of concrete foundations and a pond (Site 50-80-06-7718), an isolated buried *imu* (Site 50-80-06-7727), a buried pondfield terrace (Site 50-80-06-7728), and two buried 19th century *loʻi* soils (Sites 7733 and 7734).

It is clear that cumulative 19th and 20th century activities have had a substantial effect on the landscape of Punaluʻu Valley, changing a subsistence-based, traditional agricultural landscape to a commercial agricultural system. Much of the presumed archaeological evidence documenting these earlier activities is long destroyed; however, the results of this survey have shown that remnants of this older occupation are present, if with a limited and patchy distribution. In addition, some of the historic agricultural infrastructure and residential features have in turn become important aspects of the archaeological record.

Our results can be arranged chronologically, likely beginning sometime during the second half of the 17th through 18th centuries with the use of an *imu* (Site 7727) near Punaluʻu Stream. No other evidence for occupation or associated activities at this time was found during the survey, but the age of this oven is consistent with dates obtained from other deposits within the valley (McElroy and Eminger 2013). It is assumed that at this time the valley bottom would have been a gridded network of *loʻi* with terracing and mounds along the adjacent slopes for dryland agriculture. Although undated, the buried terrace with a pondfield soil (Site 7728) found along the southern edge of the valley may be evidence of this agriculture. By the first half of the 19th century, numerous families were growing taro and other crops throughout the area. Archaeologically, buried *loʻi* soils from parcels awarded to two *mahi ʻai* (farmers)—Pahakae and Hihia—have been recorded towards the mouth of the valley. How long through the 19th century these lands were planted in taro is unknown, but by 1907 they were still independent land holdings. During the first decades of the 20th century, however, as the valley was covered in sugarcane fields an expanding irrigation network was developed, assuredly in part using the earlier *ʻauwai* system. Multiple, integrated ditches built during the first half of the 20th century are still extant (Site 7236), and are largely in operation. One other reminder of this period is the complex of concrete building foundations and pond (Site 7718) documented in the Kahana Component.

SIGNIFICANCE EVALUATIONS

Per HAR §13-284-6 and evaluation criteria defined in 36 CRF 60, significance has been evaluated for all of the sites. As stated in §13-284-6, "[t]o be significant, a historic property shall possess integrity of location, design, setting, materials, workmanship, feeling, and association" and will meet one or more of criterion a-e. These criteria are:

Criterion a. Be associated with events that have made an important contribution to the broad patterns of our history;

Criterion b. Be associated with the lives of persons important in our past;

Criterion c. Embody the distinctive characteristics of a type, period, or method of construction; represent the work of a master; or possess high artistic value;

Criterion d. Have yielded, or is likely to yield, information important for research on prehistory or history; or

Criterion e. 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.

The state criteria, with the exception of Criterion e, are nearly identical to federal Criteria A-D as defined by 36 CFR 60 for significance evaluations for nomination to the National Register of Historic Places (NRHP). The National Register Bulletin 16A (Anonymous 1997:1) indicates that, "Properties listed in the National Register of Historic Places possess historic **significance** and **integrity**" (emphasis added in original). Historical integrity must be evident in some combination of the qualities of location, design, setting, materials, workmanship, feeling, and association. As explained in the National Register Bulletin, "All seven qualities do not need to be present for eligibility as long as the overall sense of past time and place is evident" (Anonymous 1997:4). Also, for archaeological sites (as opposed to standing historical structures), integrity is "generally based on the degree to which remaining evidence can provide important information" (Anonymous 1997:4). Finally, listed or eligible properties must be "significant when evaluated in relationship to major trends of history in their community, State, or the nation" (Anonymous 1997:1).

Based on the state criteria, five sites are recommended as being significant under Criteria a and/or d (Table 13). In addition, these five sites are potentially eligible to the NRHP under Criteria A and/or D and based on their integrity.

Site 7236, a historic irrigation ditch network, is significant under Criteria a and d (HAR §13-284-6) and Criteria A and D (NRHP). Site 7236 is a local (Punalu'u Valley) example of the 20th century agricultural infrastructure that was engineered across vast swaths of the islands as part of the archipelago-wide plantation agricultural economy (Criterion a/Criterion A). Plantation agriculture during the 19th and 20th centuries had wide-ranging and dramatic effects on the landscape, food and agricultural commodity production, larger economy, politics, and demography. This ditch network, which includes branches constructed as early as 1907 through the mid- to late-20th century, was an integral component of historic agricultural activities in the valley. The layout and orientation of these ditches provides important information pertaining to individual agricultural plots, the integration of these plots into a larger irrigated planting system, and the types of plants that could have been grown (Criterion d/Criterion D).

Site 7718, a complex of concrete foundations and a stone-lined pond, is significant under Criterion d (HAR §13-284-6) and Criterion D (NRHP). Following this criterion, recording of this site provides general information about habitation in this part of the valley during mid-20th century.

Site 7727, an *imu*, was destroyed and data recovered by excavation, and therefore is no longer significant. Data from this site does relate late pre- to early post-Contact habitation in the valley.

Site 7728, a buried terrace, is significant under Criterion d (HAR §13-284-6) and Criterion D (NRHP). Following these criteria, recording of this feature provides information about agriculture in this portion of the valley. This site is particularly informative because surface remnants of older agricultural infrastructure has been destroyed or modified by 19th and 20th century activities.

Site 7733, a buried 19th century *lo'i* soil, is significant under Criterion d (HAR §13-284-6) and Criterion D (NRHP). The agricultural soil relates to *lo'i* in production during the first half of the 19th century, and as such documents the last stage of traditional agriculture in the valley before the significant changes initiated by commercial agriculture.

Site 7734, a buried 19th century *lo'i* soil, is significant under Criterion d (HAR §13-284-6) and Criterion D (NRHP). The agricultural soil relates to *lo'i* in production during the first half of the 19th century, and as such documents the last stage of traditional agriculture in the valley before the significant changes initiated by commercial agriculture.

RECOMMENDATIONS

The stream restoration project is anticipated to have an adverse effect on the identified historic resources due to mechanical excavation or burial. The current level of documentation is recommended to be sufficient. However, in the event that new discoveries are made or otherwise significant characteristics of the sites are exposed during construction, mitigation in the form of archaeological monitoring (based on an approved Archaeological Monitoring Plan) is recommended during all ground-disturbing construction activities (see Table 13). Monitoring will also include educating the construction personnel about the presence of the archaeological site and the potential for additional discoveries.

Table 13. Punalu‘u Stream Restoration Project Sites, Significance Evaluations, and Recommended Actions.

Site (50-80-06-)	Form	State Significance	Federal (NRHP) Significance	Effect Determination	Recommended Action
7236	Historic irrigation network	a and d	A and D	Adverse effect	Monitoring
7718	Historic complex (concrete foundations and pond)	d	D	Adverse effect	Monitoring
7727	*Imu*	--	--	No adverse effect	None; site destroyed by excavation; data recovered
7728	Buried terrace and pondfield soil	d	D	Adverse effect	Monitoring; sample collection for radiocarbon dating, if possible
7733	Buried *lo‘i* soil	d	D	Adverse effect	Monitoring; sample collection for radiocarbon dating, if possible
7734	Buried *lo‘i* soil	d	D	Adverse effect	Monitoring; sample collection for radiocarbon dating, if possible

REFERENCES

Alexander, A.C.

1905 [map] Haleaha to Makaua, Koolauloa, Oahu. Traced from Private Map of J.B. Castle by F. Ohrt, Feb. 1906. Scale 200 feet=1 inch. Government Register Map 2343. In the files of the Hawaiʻi State Survey Office.

1907 [map] Map of Portion of Punaluu, Koolauloa, Oahu. Scale 200 feet=1 inch. Map 372, B.P. Bishop Estate. In the files of Kamehameha Schools.

Allen, Melinda S., Jennifer M. Huebert

2014 Short-Lived Plant Materials, Long-Lived Trees, and Polynesian ^{14}C Dating: Considerations for ^{14}C Sample Selection and Documentation. *Radiocarbon* 56:257-276.

Anonymous

1997 How to Complete the National Register Registration Form. *National Register Bulletin* 16A.

Barrera, William, Jr.

1984 *Punaluʻu, Oʻahu: Archaeological Survey at Proposed Well Locations*. Prepared for VTN Pacific. William Barrera, Jr., Honolulu.

Barrère, Dorothy B.

1994 The King's Mahele: the Awardees and their Lands. Ms. copy in the files of the State Historic Preservation Division, Department of Land and Natural Resources, Kapolei.

Bath, Joyce, and Marc Smith

1988 Burial Call from Pat's at Punaluu, Punaluu, Koolauloa, Oahu, TMK: 5-3-8:1 and 2. Memorandum on file at the Department of Land and Natural Resources, State Historic Preservation Division, Kapolei.

Bayman, James M.

2003 Stone Adze Economies in Post-Contact Hawaiʻi. In *Stone Tool Traditions in the Contact Era*, edited by Charles R. Cobb, pp. 94-108. The University of Alabama Press, Tuscaloosa and London.

2007 Ideology, Political Economy, and Technological Change in the Hawaiian Islands after AD 1778. *Indo-Pacific Prehistory Association Bulletin* 27: 3-11.

2009 Technological Change and the Archaeology of Emergent Colonialism in the Kingdom of Hawaiʻi. *International Journal of Historical Archaeology* 13:127-157.

Bishop, S.E.
1885a [map] Map of the Ahupuaas of Punaluu and Kaluanui in Koolauloa Oahu belonging to the Estate of Mrs. B.P. Bishop. Survey and map by S.E. Bishop. Scale 1:6000. Government Register Map 1500. In the files of the Hawaiʻi State State Survey Office.

1885b [map] Map of the Ahupuaas of Punaluu and Kaluanui in Koolauloa Oahu belonging to the Estate of Mrs. B.P. Bishop. Survey and map by S.E. Bishop. Scale 1:6000. Map Number 109. In the files of Kamehameha Schools.

1886 Testimony before the Commissioner of Boundaries for the Island of Oahu. February 24, 1886. Book 2:169-170. Microfilm, in the Hawaii State Archives.

Bronk Ramsey, Christopher
2009 Bayesian analysis of radiocarbon dates. *Radiocarbon* 51(1):337-360.

Chaney, A.S.
1918 [map] Hauula Forest Reserve, Koolauloa, Oahu. Government Register Map 2603. In the ffiles of the Hawaiʻi State Survey Office.

Chang, Toy Len, Arlene Lum, and Terry K. W. Luke
1988 Sailing for the Sun: The Chinese in Hawaiʻi 1789-1989. University of Hawaii Press, Honolulu.

Char, Tin Yuke, and Wai Jane Char
1988 Chinese Historic Sites and Pioneer Families of Rural Oahu. Hawaii Chinese History Center, Inc., Honolulu.

Chun, James
1983 *The Early Chinese in Punaluu*. Yin Sit Sha, Honolulu.

Colin, B.L., and H. Hammatt
2000 *Letter Report on the Disinterment of Two Human Burials at the Paniolo Café (TMK 5-3-01:52), Punaluʻu, Koʻolauloa District, Oahu. (SIHP # 50-80-06-5132)*. Cultural Surveys Hawaiʻi, Inc., Kailua.

Condè, J.C, and G.M. Best
1973 Sugar Trains: Narrow Gauge Rails of Hawaii. Glenwood Publishers, Felton, CA.

Cuddihy, Linda W., and Charles P. Stone
1990 Alteration of Native Hawaiian Vegetation. Effects of Humans, Their Activities and Introductions. University of Hawaii Cooperative National Park Resources Studies Unit, Honolulu.

Denison, David O.
1975 *An Archaeological Reconnaissance Survey of Punaluʻu Lands Punaluʻu, Oʻahu*. Prepared for Kaluanui Ventures. Department of Anthropology, Bernice P. Bishop Museum, Honolulu

Esgate, Thomas W., and Timothy Keesey
2011 Kamehameha Schools Punaluʻu Agricultural Lands, Soil and Water Conservation Plan, Punaluʻu, Oʻahu. Prepared for Kamehameha Schools.

Evening Bulletin
1897 Items from harbor front. *Evening Bulletin*, October 20, 1897, page 8. On-line at the Library of Congress Chronicling America website, www.chroniclingamerica. loc.gov.

Foote, Donald E., E. L. Hill, S. Nakamura, and F. 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. Government Printing Office, Washington, D.C.

Hammatt, H.H.
1994 *Archaeological Reconnaissance Survey of Punaluʻu Well III for Additional Installations, Punaluʻu, Koʻolauloa, Oʻahu TMK 5-3-07:14*. Prepared for CH2M Hill. Cultural Surveys Hawaiʻi, Inc., Kailua.

Hammatt, H. H., C.R. O'Hare, and D.W. Shideler
2013 *Archaeological Monitoring Report for the Kamehameha Schools Punaluʻu Beach Lots Project, Punaluʻu Ahupuaʻa, Koʻolauloa District, Oʻahu Island TMK: (1) 5- 3-001:001, 004, 006, 012, 017, 019, 020, 021, 025, 027, 028, & 036*. Cultural Surveys Hawaiʻi, Inc., Kailua, Hawaiʻi.

Handy, E.S. Craighill
1940 *The Hawaiian Planter.* Volume I. B.P. Bishop Museum Bulletin 161. The Museum, Honolulu.

Handy, E.S.C. and E.G. Handy. with M.K. Pukui
1972 *Native Planters in Old Hawaii: Their Life, Lore, and Environment*. Bishop Museum Bulletin 233. Bishop Museum Press, Honolulu.

Haraguchi, Karol
1987 *Rice in Hawaii. A Guide to Historical Resources*. Edited by Linda K. Menton. Humanities Program, State Foundation on Culture and the Arts, and the Hawaiian Historical Society, Honolulu.

ʻIʻi, John Papa
1959 *Fragments of Hawaiian History*. Bishop Museum Press, Honolulu. [1869 Hawaiian publication; translation by M.K. Pukui, edited by D.B. Barrère; reprinted in 1963].

Ilic, J.
1991 *CSIRO Atlas of Hardwoods*. Springer-Verlag, Berlin.

Indices of Awards
1929 *Indices of Awards Made by the Board of Commissioners to Quiet Land Titles in the Hawaiian Islands*. Compiled and published by the Office of the Commissioner of Public Lands of the Territory of Hawaii. Star-Bulletin Press, Honolulu.

Jourdane, Elaine

1995a Inadvertent Discovery of Human Remains at Paniolo Cafe, Punaluʻu, Oʻahu. Memorandum on file at the Department of Land and Natural Resources, State Historic Preservation Division, Kapolei. [Not seen.]

1995b Inadvertent Discovery of Skeletal Remains at 53-504 Kamehameha Hwy, Punaluʻu, Oʻahu. Memorandum on file at the Department of Land and Natural Resources, State Historic Preservation Division, Kapolei. [Not seen.]

Kam, Nadine

2007 Firmly planted. Villagers from Nam Long, China, cultivated rice paddies in Punaluu, and their descendants remain devoted to honoring that heritage. Star-Bulletin.com, Volume 12, Issue 28, January 28.

Kameʻeleihiwa, Lilikalā

1992 *Native Land and Foreign Desires; Pahea Lā E Pono Ai?* Bishop Museum Press, Honolulu.

Karpiel, Frank J.

1996 Theosophy, culture, and politics in Honolulu, 1890-1920. *Hawaiian Journal of History* 30:169-194.

Kawachi, Carol, and Marc Smith

1989 Burial Remains on "Pacific-Asian, Inc." Lands in Punaluʻu, Koʻolauloa, Oʻahu. Memorandum on file at the Department of Land and Natural Resources, State Historic Preservation Division, Kapolei.

Keaʻunui, L.M.

1915 Tradition of the Kaumakaulaula Temple, as Narrated for the Annual by Ben. Kaoao, of Punaluu. *Hawaiian Almanac and Annual for 1916*, pp. 92-95. Thos. G. Thrum, Honolulu.

Kennedy, Joseph

1992 *Survey of Proposed Well Location in the Ahupuaʻa of Punaluʻu, Koʻolauloa*. Prepared for Mink and Yuen, Inc. Archaeological Consultants of Hawaiʻi, Haleiwa.

2006 *A Report Concerning the Inspection of Two Land Areas Located in Punaluʻu Valley, Punaluʻu Ahupuaʻa Island of Oʻahu*. Prepared for Land Assets Division, Kamehameha Schools. Archaeological Consultants of the Pacific, Haleiwa.

KS (Kamehameha Schools)

2014 *Preliminary Draft Environmental Assessment. Punaluʻu Habitat Bank and Stream Restoration Project*. Prepared for U.S. Army Corps of Engineers, Honolulu District Regulatory Branch, Hawaiʻi Department of Land and Natural Resources, and City and County of Honolulu, Department of Planning and Permitting. Kamehameha Schools, Honolulu.

LaChance, Frederick, David W. Shideler, Hallett H. Hammatt

2014a *Archaeological Assessment for the Kamehameha Schools Punaluʻu Beach Lot 23, 53-097 Kamehameha Highway, Punaluʻu Ahupuaʻa, Koʻolauloa District, Island of Oʻahu; TMK: (1) 5-3-001:023*. Prepared for In+Form Design, Inc., and Kamehameha Schools. Cultural Surveys Hawaii, Inc., Kailua.

2014b *Archaeological Inventory Survey of the Kamehameha Schools Punaluʻu Beach Lot 29, 53-065 Kamehameha Highway, Punaluʻu Ahupuaʻa, Koʻolauloa District, Oʻahu Island; TMK: (1) 5-3-001:029*. Prepared for In+Form Design, Inc., and Kamehameha Schools. Cultural Surveys Hawaii, Inc., Kailua.

2014c *Archaeological Inventory Survey of the Kamehameha Schools Punaluʻu Beach Lot 31, 53-053 Kamehameha Highway, Punaluʻu Ahupuaʻa, Koʻolauloa District, Oʻahu Island; TMK: (1) 5-3-001:031*. Prepared for In+Form Design, Inc., and Kamehameha Schools. Cultural Surveys Hawaii, Inc., Kailua.

Livingston, Jeff

n.d. Koolau Railway. On-line at www.pacificng.com.

Lucas, P.F.

1995 A Dictionary of Hawaiian Legal Land-terms. Native Hawaiian Legal Corporation. University of Hawai`i Committee for the Preservation and Study of Hawaiian Language, Art and Culture. University of Hawai`i Press.

Lydgate, J.M.

1886 Overland distances. Island of Oahu. *Hawaiian Annual and Almanac for 1887*, pp. 14-15. Thomas G. Thrum, Honolulu.

Lyons, C.J.

1874 [map] Plane Table Sheet. Northeast Coast of Oahu. Government Register Map 760. In the files of the Hawaiʻi State Survey Office, Honolulu.

Maly, Kepā, and Onaona Maly

2005a *He Wahi Moʻolelo no Punaluʻu ma Koʻolauloa, Mokupuni ʻo Oʻahu – A Collection of Traditions, Historical Accounts and Kamaʻāina Recollections of Punaluʻu and Vicinity, Koʻolauloa, Island of Oʻahu*. Prepared for Kamehameha Schools. Kumupono Associates LLC, Hilo.

2005b Moʻolelo Ohana: Oral History Interviews with Kamaʻāina of the Punaluʻu Vicinity. Appendix A, K. Maly and O. Maly, *He Wahi Moʻolelo no Punaluʻu ma Koʻolauloa, Mokupuni ʻo Oʻahu – A Collection of Traditions, Historical Accounts and Kamaʻāina Recollections of Punaluʻu and Vicinity, Koʻolauloa, Island of Oʻahu*. Prepared for Kamehameha Schools. Kumupono Associates LLC, Hilo.

Matheson, R.O.
1908 Progress on Koolau side. New railroad promotes new agricultural industries. *Hawaiian Gazette*, January 7, 1908, pages 1 and 8. On-line at the Library of Congress Chronicling America website, www.chroniclingamerica.loc.gov.

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

McElroy, Windy K., and Steven Eminger
2013 [revised draft] *Archaeological Inventory Survey in Punaluʻu Ahupuaʻa, Koʻolauloa District, Island of Oʻahu*. Prepared for Kamehameha Schools. Keala Pono Archaeological Consulting, LLC, Kaneohe.

McElroy, Windy K., Carly Antone, and Steven Eminger
2011 *Archaeological Investigation of Punaluʻu, Koʻolauloa District, Island of Oʻahu; TMK (1) 5-3-011 (por.), -002 (por.), -003 (por.), -004 (por.), and -007 (por.)*. Prepared for Kamehameha Schools. Keala Pono Archaeological Consulting, LLC, Hauula.

Medical Examiner, Honolulu
1988 Medical Examiner's Report; Kamehameha Highway/Green Valley Road Burial. On file at Department of Land and Natural Resources, State Historic Preservation Division, Kapolei.

Mierzejewski, Abbey, Jon Tulchin, and Hallett H. Hammatt
2014 *Archaeological Monitoring Report for the Proposed Punaluʻu Beach Park Wastewater System Reconstruction Project, Punaluʻu Ahupuaʻa, Koʻolauloa District, Oʻahu; TMK: [1] 5-3-002:031 por*. Prepared for Kennedy/Jenks Consultants, Inc. Cultural Surveys Hawaiʻi, Inc., Kailua.

Monahan, Christopher M., and Malia K. Evans
2014 [draft] *Cultural Impact Assessment of Kamehameha Schools' Punaluʻu Stream Restoration Project, Punaluʻu Ahupuaʻa, Koʻolauloa District, Oʻahu Island, Hawaiʻi; TMK (1) 5-3-001:041; 5-3-003:001 (por.), 005, 009; 5-3-004:005, 007, 013, 018 (por.) & 019, 5-3-007:023 (por.); 5-3-011:001 (por.)*. Prepared for Kamehameha Schools. TCP Hawaiʻi, LLC, Kailua.

Munsell (Color)
2000 *Munsell Soil Color Charts.* Revised washable edition. GretagMacbeth, New Windsor, New York.

O'Hare, Constance R., Aulii Mitchell, David W. Shideler, and Hallett H. Hammatt
2005 *Archaeological Inventory Survey For Hanawao Heiau (Site 50-80-06-293) Pu'u, Punaluʻu Ahupuaʻa, Koʻolauloa District, Oʻahu*. Prepared for Board of Water Supply. Cultural Surveys Hawaiʻi, Inc., Kailua.

O'Hare, Constance R., David W. Shideler, and Hallett H. Hammatt

2007 *Archaeological Inventory Survey for Seven Kamehameha Schools Punalu'u Beach Lots Project, Punalu'u Ahupua'a, Ko'olauloa District, O'ahu Island, TMK: [1] 5-3-001:001, 015, 017, 020, 021, 027 & 028*. Prepared for Kober, Hansen, Mitchell Architects and Kamehameha Schools. Cultural Surveys Hawai'i, Inc., Kailua.

2008a *Addendum to an Archaeological Inventory Survey for Two Kamehameha Schools Punalu'u Beach Lots Project, Punalu'u Ahupua'a, Ko'olauloa District, O'ahu Island, TMK: [1] 5-3-001:012 and 019*. Prepared for Kober, Hansen, Mitchell Architects and Kamehameha Schools. Cultural Surveys Hawai'i, Inc., Kailua

2008b *An Addendum to an Archaeological Inventory Survey for Seven Kamehameha Schools Punalu'u Beach Lots Project, Punalu'u Ahupua'a, Ko'olauloa District, O'ahu Island Addressing Four Additional Lots, TMK: [1] 5-3-001:004, 006, 025, and 036*. Prepared for Kober, Hansen, Mitchell Architects and Kamehameha Schools. Cultural Surveys Hawai'i, Inc., Kailua.

2013 [preliminary final] Archaeological Monitoring Plan for Archaeological Resources Support for a Remediation Investigation/Feasibility Study (RI/FS) of the Pacific Jungle Combat Training Center FUDS, Punalu'u and Kahana Ahupua'a, Ko'olauloa District, Island of O'ahu. Prepared for Huikala, Inc. Cultural Surveys Hawai'i, Inc.

Paolello, J.M., David Shideler, and Hallett H. Hammatt

2012 *Archaeological Assessment for Kamehameha Schools Punalu'u Beach Lot 8 Project, 53-167 Kamehameha Highway, Punalu'u Ahupua'a, Ko'olauloa District, O'ahu Island TMK: [1] 5-3-001:008*. Prepared for In+Form Design, Inc., and Kamehameha Schools. Cultural Surveys Hawai'i, Inc. Kailua.

Parsons

2008 *Site Inspection Report, Pacific Jungle Combat Training Center, Island of Oahu, Hawaii*. Prepared for U.S. Army Corps of Engineers, Honolulu District, and U.S. Army Engineering and Support Center, Huntsville. Parsons, Norcross, Georgia.

Perzinski, David, and Hallett H. Hammatt

2004 *An Archaeological Monitoring Report for the Windward Mains 36" Waterline Replacement Project, Punalu'u and Kahana Ahupua'a, Ko'olauloa District, Island of O'ahu; TMK Zone 5: (Punalu'u) 5-3-01, 02, 04, 05 & 06; (Kahana) 5-2-05*. Prepared for Board of Water Supply. Cultural Surveys Hawai'i, Inc., Kailua, Hawai'i.

Pietrusewsky, Michael

1989 Human Remains on "Pacific-Asian, Inc." Property in Punaluu, Koolauloa, Oahu. M.E. No. 89-0792. State No. 50-80-06-4145. TMK: 5-3-03:01. Memorandum on file at the Department of Land and Natural Resources, State Historic Preservation Division, Kapolei.

Planters' Monthly

1887 The destruction of the forests. *The Planters' Monthly* VI:437-439. Published for the Planters' Labor and Supply Company of the Hawaiian Islands. Hawaiian Gazette Publishing Co., Honolulu.

Podmore, George

1923 [map] Estate of Bernice P. Bishop Showing Portion of Punaluu, Koolauloa, Oahu. L.C.A. 9971, R.P. 7804, Apana 25 to W.P. Leleiohoku. Scale 1 inch=200 feet. Map No. 1111, B.P. Bishop Estate. In the files of Kamehameha Schools.

Pukui, Mary Kawena

1983 ʻŌlelo Noʻeau, Hawaiian Proverbs and Poetical Sayings. Bishop Museum Press. Honolulu,

Pukui, Mary Kawena, and Samuel H. Elbert

1986 *Hawaiian Dictionary*. University of Hawaii Press, Honolulu.

Pukui, M.K., S.H. Elbert, and E.T. Mookini

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

Reimer, Paula J., Edouard Bard, Alex Bayliss, J. Warren Beck, Paul G. Blackwell, Christopher Bronk Ramsey, Caitlin E. Buck, Hai Cheng, R. Lawrence Edwards, Michael Friedrich, Pieter M. Grootes, Thomas P. Guilderson, Haflidi Haflidason, Irka Hajdas, Christine Hatté, Timothy J. Heaton, Dirk L. Hoffmann, Alan G. Hogg, Konrad A. Hughen, K. Felix Kaiser, Bernd Kromer, Stuart W. Manning, Mu Niu, Ron W. Reimer, David A. Richards, E. Marian Scott, John R. Southon, Richard A. Staff, Christian S.M. Turney, and Johannes van der Plicht

2013 IntCal 13 and Marine13 Radiocarbon Age Calibration Curves 0-50,000 Years Cal BP. *Radiocarbon* 55;1869-1887.

Rieth, Timothy M., and J. Stephen Athens

2013 Suggested Best Practices for the Application of Radiocarbon Dating to Hawaiian Archaeology. *Hawaiian Archaeology* 13:3-29.

Rock, J.

1974 *The Indigenous Trees of the Hawaiian Islands*. Charles E. Tuttle Co., Inc., Tokyo

Smith, Marc, Joyce Bath, and W. Bruce Masse

1988 Three Burials at 53-368 Kamehameha Highway, Waiʻono, Koʻolauloa, Oʻahu. Memorandum on file at the Department of Land and Natural Resources, State Historic Preservation Division, Kapolei.

Sterling, E.P. and C.C. Summers

1978 *Sites of Oahu*. Bishop Museum Press, Honolulu.

Thoene, A.W

1953 [map] *Estate of Bernice P. Bishop Showing the Makai Portion of Punaluu Koolauloa, Oahu*. Survey by A.W. Thoene, September 1953. Scale: 1 inch=100 feet. In the files of Kamehameha Schools, Honolulu.

1953 [map] *Estate of Bernice P. Bishop Showing the Mauka Portion of Punaluu Koolauloa, Oahu*. Survey by A.W. Thoene, September 1953. Scale: 1 inch=100 feet. In the files of Kamehameha Schools, Honolulu.

Thrum, Thomas G.

1908 Heiaus and heiau sites throughout the Hawaiian Islands. *Hawaiian Almanac and Annual for 1909*, pp. 38-43. Thos. G. Thrum, Honolulu.

1910 For Kahuku and beyond. Narrative of a day's outing by train. *Hawaiian Almanac and Annual for 1911*, pp. 128-133. Thos. G. Thrum, Honolulu.

1915 Completing Oahu's heiau search. *Hawaiian Almanac and Annual for 1916*, pp. 87-91. Thos. G. Thrum, Honolulu.

1923 More Hawaiian Folk Tales; a Collection of Native Legends and Traditions. A.C. McClurg & Co., Chicago.

Timmons, L.D.

1910 New cane plantation for Koolau districts. J.B. Castle and associates effecting combination with land holders between and including Heeia and Punaluu for the purpose of creating 6500 ton sugar estate—experts now at work. *The Hawaiian Star*, Final and Commercial News, July 9, 1910, page 5. On-line at the Library of Congress Chronicling America website, www.chroniclingamerica. loc.gov.

Townscape

2010 *Punalu'u Ahupua'a Plan. He 'Āina Momona 'o Punalu'u*. Prepared for the Land Assets Division, Kamehameha Schools. Townscape Inc.

Tulchin, J., and H. Hammatt

2006 *Addendum to Archaeological Inventory Survey For Hanawao Heiau (Site 50-80-06-293) Pu'u, Punalu'u Ahupua'a, Ko'olauloa District, O'ahu [TMK: (1) 5-3-03:001]*. Cultural Surveys Hawai'i, Inc., Kailua. [Not seen.]

Tulchin, J., D.W. Shideler, and H.H. Hammatt

2007 *Archaeological Literature Review and Field Inspection for the Punalu'u Farm Lots Project, Punalu'u Ahupua'a, Ko'olauloa District, O'ahu Island, TMK: [1] 5-3-005:007, 012, 025 & 026*. Cultural Surveys Hawai'i, Inc., Kailua. [Not seen.]

Turner, A.F.

1851 [map] Waiono and Makaua, Koolauloa, Oahu. Government Register Map 112. In the files of the Hawai'i State Survey Office.

1853 [map] Waiono and Makaua, Koolauloa, Oahu. Government Register Map 69. In the files of the Hawai'i State Survey Office.

U.S. Army Engineer District
1993 DERP-FUDS Inventory Project Report. Pacific Jungle Combat Training Center, Kahana and Punaluu Valleys, Island of Oahu, Hawaii. Site No. H09HI027400. U.S. Army Engineer District, Pacific Ocean Division, Fort Shafter, Hawaii.

U.S. Department of Agriculture Soil Survey Staff
1951 *Soil Survey Manual*. U.S. Government Printing Office, Washington, D.C.

1962 Supplement replacing *Soil Survey Manual* pp. 173-188. U.S. Government Printing Office, Washington, D.C.

Wagner, W.L., D.R. Herbst, and S.H. Sohmer
1990 *Manual of the flowering plants of Hawai'i*. 2 vols. University of Hawaii Press & Bishop Museum Press, Honolulu.

APPENDIX A.
TEST TRENCH SEDIMENT DESCRIPTIONS AND SUMMARIES

Trench	Layer	Layer Depths (cm bs)	Description	Interpretation
1	Ia	0-20	Very dark grayish brown (10YR 3/2) loam; weak structure, medium subangular blocky peds; moist consistence: friable, wet consistence: slightly sticky, slightly plastic; roots common; abrupt smooth lower boundary	A Horizon
	IIa	0-20	Very dark brown (10YR 2/2) loam; moderate to strong coarse or thick angular blocky structure; moist consistence: firm; wet consistence: slightly sticky, plastic; 30% subrounded to subangular pebbles and cobbles; abrupt smooth lower boundary; cobble pebble path present at surface of trench	Fill
	IIIa	40-80	Very dark grayish brown (10YR 4/2) sandy loam; strong brown (7.5YR 5/6) distinct medium mottles common; weak fine crumb structure; moist consistence: loose, very friable, wet consistence: slightly sticky, slightly plastic; clear smooth lower boundary	Alluvial deposit
	IVa	30-150 (BOE)	Brown (10YR 4/3) clay; moderate coarse blocky structure; moist consistence: friable, wet consistence: sticky, plastic; clear irregular lower boundary	Disturbed alluvial deposit
	Va	80-155 (BOE)	Very dark grayish brown (10YR 3/2) loamy sand; moderate fine angular blocky crumb structure; moist consistence: very friable to friable, wet consistence: sticky, slightly plastic; clear wavy lower boundary	Stream deposit
	Vb	80-145 (BOE)	Very dark grayish brown (10YR 3/2) loamy sand; moderate fine angular blocky crumb structure; moist consistence: very friable to friable, wet consistence: sticky, slightly plastic; 80% subrounded to subangular granules to cobbles	Alluvial deposit
2	Ia	0-30	Dark brown (10YR 3/3) silty clay; weak to moderate medium to coarse angular blocky structure; moist consistence: very friable to friable; wet consistence: slightly sticky, slightly plastic; very fine to coarse roots common; abrupt smooth lower boundary	A Horizon
	VIa	30-100	Dark yellowish brown (10YR 3/4) clay; weak to moderate fine to medium single grain subangular blocky structure; moist consistence: friable; wet consistence: slightly sticky, slightly plastic; abrupt wavy lower boundary	Flood deposit
	VIb	45-90	Dark yellowish brown (10YR 3/4) silty clay; weak to moderate fine to medium single grain subangular blocky structure; moist consistence: friable; wet consistence: slightly sticky slightly plastic; 70-95% rounded to subrounded pebbles and cobbles, varying in places; abrupt wavy lower boundary	Flood deposit

Trench	Layer	Layer Depths (cm bs)	Description	Interpretation
	VIIa	40-120 (BOE)	Dark yellowish brown (10YR 3/4) silty clay; moderate fine to medium angular blocky structure; moist consistence: very friable; wet consistence: slightly sticky, slightly plastic; abrupt wavy lower boundary	Flood deposit
	VIIb	40-120 (BOE)	Dark yellowish brown (10YR 3/4) silty clay; moderate fine to medium angular blocky structure; moist consistence: very friable; wet consistence: slightly sticky, slightly plastic; 70-95% rounded to subrounded pebbles and cobbles; abrupt wavy lower boundary	Flood deposit
3	Ia	0-15	Very dark grayish brown (10YR 3/2) silt loam; moderate to strong medium subangular blocky structure; moist consistence: friable; wet consistence: slightly sticky, slightly plastic; very fine to fine roots common; clear smooth lower boundary	A Horizon
	IVb	15-100 (BOE)	Dark grayish brown (10YR 3/2) gravel and gravelly silty clay; weak to moderate fine to medium subangular blocky structure; moist consistence: very friableto friable; wet consistence: slightly sticky, slightly plastic; lower boundary descends below waterline	Natural alluvial deposit
4	Ia	0-15	Dark grayish brown (10YR 4/2) loam; structureless; moist consistence: loose, very friable; wet consistence: non sticky, non plastic; very fine to medium roots common; 5% subrounded to rounded pebbles; clear smooth lower boundary	A Horizon
	VIII	15-80 (BOE)	Dark brown (10YR 3/3) clay loam; moderate medium to very coarse granular crumb structure; moist consistence: friable; wet consistence: sticky, slightly plastic; 15% subrounded to rounded pebbles; moisture in layer increases with depth	Natural alluvial deposit
5	Ia	0-25	Dark brown (10YR 3/3) loam; structureless; moist consistence: loose; wet consistence: non sticky, non plastic; fine to medium roots common; 5% subrounded to rounded pebbles; clear smooth lower boundary	A Horizon
	VIII	25-100 (BOE)	Dark brown (10YR 3/2) clay loam; weak medium to very coarse granular crumb structure; moist consistence: very friable; wet consistence: slightly sticky, slightly plastic; 10% subrounded to rounded pebbles, cobbles, and boulders;moisture in layer increases with depth	Natural alluvial deposit
6	Ia	0-30	Dark brown (10YR 3/3) silty clay; moderate medium to coarse subangular blocky structure; moist consistence: very friable; wet consistence: slightly sticky, slightly plastic; fine to medium roots common; abrupt smooth lower boundary	A Horizon
	IVa	30-50	Dark brown (7.5 yr 3/3) silty clay, Strong brown (7.5YR 5/6) distinct medium mottles common; moderate coarse to very coarse subangular blocky structure; moist consistence: friable, firm; wet consistence: non sticky, slightly plastic; abrupt wavy lower boundary	Disturbed alluvial deposit

Trench	Layer	Layer Depths (cm bs)	Description	Interpretation
	IVb	50-165 (BOE)	Very dark grayish brown (10YR 3/2) silty clay; moderate medium , coarse angular blocky, subangular blocky sturcture; moist consistence: very friable, friable; wet consistence: slightly sticky, plastic	Natural alluvial deposit
	Vb	30-110 (BOE)	Dark brown (10yr 3/3) sandy loam; weak fine crumb structure; moist consistence: very friable to friable; wet consistence: slightly sticky, plastic; 70% subrounded to rounded granules, pebbles, cobbles, and boulders;	Alluvial deposit
7	IIb	0-50	Very dark grayish brown (10YR 3/2) sandy loam; moderate fine to medium angular blocky granular structure; moist consistence: firm; wet consistence: slightly sticky, slightly plastic; very fine to medium roots few to common; 5-20% subrounded to subangular pebbles and cobbles; abrupt smooth lower boundary	Fill
	IIc	25-40	Light olive brown (2.5Y 5/4) stones and very coarse sand; structureless; moist consistence: loose; wet consistence: non sticky, non plastic; many fine to coarse roots; 0-25% subrounded to subangular pebbles and cobbles; clear smooth lower boundary	Fill
	IVa	15-35	Very dark grayish brown (10 yr 3/2) silty clay loam , many dark reddish brown (5YR 3/3) fine distinct mottles; strong to medium blocky to angular blocky structure; moist consistence: friable; wet consistence: sticky, plastic;very fine to fine roots few to common; very few clay films on ped faces; 25-40% subrounded to subangular pebbles and cobbles; gradual wavy lower boundary	Disturbed alluvial deposit
	VIII	60-140 (BOE)	Dark reddish brown (5YR 3/3) clay loam; many reddish brown (5YR 4/6) fine prominent mottles; moderate fine to medium platy structure; moist consistence: friable; wet consistence: very sticky, very plastic; abrupt smooth lower boundary	Natural alluvial deposit
8	Ia	0-20	Dark brown (10YR 3/3) silty clay; moderate medium to coarse subangular blocky structure; moist consistence: very friable; wet consistence: slightly sticky, slightly plastic; fine to medium roots common; abrupt smooth lower boundary	A horizon
	IVa	20-70	Dark brown (7.5YR 3/3) silty clay; dark reddish brown (5YR 3/3) fine distinct mottles common; moderate fine to medium angular blocky structure; moist consistence: friable; wet consistence: slightly sticky, plastic; clear smooth lower boundary	Disturbed alluvial deposit
	IVb	20-120 (BOE)	Dark reddish brown (5YR 3/2) silty clay; dark reddish brown (5YR 3/3) fine distinct mottles common; moderate fine to medium angular blocky structure; moist consistence: friable; wet consistence: slightly sticky, plastic; clear smooth lower boundary	Natural alluvial deposit

Trench	Layer	Layer Depths (cm bs)	Description	Interpretation
	VIII	100-120 (BOE)	Brown (10YR 4/3) clay loam; dark reddish brown (5YR 3/3) fine faint mottles common; weak fine to medium angular blocky structure; moist consistence: friable; wet consistence: slightly sticky, plastic	Natural alluvial deposit
9	Ia	0-40	Dark brown (10YR 3/3) silty clay; moderate medium to coarse subangular blocky structure; moist consistence: very friable; wet consistence: slightly sticky, slightly plastic; fine to medium roots common; abrupt smooth lower boundary	A horizon
	IVa	30-130 (BOE)	Dark reddish brown (5YR 3/2) silty clay; dark reddish brown (5YR 3/3) fine distinct mottles common; moderate fine to medium angular blocky structure; moist consistence: friable; wet consistence: slightly sticky, plastic; clear smooth lower boundary	Disturbed alluvial deposit
	X	50-130 (BOE)	Very dark grayish brown (10YR 3/3) sandy clay loam; moderate, fine granular, crumb structure; moist consistence: friable; wet consistence: sticky, slightly plastic; >75 well rounded to rounded granules, pebbles, cobbles, and boulders	Stream deposit
10	IIIb	0-20	Veryt dark gray (10YR 3/1) silt loam; moderate medium to coarse angular blocky structure; moist consistence: firm; wet consistence: slightly sticky, plastic; abrupt smooth lower boundary	Possible Agriculture
	IVb	15-80	Dark gray (10YR 4/1) silty clay , dark yellowish brown (10YR 4/6) medium distinct mottles common; moderate fine to medium subangular blocky structure; moist consistence: very friable; wet consistence: slightly sticky, plastic	Natural alluvial deposit
	IX	60-120 (BOE)	Very dark gray (1Gley 4/n) clay; weak to moderate, very fine to fine, platy structure; moist consistence: very friable; wet consistence: slightly sticky, plastic	Agricultural
11	Ia	0-10	Dark brown (10YR 3/3) silty clay; moderate medium to coarse subangular blocky structure; moist consistence: very friable; wet consistence: slightly sticky, slightly plastic; fine to medium roots common; abrupt smooth lower boundary	A Horizon
	IVb	5-60	Very dark grayish brown (10YR 3/2) silty clay loam; many dark reddish brown (5YR 3/3) fine distinct mottles; strong medium blocky to angular blocky structure; moist consistence: friable; wet consistence: sticky and plastic; common very fine to fine root; very few thin clay films on ped faces; 25-40% rounded to sub rounded to sub angular pebbles and cobbles; gradual, wavy lower boundary	Natural alluvial deposit
	XI	10-120 (BOE)	Dark reddish brown (5YR 3/3) clay loam; many yellowish red (5YR 4/6) fine prominent mottles; moderate, fine to medium, platy structure; moist consistence: friable; wet consistence: very sticky, very plastic; abrupt, smooth lower boundary	Alluvial deposit

Trench	Layer	Layer Depths (cm bs)	Description	Interpretation
12	Ia	0-25	Dark brown (10YR 3/3) silty clay; moderate medium to coarse subangular blocky structure; moist consistence: very friable; wet consistence: slightly sticky, slightly plastic; fine to medium roots common; abrupt smooth lower boundary	A Horizon
	IIb	5-25	Very dark brown (10YR 3/2) sandy loam; moderate, fine to medium, angular, blocky, granular structure; moist consistence: firm; wet consistence: slightly sticky, slightly plastic; few to common, very fine to medium roots; 5-20% sub rounded to sub angular pebbles and cobbles; abrupt ,smooth lower boundary	Fill
	IIIb	10-110	Dark brown (7.5YR 3/2) silt loam; moderate, medium to coarse, angular blocky, granular structure; moist consistence: friable; wet consistence: slightly sticky, slightly plastic; few to common, very fine to fine roots; 5-15% well rounded to rounded to sub rounded pebbles and cobbles; clear, wavy lower boundary	Possible Agriculture
	VIII	45-100	Dark reddish brown (5YR 3/3) clay loam; many yellowish red (5YR 4/6) fine prominent mottles; moderate, fine to medium, platy structure; moist consistence: friable; wet consistence: very sticky, very plastic; abrupt, smooth lower boundary	Alluvial deposit
	X	50-150 (BOE)	Very dark grayish brown (10YR 3/3) sandy clay loam; moderate, fine granular, crumb structure; moist consistence: friable; wet consistence: sticky, slightly plastic; >75 well rounded to rounded granules, pebbles, cobbles, and boulders	
13	Ia	0-5	Dark brown (10YR 3/3) silty clay; moderate medium to coarse subangular blocky structure; moist consistence: very friable; wet consistence: slightly sticky, slightly plastic; fine to medium roots common; abrupt smooth lower boundary	A Horizon
	IIb	5-30	Very dark grayish brown (10YR 3/2) sandy loam; moderate, fine to medium, angular blocky, granular structure; moist consistence: firm; wet consistence: slightly sticky, slightly plastic; few to common, very fine to medium roots; 5-20% sub rounded to sub angular pebbles and cobbles; abrupt, smooth lower boundary	Fill
	IIc	20-30	Light olive brown (2.5Y 5/4) sand; structureless; moist consistence: loose; wet consistence: non sticky, non plastic; many, fine to coarse roots; 0-25% rounded to sub rounded to sub angular pebbles and cobbles; clear, smooth lower boundary	Fill
	IIIb	5-110	Dark brown (7.5YR 3/2) silt loam; moderate, medium to coarse, angular blocky, granular structure; moist consistence: friable; wet consistence: slightly sticky, slightly plastic; few to common, very fine to fine roots; 5-15% well rounded to rounded to sub rounded pebbles and cobbles; clear, wavy lower boundary	Possible Agriculture

Trench	Layer	Layer Depths (cm bs)	Description	Interpretation
	VIII	95-120 (BOE)	Dark reddish brown (5YR 3/3) clay loam; many, fine, prominent mottles 5 yr 4/6 (yellowish red); moderate, fine to medium, platy structure; moist consistence: friable; wet consistence: very sticky, very plastic; abrupt, smooth lower boundary	Natural alluvial deposit
	X	80-120 (BOE)	Very dark grayish brown (10YR 3/3) sandy clay loam; moderate, fine granular, crumb structure; moist consistence: friable; wet consistence: sticky, slightly plastic; >75 well rounded to rounded granules, pebbles, cobbles, and boulders	stream bed deposit
14	Ia	0-5	Dark brown (10YR 3/3) silty clay; moderate medium to coarse subangular blocky structure; moist consistence: very friable; wet consistence: slightly sticky, slightly plastic; fine to medium roots common; abrupt smooth lower boundary	A Horizon
	IIb	5-20	Very dark grayish brown (10YR 3/2) sandy loam; moderate, fine to medium, angular blocky, granular structure; moist consistence: firm; wet consistence: slightly sticky, slightly plastic; few to common, very fine to medium roots; 5-20% sub rounded to sub angular pebbles and cobbles; abrupt, smooth lower boundary	Fill
	IIc	5-50	Light olive brown (2.5Y 5/4) sand; structureless; moist consistence: loose; wet consistence: non sticky, non plastic; many fine to coarse roots; 0-25% rounded to sub rounded to sub angular pebbles and cobbles; clear, smooth lower boundary	Fill
	IVb	45-95	Very dark grayish brown (10YR 3/2) silty clay loam; many dark reddish brown (5YR 3/3) fine distinct mottles; strong, medium, blocky, angular blocky structure; moist consistence: friable; wet consistence: sticky, plastic; few to common, very fine to fine roots; very few, thin clay films on ped faces; 25-40% rounded to sub rounded to sub angular pebbles and cobbles; gradual wavy lower boundary	Natural alluvial deposit
	X	80-110	Very dark grayish brown (10YR 3/3) sandy clay loam; moderate, fine, granular, crumb structure; moist consistence: friable; wet consistence: sticky, slightly plastic; >75 well rounded to rounded granules, pebbles, cobbles, and boulders;	Stream bed deposit
	XI	95-125 (BOE)	Dark reddish brown (5YR 3/3) clay loam; many, fine, prominent mottles 5 yr 4/6 (yellowish red); moderate, fine to medium, platy structure; moist consistence: friable; wet consistence: very sticky, very plastic; abrupt, smooth lower boundary	Natural terrigenous deposit
15	IIb	0-35	Very dark grayish brown (10YR 3/2) sandy loam; moderate, fine to medium, angular blocky, granular structure; moist consistence: firm; wet consistence: slightly sticky, slightly plastic; few to common, very fine to medium roots; 5-20% sub rounded to sub angular pebbles and cobbles; abrupt, smooth lower boundary	Fill

Trench	Layer	Layer Depths (cm bs)	Description	Interpretation
	IVb	30-90	Very dark grayish brown (10YR 3/2) silty clay loam; many dark reddish brown (5YR 3/3) fine distinct mottles; strong, medium, blocky, angular blocky structure; moist consistence: friable; wet consistence: sticky, plastic; few to common, very fine to fine roots; very few, thin clay films on ped faces; 25-40% rounded to sub rounded to sub angular pebbles and cobbles; gradual, wavy lower boundary	Alluvial deposit
	XI	80-120 (BOE)	Dark reddish brown (5YR 3/3) clay loam; many yellowish red (5YR 4/6) fine prominent; moderate, fine to medium, platy structure; moist consistence: friable; wet consistence: very sticky, very plastic; abrupt, smooth lower boundary	Natural alluvial deposit
16	Ia	0-25	Dark brown (10YR 3/3) silty clay; moderate medium to coarse subangular blocky structure; moist consistence: very friable; wet consistence: slightly sticky, slightly plastic; fine to medium roots common; abrupt smooth lower boundary	A Horizon
	IIb	5-40	Very dark grayish brown (10YR 3/2) sandy loam; moderate, fine to medium, angular blocky, granular structure; moist consistence: firm; wet consistence: slightly sticky, slightly plastic; few to common, very fine to medium roots; 5-20% sub rounded to sub angular pebbles and cobbles; abrupt, smooth lower boundary	Fill
	IIc	15-30	Light olive brown (2.5Y 5/4) sand; structureless; moist consistence: loose; wet consistence: non sticky, non plastic; many, fine to coarse roots; 0-25% rounded to sub rounded to sub angular pebbles and cobbles; clear, smooth lower boundary	Fill
	IVb	30-100	Very dark grayish brown (10YR 3/2) silty clay loam; many dark reddish brown (5YR 3/3) fine distinct mottles; strong, medium, blocky, angular blocky structure; moist consistence: friable; wet consistence: sticky, plastic; few to common, very fine to fine roots; very few thin clay films on ped faces; 25-40% rounded to sub rounded to sub angular pebbles and cobbles; gradual, wavy lower boundary	Natural alluvial deposit
	VIII	70-120 (BOE)	Dark brown (10YR 3/3) clay loam; many yellowish red (5YR 4/6) fine prominent mottles; moderate, fine to medium, platy structure; moist consistence: friable; wet consistence: very sticky, very plastic; abrupt smooth lower boundary	Alluvial deposit
17	IIc	0-35	Light olive brown (2.5Y 5/4) sand; structureless; moist consistence: loose; wet consistence: non sticky, non plastic; many, fine to coarse roots; 0-25% rounded to sub rounded to sub angular pebbles and cobbles; clear, smooth lower boundary	Fill

Trench	Layer	Layer Depths (cm bs)	Description	Interpretation
	IVa	20-110	Very dark grayish brown (10YR 3/2) silty clay loam; many dark reddish brown (5YR 3/3) fine distinct mottles; strong, medium, blocky, angular blocky structure; moist consistence: friable; wet consistence: sticky, plastic; few to common, very fine to fine roots; very few thin clay films on ped faces; 25-40% rounded to sub rounded to sub angular pebbles and cobbles; gradual, wavy lower boundary	Disturbed alluvial deposit
	VIII	80-120 (BOE)	Dark brown (10YR 3/3) clay loam; many yellowish red (5YR 4/6) fine prominent mottles; moderate, fine to medium, platy structure; moist consistence: friable; wet consistence: very sticky, very plastic; abrupt, smooth lower boundary	Alluvial deposit
	IX	125-140 (BOE)	Dark greenish gray (Gley1 3/10) clay; many yellowish red (5YR 4/6) fine distinct mottles; moderate, fine to medium, platy structure; moist consistence: very friable; wet consistence: very sticky, very plastic	Agricultural
18	Ia	0-15	Black (10YR 2/1) silty clay loam; moderate, medium, subangular blocky structure; moist consistence: firm; wet consistence: slightly sticky, slightly plastic; few, very fine to fine roots; gradual, smooth lower boundary	A Horizon
	IVb	15-80	Dark brown (7.5YR 3/2) silty clay; strong brown (7.5YR 4/6) medium distinct mottles common; moderate, medium, subangular blocky structure; moist consistence: friable; wet consistence: slightly sticky, plastic; gradual, smooth lower boundary	Natural alluvial deposit
	IX	80-130 (BOE)	Dark gray (10YR 4/1) silty clay, clay; moderate, medium, blocky structure; moist consistence: friable; wet consistence: sticky, plastic	Agricultural
19	Ia	0-10	Dark brown (10YR 3/3) silty clay; moderate medium to coarse subangular blocky structure; moist consistence: very friable; wet consistence: slightly sticky, slightly plastic; fine to medium roots common; abrupt smooth lower boundary	A Horizon
	IVa	10-70	Dark brown (10YR 3/3) clay loam; many yellowish red (5YR 4/6) fine, prominent mottles; moderate, fine to medium, platy structure; moist consistence: friable; wet consistence: very sticky, very plastic; abrupt, smooth lower boundary	Disturbed alluvial deposit
	X	25-140 (BOE)	Very dark grayish brown (10YR 3/3) sandy clay loam; moderate, fine, granular, crumb structure; moist consistence: friable; wet consistence: sticky, slightly plastic; >75% well rounded to rounded granules, pebbles, cobbles, and boulders	Ditch deposit
20	IVa	0-25	Dark brown (10YR 3/3) clay loam; many yellowish red (5YR 4/6) fine prominent mottles; moderate, fine to medium, platy structure; moist consistence: friable; wet consistence: very sticky, very plastic; abrupt, smooth lower boundary	Disturbed alluvial deposit

Trench	Layer	Layer Depths (cm bs)	Description	Interpretation
	X	20-90 (BOE)	Very dark grayish brown (10YR 3/3) sandy clay loam; moderate, fine, granular, crumb structure; moist consistence: friable; wet consistence: sticky, slightly plastic; >75% well rounded to rounded granules, pebbles, cobbles, and boulders	Ditch deposit
21	IVa	0-40	Dark brown (10YR 3/3) clay loam; many, fine, prominent mottles 5 yr 4/6 (yellowish red); moderate, fine to medium, platy structure; moist consistence: friable; wet consistence: very sticky, very plastic; abrupt, smooth lower boundary	Disturbed alluvial deposit
	X	30-120 (BOE)	Very dark grayish brown (10YR 3/3) sandy clay loam; moderate, fine, granular, crumb structure; moist consistence: friable; wet consistence: sticky, slightly plastic; >75% well rounded to rounded granules, pebbles, cobbles, and boulders	Stream deposit
22	Ib	0-30	Black (5YR 2.5/1) sandy loam; moderate, medium, angular blocky structure; dry consistence: slightly hard; wet consistence: slightly sticky, plastic; few to common, fine to coarse roots; abrupt to clear, smooth to wavy lower boundary	A Horizon
	XIV	30-110 (BOE)	Very pale brown (10YR 8/2) very coarse sand, sand, loamy coarse sand; weak, fine, granular, crumb structure; moist consistence: slightly hard, very friable; wet consistence: slightly sticky, slightly plastic; few to common, fine to coarse roots; very abrupt, smooth and wavy lower boundary	Beach sand deposit
23	Ib	0-50	Black (5YR 2.5/1) sandy loam; moderate, medium, angular blocky structure; dry consistence: slightly hard; wet consistence: slightly sticky, plastic; few to common, fine to coarse roots; abrupt to clear, smooth to wavy lower boundary	A Horizon
	XIV	30-110 (BOE)	Very pale brown (10YR 8/2) very coarse sand, sand, loamy coarse sand; weak, fine, granular, crumb structure; moist consistence: slightly hard, very friable; wet consistence: slightly sticky, slightly plastic; few to common, fine to coarse roots; very abrupt, smooth to wavy lower boundary	Beach sand deposit
24	Ib	0-60	Black (5YR 2.5/1) sandy loam; moderate, medium, angular blocky structure; dry consistence: slightly hard; wet consistence: slightly sticky, plastic; few to common, fine to coarse roots; abrupt to clear, smooth to wavy lower boundary	A Horizon
	XIV	30-120 (BOE)	Very pale brown (10YR 8/2) very coarse sand, sand, loamy coarse sand; weak, fine, granular, crumb structure; moist consistence: slightly hard, very friable; wet consistence: slightly sticky, slightly plastic; few to common, fine to coarse roots; very abrupt, smooth to wavy lower boundary	Beach sand deposit
25	Ib	0-15	Dark brown (10YR 3/3) loam; moderate, medium, subangular blocky structure; moist consistence: friable; wet consistence: sticky, plastic; clear, smooth lower boundary	A Horizon

Trench	Layer	Layer Depths (cm bs)	Description	Interpretation
	IIIa	0-50	Very dark brown (7.5YR 2.5/2) sandy loam; weak, fine, granular, crumb structure; moist consistence: loose, very friable; wet consistence: non sticky, slightly plastic; clear, wavy lower boundary	Natural deposit
	XII	15-40	Very pale brown (10YR 7/3) very coarse sand, coarse sand (dry); structureless; dry consistence: loose; wet consistence: non sticky, non plastic; clear, smooth lower boundary	Beach sand deposit
	XIII	40-120	Brown (10YR 4/3) clay loam; weak, medium, angular blocky structure; moist consistence: friable; wet consistence: slightly sticky, slightly plastic; clear, smooth lower boundary	Fill or alluvial flood deposit
	XIV	80-120 (BOE)	Very pale brown (10YR 8/2) very coarse sand, coarse sand (dry); structureless; dry consistence: loose; wet consistence: non sticky, non plastic	Beach sand deposit

BOE = Base of excavation

APPENDIX B.
TEST TRENCH PROFILES

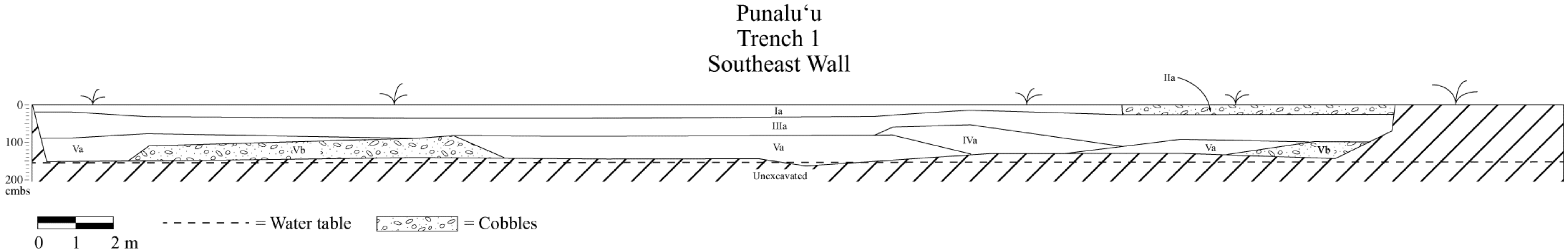


Figure 31. Southeast wall of Trench 1.

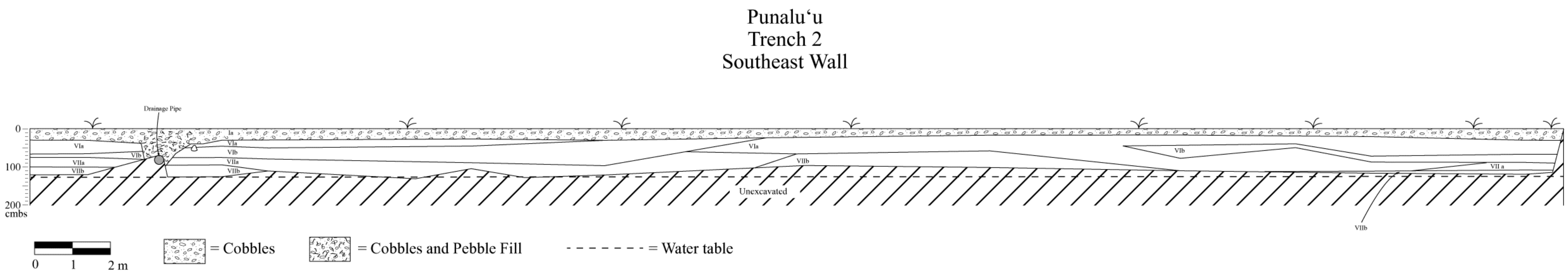


Figure 32. Southeast wall of Trench 2.

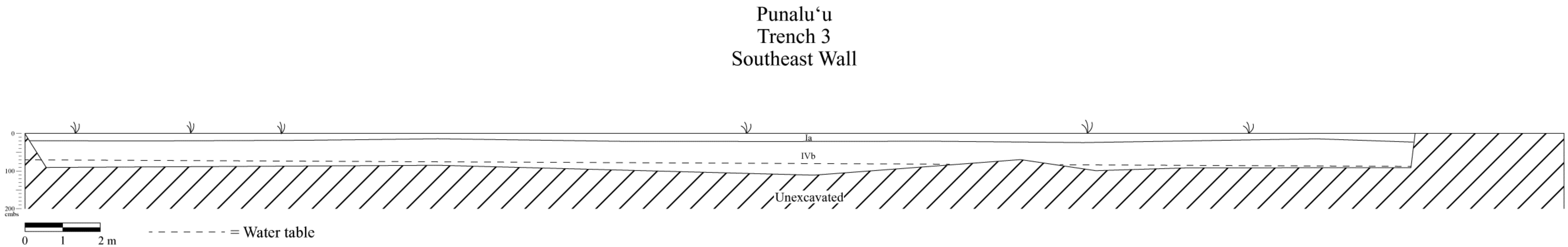


Figure 33. Southeast wall of Trench 3.

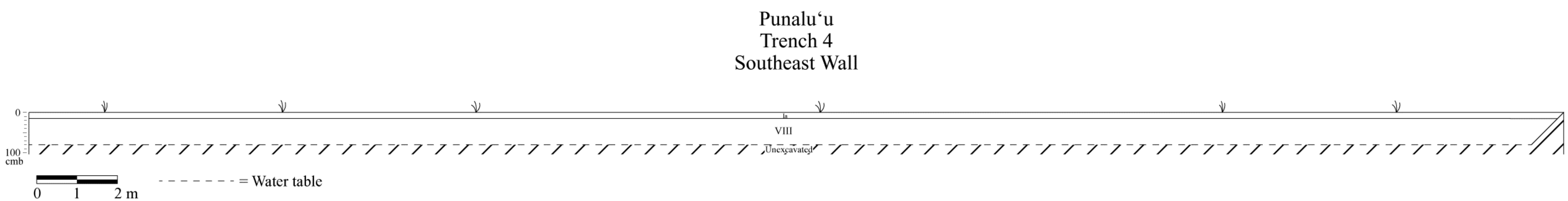


Figure 34. Southeast wall of Trench 4.

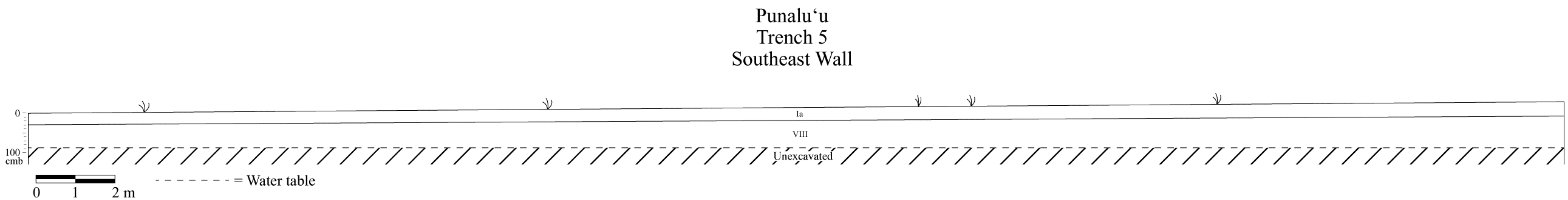


Figure 35. Southeast wall of Trench 5.

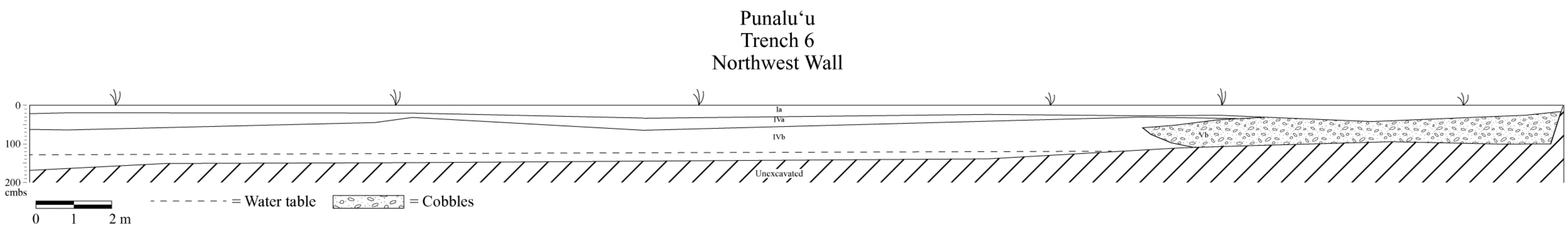


Figure 36. Northwest wall of Trench 6.

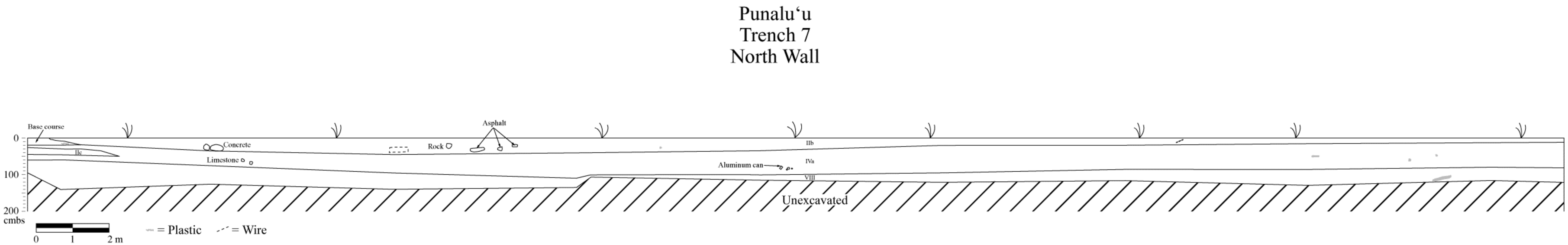


Figure 37. North wall of Trench 7.

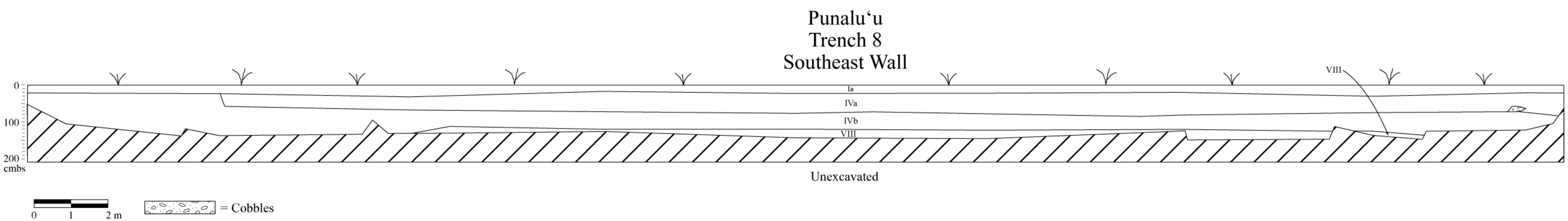


Figure 38. Southeast wall of Trench 8.

Punalu‘u
Trench 9
Northwest Wall

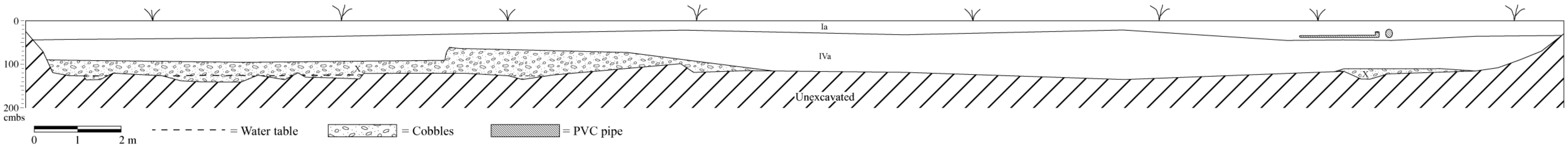


Figure 39. Northwest wall of Trench 9.

Punalu‘u
Trench 10
North Wall

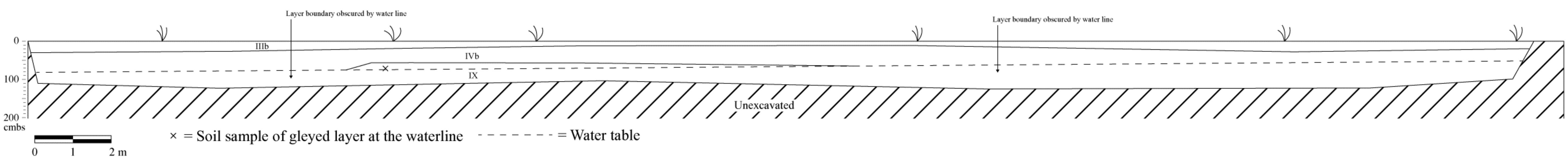


Figure 40. North wall of Trench 10.

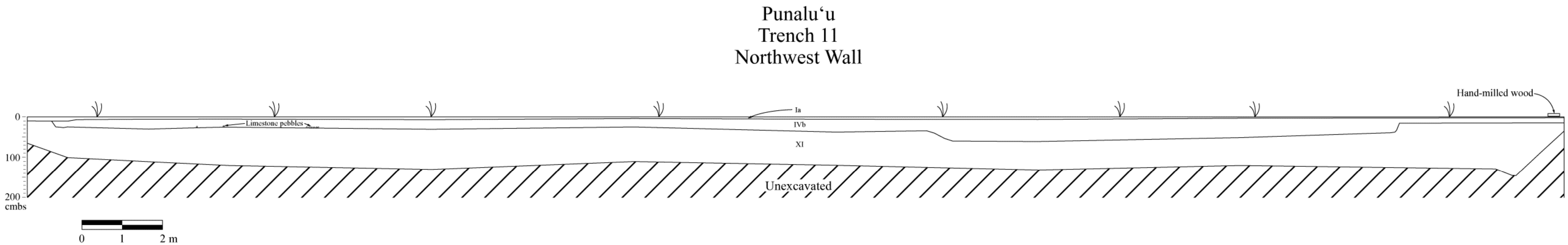


Figure 41. Northwest wall of Trench 11.

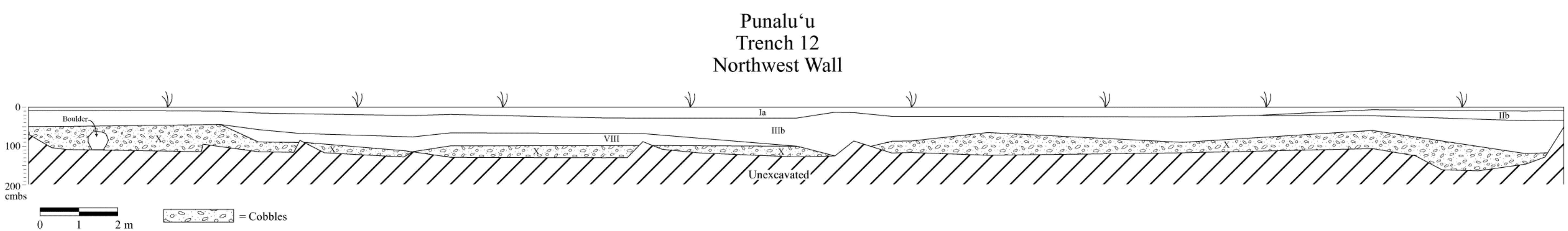


Figure 42. Northwest wall of Trench 12.

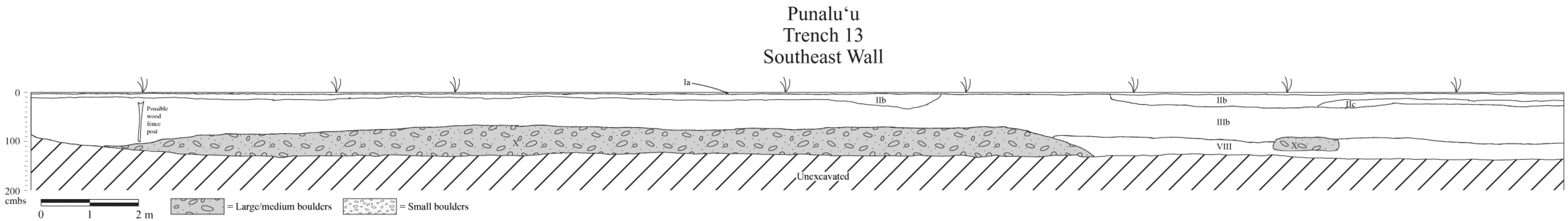


Figure 43. Southeast wall of Trench 13.

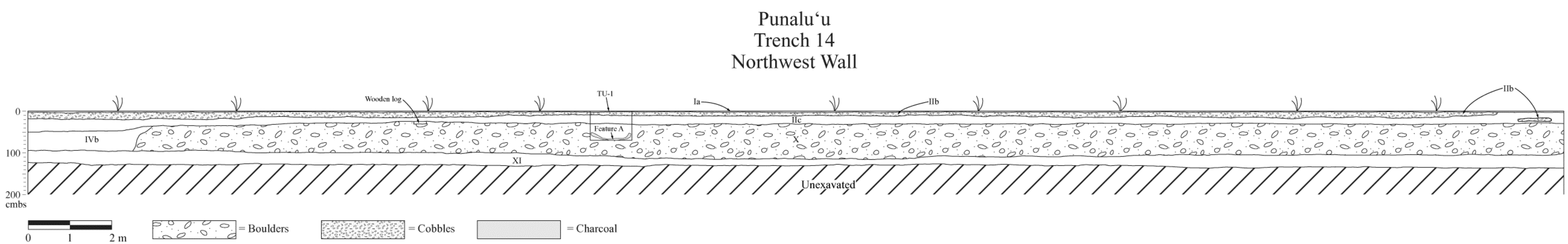


Figure 44. Northwest wall of Trench 14.

Punalu‘u
Trench 15
North Wall

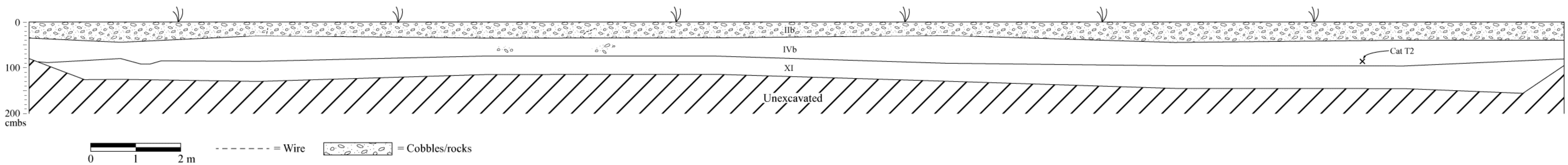


Figure 45. North wall of Trench 15.

Punalu‘u
Trench 16
North Wall

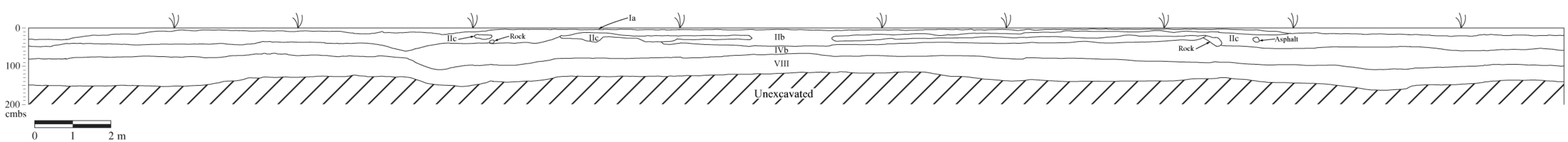


Figure 46. North wall of Trench 16.

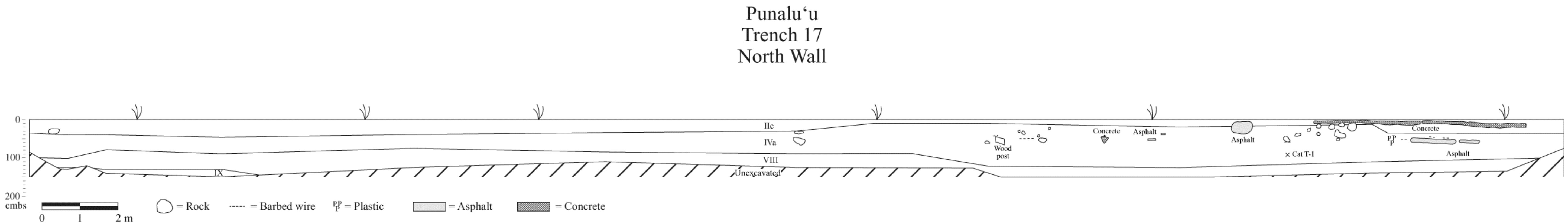


Figure 47. North wall of Trench 17.

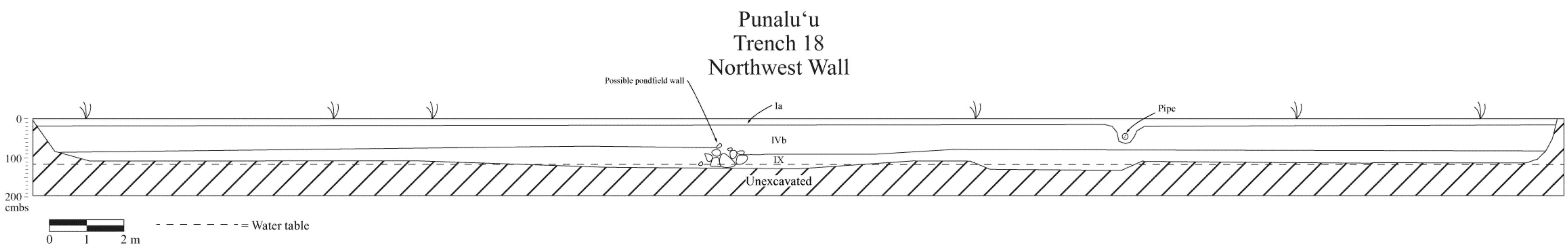


Figure 48. Northwest wall of Trench 18.

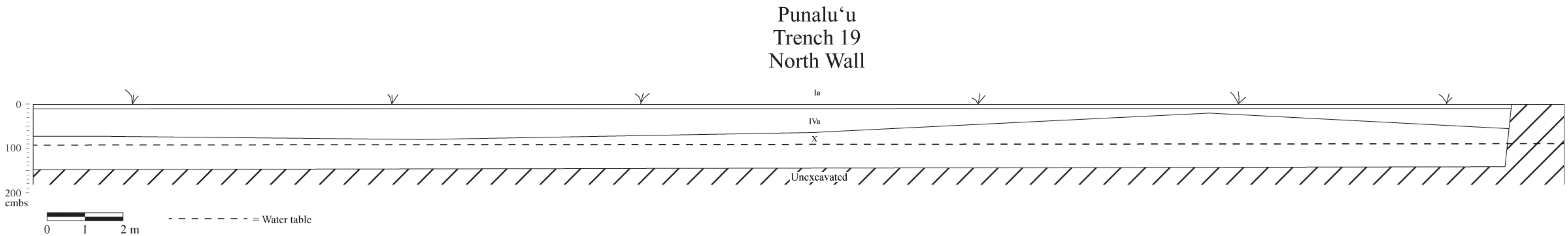


Figure 49. North wall of Trench 19.

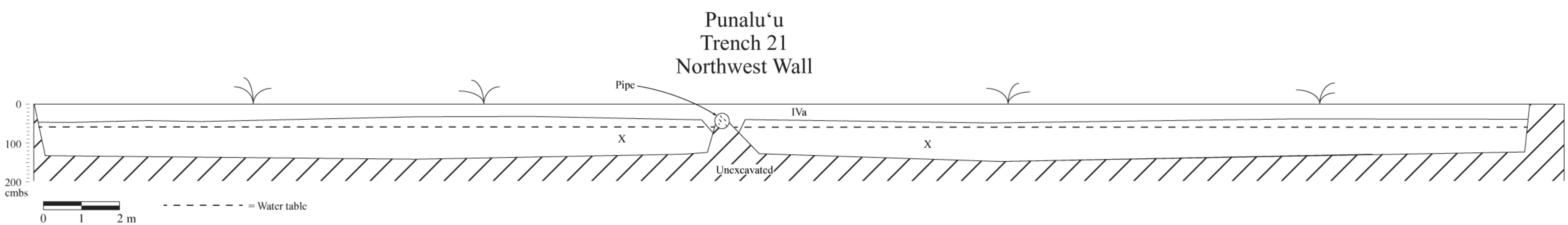


Figure 50. Northwest wall of Trench 20.

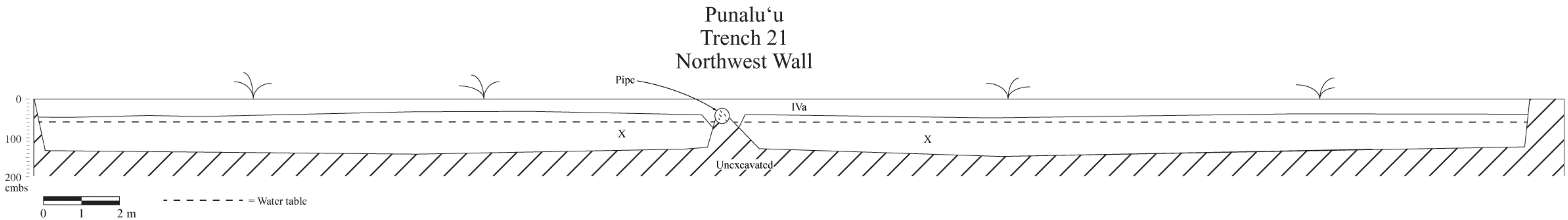


Figure 51. Northwest wall of Trench 21.

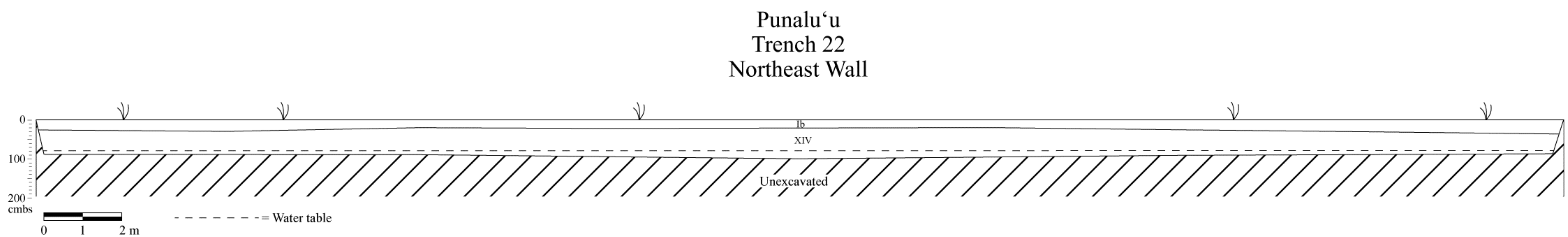


Figure 52. Northeast wall of Trench 22.

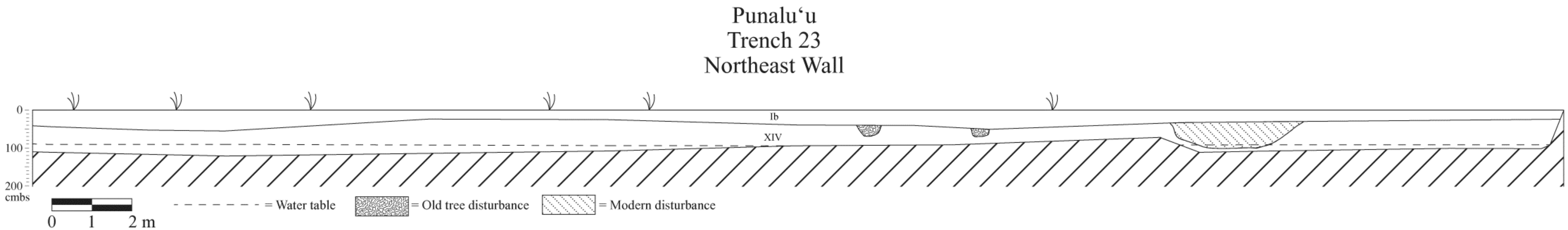


Figure 53. Northeast wall of Trench 23.

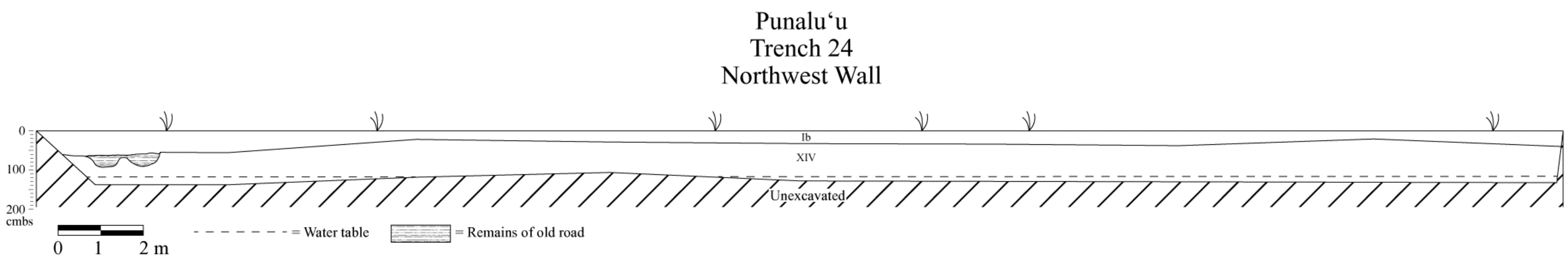


Figure 54. Northwest wall of Trench 24.

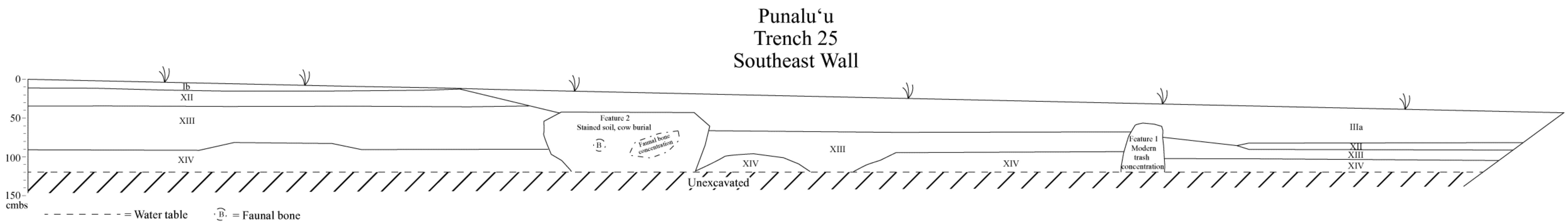


Figure 55. Southeast wall of Trench 25.

APPENDIX C.
RADIOCARBON RESULTS

Consistent Accuracy . . .
. . . Delivered On-time

Beta Analytic Inc.
4985 SW 74 Court
Miami, Florida 33155 USA
Tel: 305 667 5167
Fax: 305 663 0964
Beta@radiocarbon.com
www.radiocarbon.com

Darden Hood
President

Ronald Hatfield
Christopher Patrick
Deputy Directors

November 26, 2014

Dr. J. Stephen Athens
International Archaeological Research Institute, Incorporated
2081 Young Street
Honolulu, HI 96826-2231
USA

RE: Radiocarbon Dating Result For Sample 2014091420-1

Dear Dr. Athens:

Enclosed is the radiocarbon dating result for one sample recently sent to us. As usual, specifics of the analysis are listed on the report with the result and calibration data is provided where applicable. The Conventional Radiocarbon Age has been corrected for total fractionation effects and where applicable, calibration was performed using 2013 calibration databases (cited on the graph pages).

The web directory containing the table of results and PDF download also contains pictures, a cvs spreadsheet download option and a quality assurance report containing expected vs. measured values for 3-5 working standards analyzed simultaneously with your samples.

The reported result is accredited to ISO/IEC 17025:2005 Testing Accreditation PJLA #59423 standards and all pretreatments and chemistry were performed here in our laboratories and counted in our own accelerators here in Miami. Since Beta is not a teaching laboratory, only graduates trained to strict protocols of the ISO/IEC 17025:2005 Testing Accreditation PJLA #59423 program participated in the analysis.

As always Conventional Radiocarbon Ages and sigmas are rounded to the nearest 10 years per the conventions of the 1977 International Radiocarbon Conference. When counting statistics produce sigmas lower than +/- 30 years, a conservative +/- 30 BP is cited for the result.

When interpreting the result, please consider any communications you may have had with us regarding the sample. As always, your inquiries are most welcome. If you have any questions or would like further details of the analysis, please do not hesitate to contact us.

The cost of the analysis was charged to the MASTERCARD card provided. Thank you. As always, if you have any questions or would like to discuss the results, don’t hesitate to contact me.

Sincerely,

Darden Hood
Digital signature on file

BETA ANALYTIC INC.
DR. M.A. TAMERS and MR. D.G. HOOD
4985 S.W. 74 COURT
MIAMI, FLORIDA, USA 33155
PH: 305-667-5167 FAX:305-663-0964
beta@radiocarbon.com

REPORT OF RADIOCARBON DATING ANALYSES

Dr. J. Stephen Athens — Report Date: 11/26/2014

International Archaeological Research Institute, Incorporated — Material Received: 11/17/2014

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 396329	260 +/- 30 BP	-28.7 o/oo	200 +/- 30 BP

SAMPLE : 2014091420-1
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal AD 1650 to 1685 (Cal BP 300 to 265) and Cal AD 1730 to 1810 (Cal BP 220 to 140) and Cal AD 1925 to Post 1950 (Cal BP 25 to Post 0)

Dates are reported as RCYBP (radiocarbon years before present, "present" = AD 1950). By international convention, the modern reference standard was 95% the 14C activity of the National Institute of Standards and Technology (NIST) Oxalic Acid (SRM 4990C) and calculated using the Libby 14C half-life (5568 years). Quoted errors represent 1 relative standard deviation statistics (68% probability) counting errors based on the combined measurements of the sample, background, and modern reference standards. Measured 13C/12C ratios (delta 13C) were calculated relative to the PDB-1 standard.

The Conventional Radiocarbon Age represents the Measured Radiocarbon Age corrected for isotopic fractionation, calculated using the delta 13C. On rare occasion where the Conventional Radiocarbon Age was calculated using an assumed delta 13C, the ratio and the Conventional Radiocarbon Age will be followed by "*". The Conventional Radiocarbon Age is not calendar calibrated. When available, the Calendar Calibrated result is calculated from the Conventional Radiocarbon Age and is listed as the "Two Sigma Calibrated Result" for each sample.

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12 = -28.7 o/oo : lab. mult = 1)

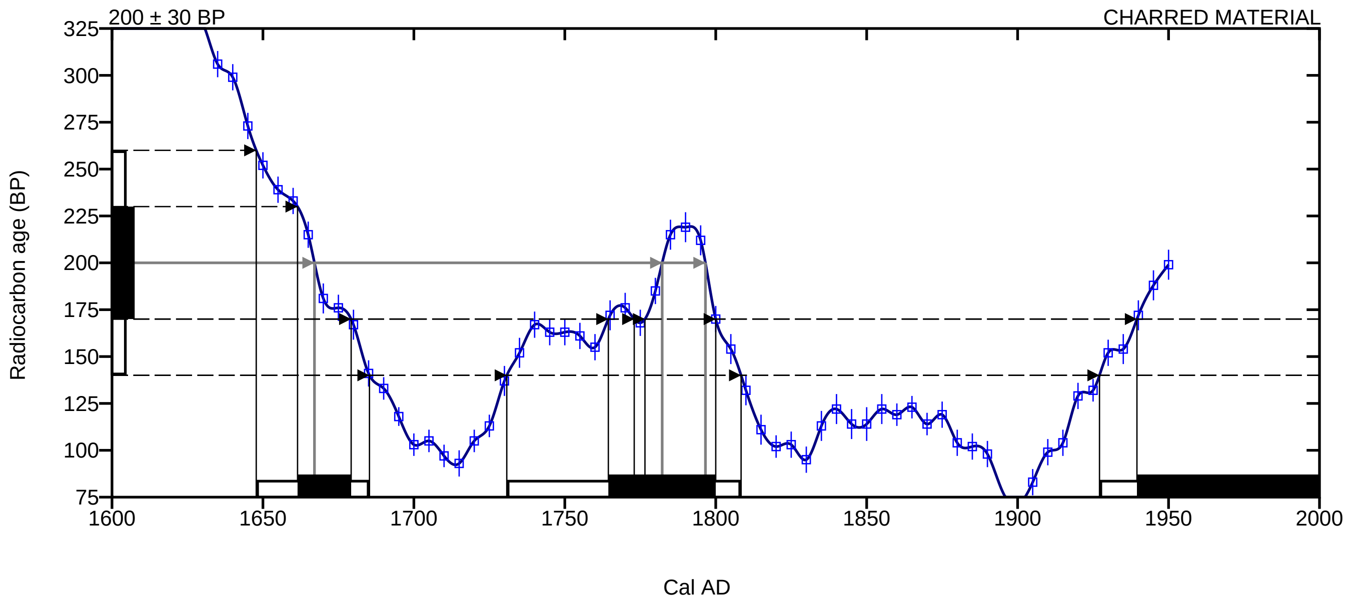
Laboratory number **Beta-396329**

Conventional radiocarbon age **200 ± 30 BP**

2 Sigma calibrated result 95% probability
Cal AD 1650 to 1685 (Cal BP 300 to 265)
Cal AD 1730 to 1810 (Cal BP 220 to 140)
Cal AD 1925 to Post 1950 (Cal BP 25 to Post 0)

Intercept of radiocarbon age with calibration curve
Cal AD 1665 (Cal BP 285)
Cal AD 1780 (Cal BP 170)
Cal AD 1795 (Cal BP 155)

1 Sigma calibrated results 68% probability
Cal AD 1660 to 1680 (Cal BP 290 to 270)
Cal AD 1765 to 1800 (Cal BP 185 to 150)
Cal AD 1940 to Post 1950 (Cal BP 10 to Post 0)



Database used
INTCAL13

References
Mathematics used for calibration scenario
A Simplified Approach to Calibrating C14 Dates, Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2):317-322
References to INTCAL13 database
Reimer PJ et al. IntCal13 and Marine13 radiocarbon age calibration curves 0–50,000 years cal BP. Radiocarbon 55(4):1869–1887.