KAWAI NUI STREAM FLOW RESTORATION

KAILUA, OAHU, HAWAI‘I

Preliminary Environmental Assessment

July 2016

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ACRONYMS AND ABBREVIATIONS

BMP	Best Management Practice(s)
CDUP	Conservation District Use Permit
CFS	cubic feet per second
CWA	Clean Water Act
CZM	Coastal Zone Management
DLNR	Department of Land and Natural Resources
EA	Environmental Assessment
ft	foot/feet
HDPE	High density polyetheline pipe – large capacity plastic water pipe
HEPA	Hawai‘i Environmental Protection Agency
HDOH	Hawai‘i Department of Health
KWS	Kailua Waterways System
MCF	Million Cubic Feet
MLLW	Mean Lower Low Water – locally established to ocean tides, = -0.30 ft MSL
MSL	Mean Sea Level – established to City’s survey base
NPDES	National Pollution Discharge Elimination System
PVC	Poly-vinyl chloride – plastic water pipe
SEM	Standard err from mean
SMA	Special Management Area
µg/m3	Micrograms per cubic meter
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
USGS	United State Geological Society
WQC	Section 401 of the CWA, State Water Quality Certification

General Information Summary

Applicant: City and County of Honolulu
Department of Facility Maintenance

Owner: Department of Land and Natural Resources
P.O. Box 373
Honolulu, Hawaii 96809

Consultant/Preparer: Oceanit Laboratories, Inc.
828 Fort Street Mall, Suite 600
Honolulu, Hawaii 96813

Approving Agency: Department of Land and Natural Resources
P.O. Box 373
Honolulu, Hawaii 96809

Project Description: The project is located in Kailua on the windward side of Oahu. The purpose of the proposed structure is to restore partial water flow from the Kawai Nui Marsh to the Kawai Nui Stream without increasing the flood threat to the area protected by the existing flood control levee. Kawainui Stream is part of the 142 acre Kailua Waterways System (KWS) that includes the ITT Wetland, Kawai Nui Stream, Hamakua Wetland, Kaelepulu Stream, Kaelepulu Pond, Kaelepulu Wetland and stream mouth to the ocean at Kailua Beach.

Historically, Kawai Nui Stream was part of the Kawai Nui Marsh (Marsh) and water from the Marsh flowed into KWS through Kawai Nui and Kaelepulu Streams before discharging into the ocean at the south end of Kailua Bay. Construction of the Oneawa Canal in 1952 and the 9,000 foot long flood protection levee, that separated Kawai Nui Stream from the Marsh, constructed in 1966, diverted the water from the Marsh directly to the north end of Kailua Bay. This deprived the KWS of the historical flow from the Marsh, changed the water quality of the system and also adversely impacted the stability of the stream mouth at Kailua Beach. Currently, the stream mouth is closed most of the time by a sand berm piled up by the waves which effectively blocks water exchange between KWS and the ocean. During dry weather, evaporation lowers the water level elevation of KWS and exposes submerged areas resulting in odor problems from rotting aquatic vegetation. During wet weather, runoff into KWS elevates the water level behind the sand berm causing flooding in low-lying roadways and residential areas. The City and County of Honolulu (City) mechanically cuts open the sand bar and allows the stream to release excess water to the ocean as a flood threat minimization measure.

A 3-month temporary flow restoration trial demonstrated that restoration of a small fraction (2 CFS) of the historical inflow from the Marsh to the KWS resulted in;

- increased circulation,
- increased stratification,
- enhanced wetland bird habitat,
- reduced the magnitude of water level variation in KWS and
- improved the efficacy of stream mouth ocean water exchange.

During the period when flow was restored there was also an absence of low-dissolved oxygen events, fish die-offs, avian botulism outbreaks, or any episodes of foul odors produced from the system in this highly urbanized area.

The selected preferred alternative project proposes to restore partial water flow from the Marsh to Kawai Nui Stream by installing a 12-inch diameter pipe around the south end of the existing Levee. This pipe is designed to convey 2 cubic feet per second (CFS) of water from the marsh to Kawai Nui Stream via the ITT Wetland.

Project Duration: The proposed project would take about 3 to 6 months for construction and would become a permanent added feature.

Project Location:
Koolaupoko Watershed
Kawai Nui Marsh and Kawai Nui Stream
Island of Oʻahu, Hawaiʻi
Tax Map Key: 4-2-016:015 (Kawai Nui Marsh) and,
4-2-016:013 (Kawai Nui Stream and adjacent lands)

State Land Use District: Conservation

County General Plan: Conservation

C&C Honolulu Zoning: Restricted Preservation District (P-1)

Anticipated Final Determination: Finding of No Significant Impact (FONSI)

Additional Information:
Gayson Ching, P.E.
Engineering Division
Department of Land and Natural Resources
P.O. Box 373
Honolulu, Hawaiʻi 96809

Agencies Consulted:

Federal
U.S. Army Corps of Engineers
U.S. Coast Guard
U.S.D.A. – Natural Resources Conservation Service
U.S. EPA-Pacific Islands Office
U.S. Fish & Wildlife
U.S. Geological Service
National Oceanic and Atmospheric Administration

State of Hawaiʻi
Department of Accounting and General Services
Department of Agriculture
Department of Business, Economic Development,
Tourism and Management - Office of Planning
Department of Education
Department of Hawaiian Home Lands
Department of Health, Environmental Planning Office
Department of Land and Natural Resources
Commission on Water Resource Management
Division of Aquatic Resources
Division of Boating and Oceanic Recreation
Division of Forestry and Wildlife
Land Division
Office of Conservation and Coastal Lands
State Historic Preservation Division
Department of Transportation, Highways Division
Office of Hawaiian Affairs

City and County of Honolulu
Board of Water Supply
Department of Community Services
Department of Design and Construction
Department of Environmental Services
Department of Facility Maintenance
Department of Parks and Recreation
Department of Planning and Permitting
Department of Transportation Services
Honolulu Fire Department
Honolulu Police Department
Kailua Neighborhood Board

1 Description of the Proposed Action

1.1 Introduction

The Department of Land and Natural Resources (DLNR) proposes to partially restore water flow to the Kailua waterways system (KWS) by gravity at a rate of 2 cubic feet per second (CFS) by installing a flow pipe between the Kawai Nui Marsh (Marsh) and Kawai Nui Stream.

The Marsh and Kawai Nui Stream have been separated from each other since 1966 by construction of the Kawai Nui Flood Control Levee (Levee). The proposed project area would extend from the pipe's inlet in the Marsh to the outlet terminating either in the ITT wetland or in the Kawai Nui Stream. Implementing the proposed project would restore aquatic ecosystem functions and services in KWS by improving water quality, increasing flow rates and circulation, decreasing residence time, enhancing wetland habitat within the downstream estuary and improving the ability of the City maintenance crews to open the stream mouth to effective tidal flow. The project proposed is planned to be constructed in the spring of 2019.

The project may have impacts on the Marsh, the flood control levee, Kawai Nui Stream, ITT Wetland, Hamakua Wetlands, Kaelepulu Stream, Kaelepulu Pond, and Kaelepulu Wetland. Department of Land and Natural Resources (DLNR) owns the Kawainui Marsh, the flood control levee and the Hamakua Wetland. The City owns Kawai Nui Stream and Kaelepulu Stream (Figure 1). The Kaelepulu Pond and Kaelepulu Wetland are privately owned. The tax map key numbers for this proposed project are 4-2-016:015 (the Marsh) and, 4-2-016:013 (Kawai Nui Stream and adjacent lands) (Figure 10). Although the City transferred ownership of the the Marsh and flood control levee to the State in 2008, from the viewpoint of the US Army Corps of Engineers (USACE), the City retains maintenance responsibility for the levee.

1.2 Purpose of this document

The purpose of this preliminary Environmental Assessment (PEA) is to provide information to decision makers and the public regarding the practicability and environmental advisability of installing a permanent water flow restoration structure between the Marsh and Kawai Nui Stream. This PEA reviews several alternatives (discussed in greater detail in the Engineering Report) to restore water flow, evaluates the likely environmental consequences, and recommends a preferred alternative for water transfer. This document also discusses: history of the project site; water quality challenges in the watershed; results of the water transfer experiment conducted in 2015; and likely impacts of implementing the preferred alternative.

If this project progresses forward then a complete EA will need to be prepared to also include Social, Economic, and Archaeological considerations not addressed in this PEA. The type of EA to be prepared will be dependent upon whether or not the proposed structure impacts other structures built by the USACE. The flood protection Levee and the Oneawa Canal are a part of the flood protection scheme designed by the USACE. It should be noted that if the project does not impact the Levee or Oneawa Canal, as determined by the USACE, an EA to satisfy Hawaii Revised Statutes (HRS) Chapter 343 EA is required. However, if the project impacts the Levee or Oneawa Canal, an EA to satisfy the the National Environmental Policy Act (NEPA) and a Section 408 permit will be required in addition to the Chapter 343 EA.

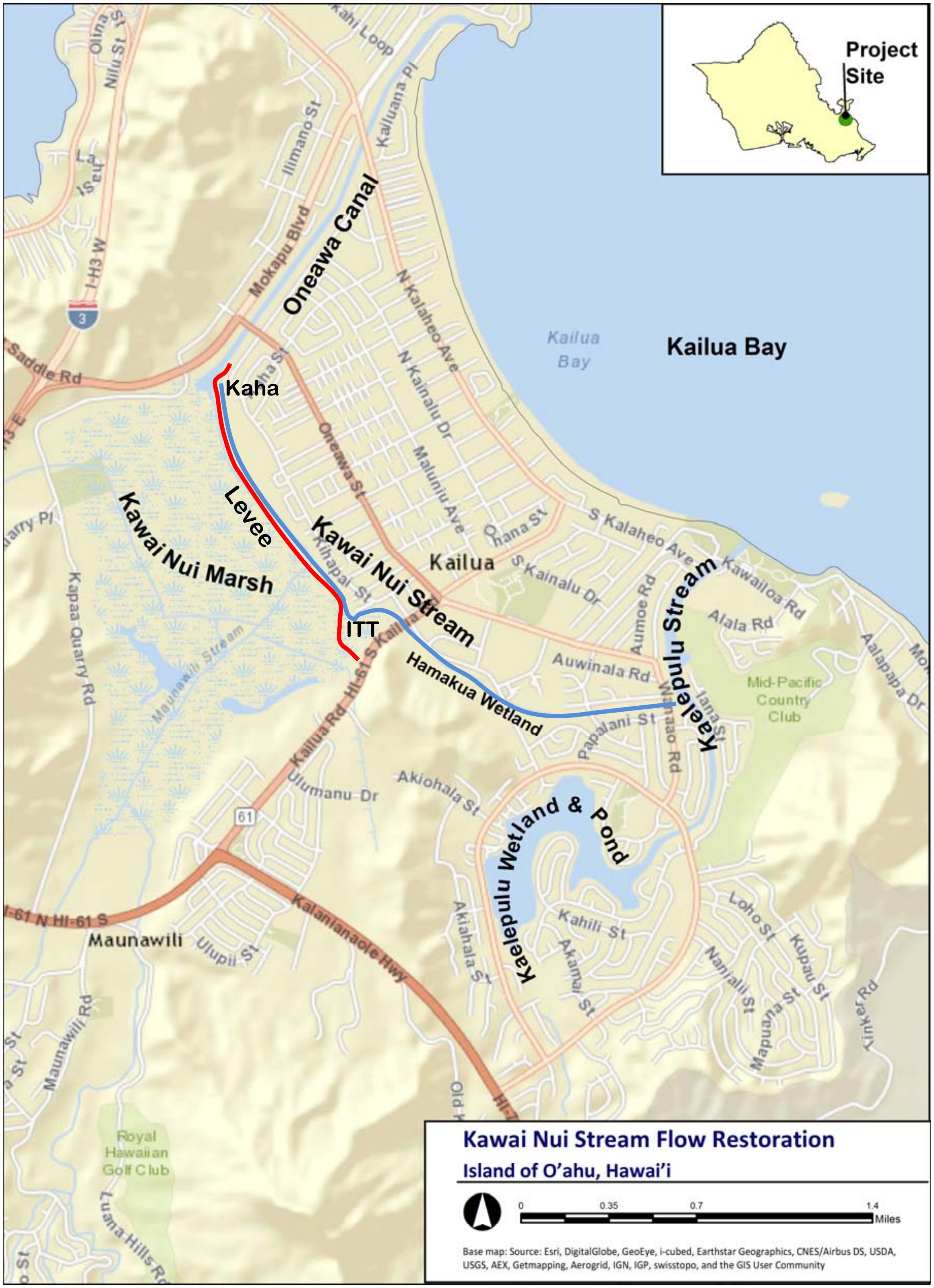

Figure 1. Map showing the Kailua Waterways and Kawai Nui flood control levee

1.3 Project Purpose and Need

The primary purpose of the project is to restore a portion of water flow to the Kawai Nui Stream that was blocked when the Levee was constructed. Construction of the Levee and Oneawa Canal diverted flow from the Marsh to the Oneawa Canal and to the north end of Kailua Bay. Prior to the construction of the Levee, the monthly average water flow from the Marsh to Kawai Nui Stream and the Kailua Waterway System (KWS) was about 28.5 million cubic feet (MCF) and the average monthly discharge from KWS to the south end of Kailua Bay was 30 MCF. The historic water balance of the Marsh and KWS is shown diagramatically in Figure 5. After construction of the Levee, and to the present day, flow from the Marsh to KWS was reduced to zero and flow from KWS to Kailua Bay reduced from 30 MCF to 1.5 MCF per month. The purpose of the project is to restore about 5 MCF of water per month (~2 CFS) from the the Marsh to KWS. This restored flow will improve water quality, ecology and seasonal stability of water level elevations while improving the ease of mechanical opening conducted by the City, and flow characteristics at the stream mouth.

Water flow restoration to KWS is needed to offset a trend towards eutrification resulting from reduced flow and increased urbanization experienced over the past half century. As a result of the decrease in headflow, resident time of water in KWS has increased approximately twenty-fold. The majority of the runoff to KWS now comes primarily from City storm drains from an increasingly urbanized watershed. During summer months, rainfall is not sufficient to offset evaporative losses in the KWS and water surface elevations fall, drying wetlands, releasing foul odors, and occasionally resulting in fish-kill episodes. Numerous studies of KWS have been conducted looking for sources of pollutants to the water, but none have addressed the lack of water flow to the system as a major contributing factor to poor water quality.

1.4 Project Background

Until 1952 Kaelepulu Stream provided the only outlet draining the 11,000 acre Kaelepulu watershed, which contained Kawai Nui (Figure 3). The streams flowing into the Marsh (Kapa`a, Maunawili and Kahanaiki) maintained an annual average flow rate of approximately 16 cubic feet per second (CFS) (USGS gage data, Figure 28). The Kawai Nui Stream combined with Kaelepulu Stream before discharging into the ocean across Kailua Beach. The long term average flow rate out of the mouth of Kaelepulu was about 11 CFS (30 MCF/mo.) (Figure 5). The difference in flows (16 CFS inflow vs 11 CFS outflow) is attributed to evaporative losses from the wetland and pond surfaces. The flow was sufficient to maintain a deep channel below the Lanikai Bridge and an open stream mouth across Kailua Beach during all but the driest months of summer (Turner-Devries, Morley, personal communication).

The Oneawa Canal was constructed in 1952 by the USACE to provide an alternate outlet for the Marsh to control flooding over the Coconut Grove area of Kailua. Flooding persisted however, and the 9,900 ft long 120-ft wide Levee was constructed in 1966 to control flooding impacting Kailua town. Flooding from the Marsh overtopped the levee on New Year's Eve in 1988 and prompted the USACE to increase the width of the levee to 200 feet and raise the height of the levee to include a 4-ft high concrete flood wall on the top (Figure 2, Figure 6). While construction of the levee reduced the threat of flooding, it created two separate watersheds; Kawai Nui (~7,500 acres), and Kaelepulu (3,450 acres) with separate outflows to Kailua Bay (Figure 4). This division has resulted in low water flow rates, water levels, and poor water quality in the 142-acre KWS, which includes the Kawai Nui Stream, Hamakua Wetlands, Kaelepulu Pond, Kaelepulu Wetland, and Kaelepulu Stream.

Lacking this natural flow, the stream mouth now requires manual opening to support flow and minimize flood threat caused when the sand bar builds to above the flood elevation. Presently, about 9 times a year, the City Department of Facility Maintenance, Roads Division, uses heavy equipment to remove sand built up in the stream and dig a channel through the berm obstructing flow to Kailua Bay. When the stream mouth is closed at the beach there is no flow to the ocean and any sediment and pollutant loads reaching KWS from surrounding areas remain in the KWS.

Kawai Nui Marsh is the largest remaining wetland in Hawai'i, encompassing approximately 894 acres. The Marsh is a habitat for introduced and indigenous aquatic wildlife, including four endangered species of native Hawaiian waterbirds. The U.S. Fish and Wildlife Service (USFWS) identifies the area as a waterbird recovery area and it is also recognized as a Ramsar Convention international site of ecological significance. The 142-acre KWS contains two important wetlands, Kaelepulu and Hamakua, both of which contain important breeding populations of three species of native Hawaiian waterfowl on the endangered species list.

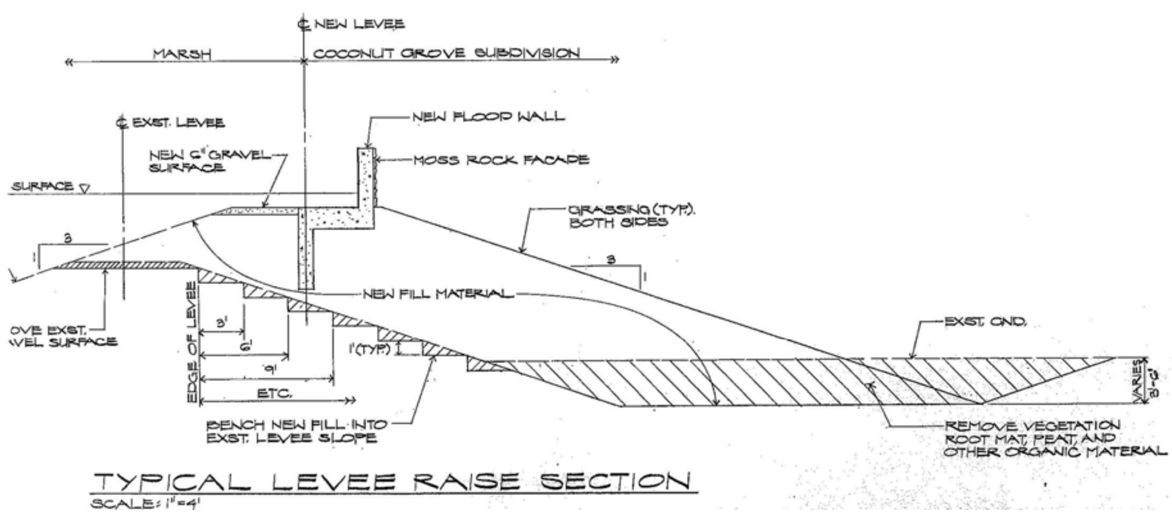

Figure 2. 1993 plan showing original 1966 levee height and width increased and topped with a 4-foot concrete flood wall in response to the 1989 flood that overtopped the levee.

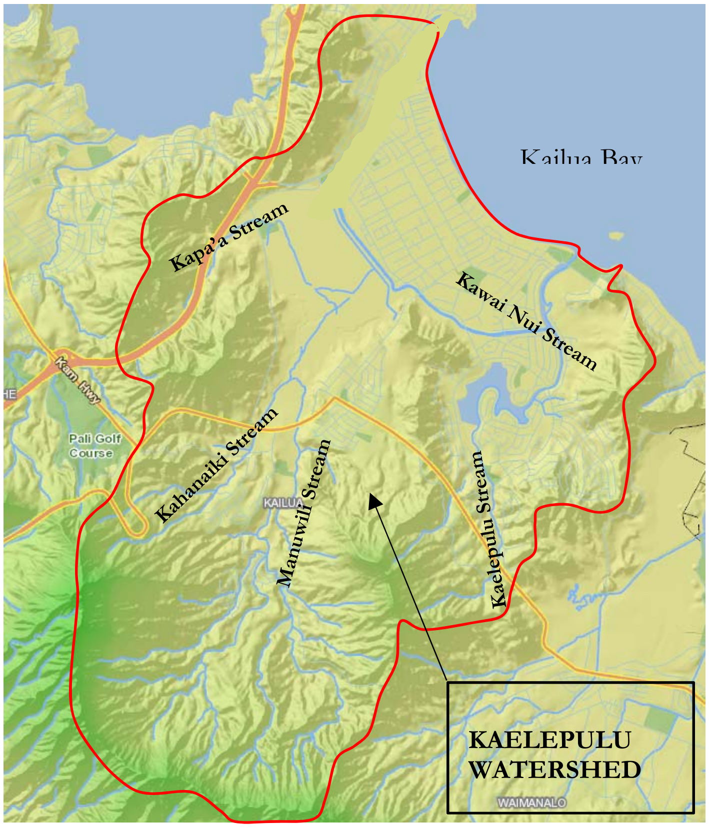

Figure 3 Prior to 1950, the Kaelepulu Watershed encompassed about 11,000 acres of land with a single outlet at the southern end of Kailua Bay.

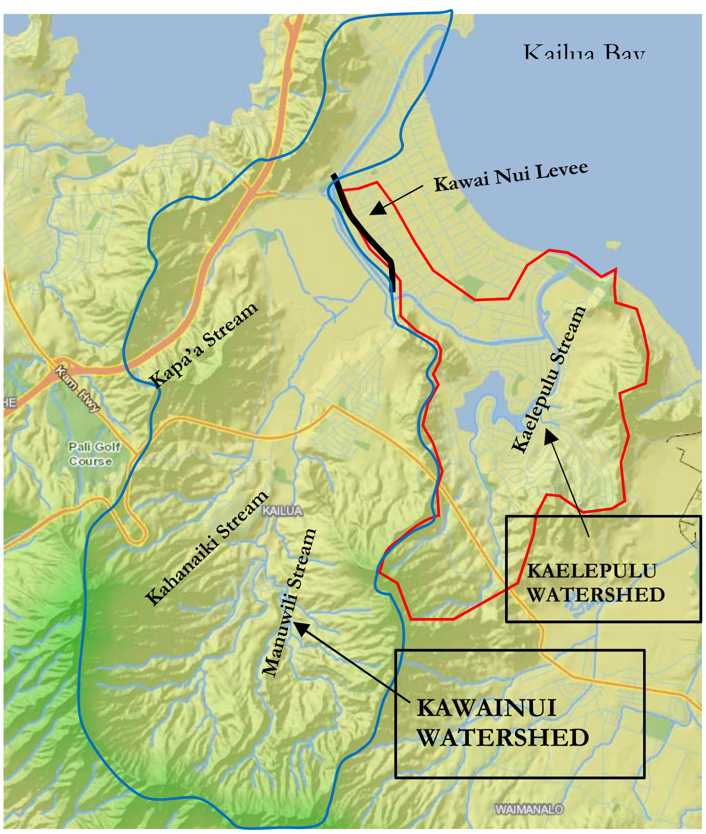

Figure 4 By 1966 the construction of the Kawai Nui Levee and the Oneawa Canal draining to the north end of Kailua Bay had created the new Kawai Nui Watershed. This divorced the Kaelepulu Watershed from the main source of its water flow.

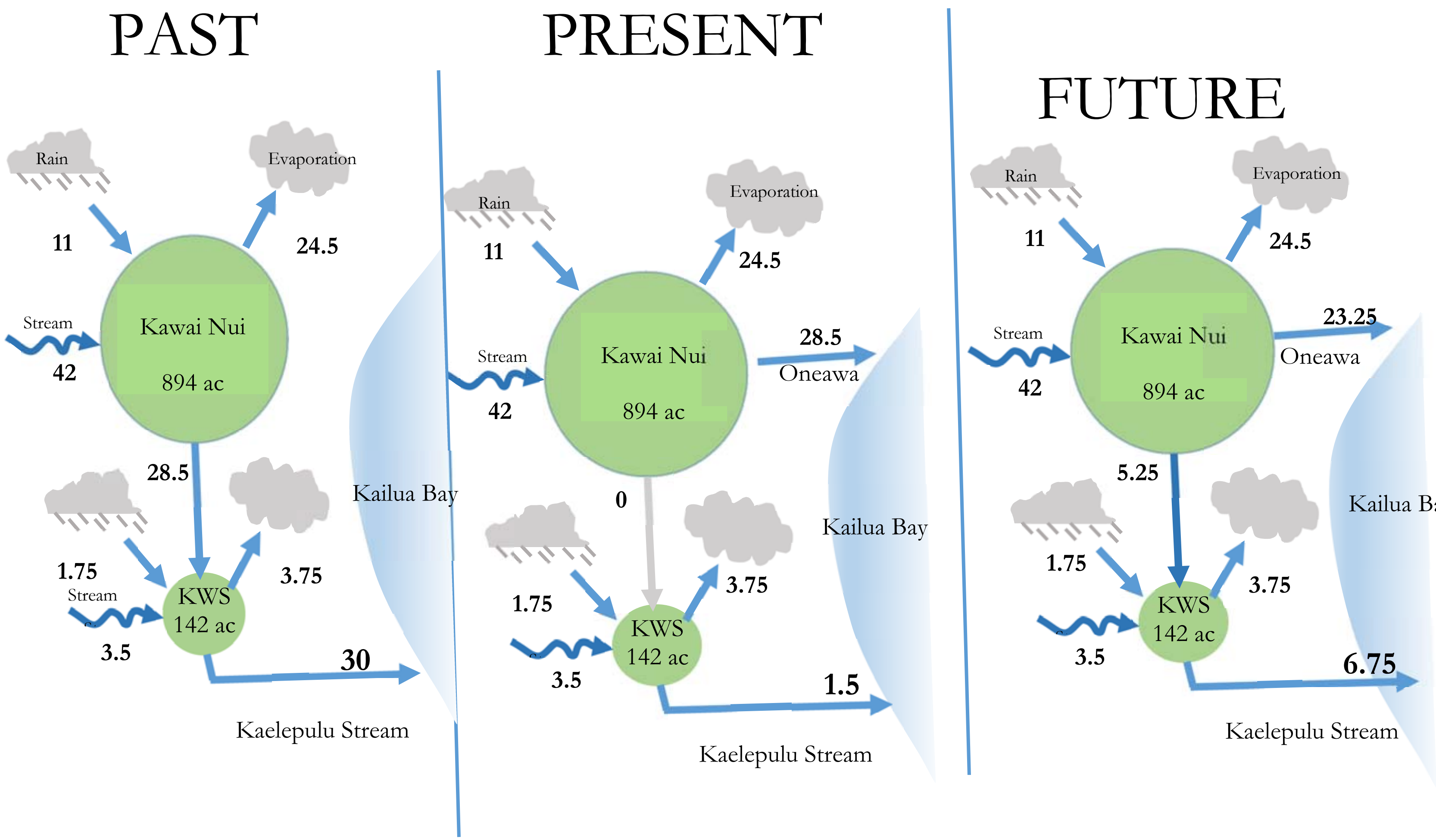

Figure 5 Monthly average flow of fresh water through the Kawai Nui and Kaelepulu systems in millions of cubic feet (MCF) per month prior to 1952 (left), after construction of the Oneawa Canal and flood control levee (center), and in the future if flow is restored as proposed (right).

Figure 6 Kawai Nui Levee:
Top: at northern terminus of Kawainui Stream looking across to Oneawa Canal

Middle: Station 14.00 at USGS gage.

Bottom: South end of levee at junction with Kailua Road

1.5 Previous Studies

1.5.1 General Watershed Studies

A number of studies have been conducted within the KWS during the past 25-years in an attempt to ascertain the extent and causes for flooding and poor water quality. Following reconstruction of the Levee, the City conducted a hydraulic study of the KWS to determine the flood carrying capacity of the system (ParEn, 1993). Results of the ParEn study are discussed in more detail in Section 4.4 (Flooding). As part of a larger study to understand whether or not the ocean outfall from the Kailua Waste Water Treatment Facility was contaminating the nearshore beach waters, the University of Hawaii investigated potential sources of bacterial contamination in the KWS (Roll and Fujioka, 1993). They showed that nearshore waters off Kailua Beach displayed concentrations of total phosphorus and bacterial levels (*Enterococcus*) elevated above State of Hawaii water quality standards when the Kaelepulu Stream mouth was open to flow. However, elevated Enterococcus bacterial concentrations were attributed to bacteria from birds (feral ducks and other waterbird populations) or soil, because tests for bacteria more specific to humans (*Clostridium sp.*) were negative. In 2003 the Kailua Bay Advisor Committee (KBAC) published their draft Kailua Waterways Improvement Plan (Tetra-Tech, 2003), in which the concept for restoration of flow from the Marsh to KWS was listed as a plan element. The KBAC plan was then modified to create the Koolaupoko Watershed Restoration Action Strategy (KBAC, 2007). A 2003-2004 survey of storm runoff to the pond concluded that a large portion of the sediment load to the pond was derived from open construction sites (Bourke, 2004).

In 2004, the KWS was placed on the State of Hawaii's list of "Water Quality Impaired Waterways" for perceived exceedance of nutrients (total phosphorous, total nitrogen) and turbidity. As a high priority watershed, the State Department of Health (DOH) instigated a Total Maximum Daily Load (TMDL) study that included investigations by Tamaru and Babcock (Sampling Plan Draft, 2005; Sample Plan Final, 2009; Progress Report, 2011), the USGS (Hunt, 2008), and a report to the legislature by the DOH (Penn, 2006). The USGS study tested for physical water quality parameters, nutrients, stable isotopes, 20 pharmaceuticals, and 10 waste indicator compounds at 27 stations throughout the entire KWS during a single dry weather sampling event. The only sewage indicator detected above laboratory detection limits was caffeine at three stations (two of which were adjacent to coffee shops). Tamaru and Babcock obtained surface samples from 80 sites on 14 occasions between June 2009 and December 2010. Comparing their results to the State of Hawaii water quality standard for "specific criteria for recreational areas" (HAR 11-54-5.2 and 11-54-8) they found that ammonia, chlorophyll-a and turbidity exceeded the geometric mean standard, but that total nitrogen, nitrate plus nitrite, total phosphorus, and Enterococcus bacterial counts were all within the water quality standards established by the State. Their data does show a very high degree of variability both between sample dates and between individual sample sites. This variability was attributed to different weather and runoff conditions between sampling dates, and to real differences in physical conditions between the various sample sites. A biological condition study conducted as part of the TMDL study (Tamaru and Babcock, 2011) found that ecosystem conditions within the Kawai Nui Branch of the system were very poor in almost every criteria ranked. The City initiated a study of the storm drain system of the watershed surrounding Kaelepulu Pond in an effort to develop storm drain best management plans (AECom, 2008) and then implemented a water quality monitoring program of these same drainage-ways (2014 (Cardno TEC, 2014).

Review of the above previous studies presents a consistent view of the problems associated with poor water quality in the KWS. Five principle constraints to water quality within the system have been identified (Bourke 2016):

1. Overgrowth of invasive mangrove within the KWS.
2. Presence of a submerged berm in Kaelepulu Stream that restricts internal circulation and limits mixing.
3. Uncontrolled pollutant loads from storm drains into the KWS
4. Limited and irregular water exchange with the ocean at the stream mouth.
5. Lack of headwater flow into Kawai Nui Stream.

1.5.2 Flow Restoration Experiment

To obtain information specific to the proposed project a 3-month flow restoration experiment was conducted. The purpose of the experiment was to determine the impact of the restored water flow upon the water quality and ecosystem quality within the KWS. In addition multiple stream mouth openings were monitored to better understand the opening dynamics that would lead to improved exchange during these events. In the experiment four 6-inch plastic pipe siphons were installed up and over the Levee (Figure 7). These pipes transferred 1 to 2 CFS water from the Marsh to Kawai Nui Stream between three stream mouth opening events from May to August 2015. The complete flow restoration experimental report is attached as Appendix B.

The restored flows were successful in raising the elevation of KWS between 4 to 7 inches (0.31 ft to 0.7 ft) during each of the three 4 week trials between stream mouth opening events. The restored flow was sufficient to more than offset water loss by evaporation during the hot summer months. Physical water quality was measured at multiple sites throughout the KWS before and after each opening event to help determine what happened to the restored water, its impact upon the water quality and general ecosystem conditions within the KWS.

The volume of water transferred during each of the three 1-month trials (~5 MCF) was about twice the volume of the Kawai Nui Stream branch of the KWS. Somewhat surprisingly, the restored water flow did not displace this stream volume however, but spread downstream along the surface into the Kaelepulu portion of the system (Figure 8). The continual addition of this flow tended to maintain stratification in the estuary between opening events. Because the added water tended to spread along the surface, there were no significant improvements to the low pH, high turbidity, and very low dissolved oxygen levels that typically occur within the Kawai Nui Stream. Given the thick canopy of mangrove and decades of organic mud deposition in this reach of the system, it is not surprising that the relatively low flow rate of 2 CFS was not able to make significant improvements to the physical water parameters along this reach of the system.

Raising the water surface elevation appeared to have a positive impact upon both the Kaelepulu and Hamakua wetlands. In contrast to previous years, during the 2015 summer when flow was restored, the wetlands remained inundated, there were no incidents of fish die-offs, no threat

Figure 7 Instalation of a temporary siphon flow restoration structure up and over the Kawai Nui Levee (top), with ramp to allow for pedestrian and vehical passage. The four pipes discharged about 2 CFS water into the Kawai Nui Stream (right).

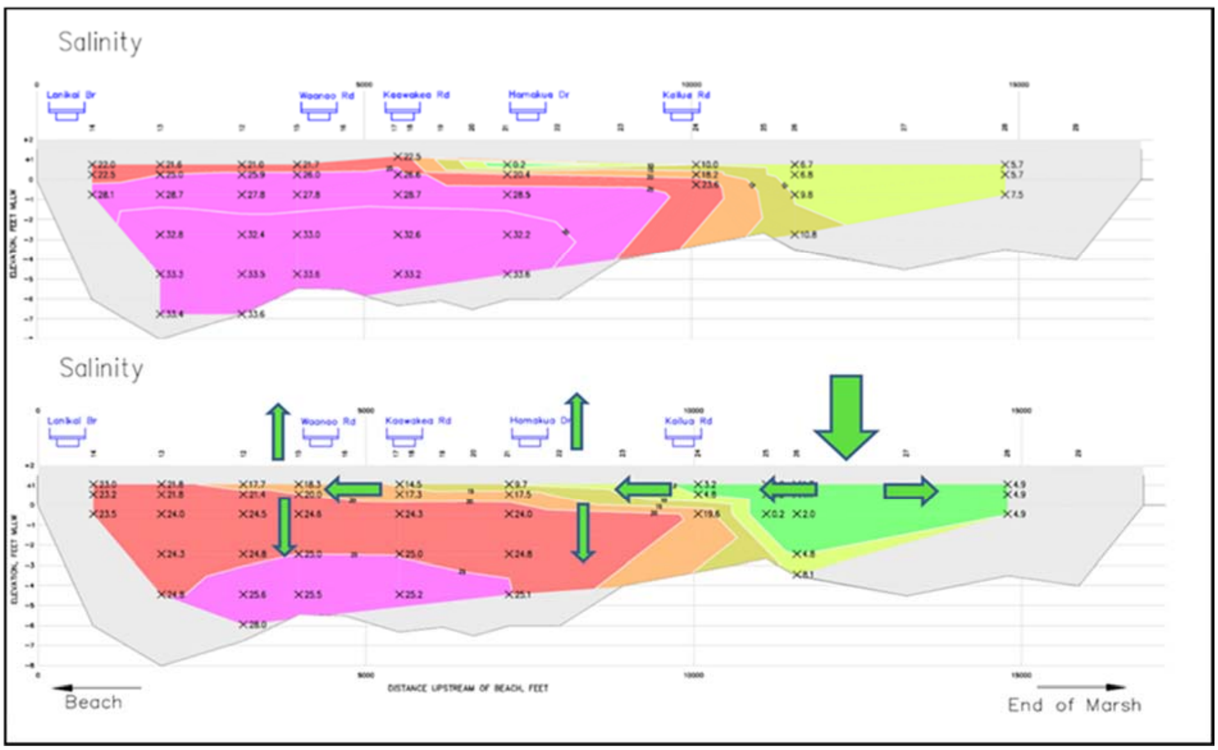

Figure 8. Salinity cross sections through the Kawai Nui branch of KWS from Kailua Beach (left) to end of stream near Oneawa Canal (right). Location of various bridges noted for relative positioning. Salinity is displayed by color, with pink as high salinity (ocean water) and green as fresh water. Upper graphic is condition without additional flow from Marsh. Lower graphic shows inflow location (large green arrow) and flow pattern primarily across entire surface of estuary.

of avian botulism, and no egg or fledgling mortalities resulting from flooded nests. During low-water events in prior summers episodes of foul odors emanating from wetlands and exposed mangrove would commonly elicit numerious complaints from residents to City and State agencies. During the 2015 summer when water elevations remained high there were no episodes of foul odors and no complaints reported to any of the City or State agencies.

Raising the water surface elevation increased the hydraulic head pressure in the stream and appeared to have a small but positive impact upon the City's efforts to open the stream mouth and to maintain flow over a longer period of time. Other factors, including the timing of the opening with tides, were shown to significantly improve exchange through the stream mouth.

1.6 Project Objectives

This project proposes to install a permanent structure that will restore 2 CFS water flow from the Marsh to the KWS system. The objectives of this restored flow are to

- Increase headflow into the Kawai Nui Stream,
- Improve exchange at the stream mouth through improved opening dynamics,
- Improve water quality, and
- Restore aquatic ecosystem functions and services.

1.6.1 Increase headflow into the Kawai Nui Stream

Prior to construction of the Kawainui Levee and the Oneawa Canal, approximately 28.5 million cubic feet (MCF) of water flowed monthly from the Marsh to the KWS system and 30 MCF flowed through the Kaelepulu Stream mouth to the ocean (Figure 5). This quantity is estimated from the USGS data for stream flow into The Marsh (42 MCF), plus rainfall over the 894 acre Marsh (11 MCF), minus evaporation (24.5 MCF) per month (Figure 5). Presently, the flow rate from the Marsh to KWS is 0 MCF and flow to the ocean is only about 1.5 MCF monthly. These rates are not sufficient to keep the upper Kawai Nui Stream from becoming stagnant, nor to sustain flow across the beach sand berm and discharge into the ocean.

The low water levels encountered during dry summer months occur when evaporation from the estuary exceeds the rate of inflow from rainfall runoff. These conditions result in odors emanating from exposed mudflats and decomposing vegetation. The stagnation resulting from a lack of inflow and low water levels leads to eutrophication, low dissolved oxygen levels, and occasional episodes of fish dieoffs which exacerbate all of the above problems. In addition, the occasional fish die-offs associated with prolonged periods of low water elevation are conducive to outbreaks of avian botulism which threatens three species of native waterfowl on the endangered species list that nest in both the Hamakua and Kaelepulu Wetlands. These conditions impact the quality of life for residents in the area and can pose a public health threat. Increased water inflow from the Marsh will minimize the occurrence and duration of low-water events in KWS.

1.6.2 Improve stream mouth opening dynamics and exchange in KWS

According to longtime residents (Turner-DeVries, 2016; Morley, 2007; personal communications) prior to 1966, the combined flow of Kawai Nui and Kaelepulu Streams was sufficient to sustain the stream mouth open during all but the driest months of summer. Presently, about 9 times a year, the City Department of Facility Maintenance, Roads Division, uses heavy equipment to excavate a channel through the beach sand berm, allowing the stream to discharge into Kailua Bay and the ocean to flow back into KWS during subsequent rising tides. However, there is often insufficient hydraulic head within the KWS to sustain an opening for more than a few hours. Improving exchange with the ocean is an important factor both for improving water quality as well as facilitating the movement of fish and plankton between the estuary and the ocean. Increasing the average monthly flow through the stream mouth from 1.5 MCF to 6.75 MCF will increase the water surface elevation of the system providing more hydraulic head to develop and sustain the opening between the ocean and KWS.

More frequent openings of the stream mouth will result in a lower average berm height in between periods of flow. The beach naturally builds across the opening under low flow conditions and slowly increases in height as waves and tradewinds push the sand up on the beach. Initiation of flooding to low-laying residential homes occurs at an elevation of 3.0 ft. MSL. Whenever the beach sandbar rises above 3.0 ft, the flood risk to low-lying homes increases because the sand bar will prevent the water from draining to the ocean.

1.6.3 Improve water quality

The KWS functions as an estuary and regular exchange from both fresh water and ocean water sources is critical to maintain balance within the system. During periods of heavy rainfall nutrient pollutants are carried into the system diluted with a large quantity of water and either discharged to the ocean or processed into the ecosystem web within the estuary. However, during dry periods, the occasional small rainfall events still carry these nutriennts into the estuary but with reduced water volume and minimal flow. A week or two following small rainfall events, it is not uncommon to witness algae blooms and occasional fish die-offs within very well defined segments of the KWS. Initiation of flow within the system will promote mixing, dilution, and transfer of nutrients across a wider reach of habitats within the estuary. Partial restoration of flow should reverse some of the adverse impacts to water quality by decreasing residence time and increasing the exchange rate.

1.6.4 Restore aquatic ecosystem functions and services

The adverse water quality and accumulation of vegetation have resulted in the loss of ecosystem services (boating, fishing) from these waters to the general public. The compensatory mitigation act of 2008 (Section 404(b)(1) calls for federally permitted projects to mitigate for ecosystem functions and services lost as a result of project implementation. Improving water quality in KWS by the water transfer will enhance ecological functions and services of KWS partially offsetting the adverse impacts resulting from levee construction and use of the system as storm drain conveyance by the City.

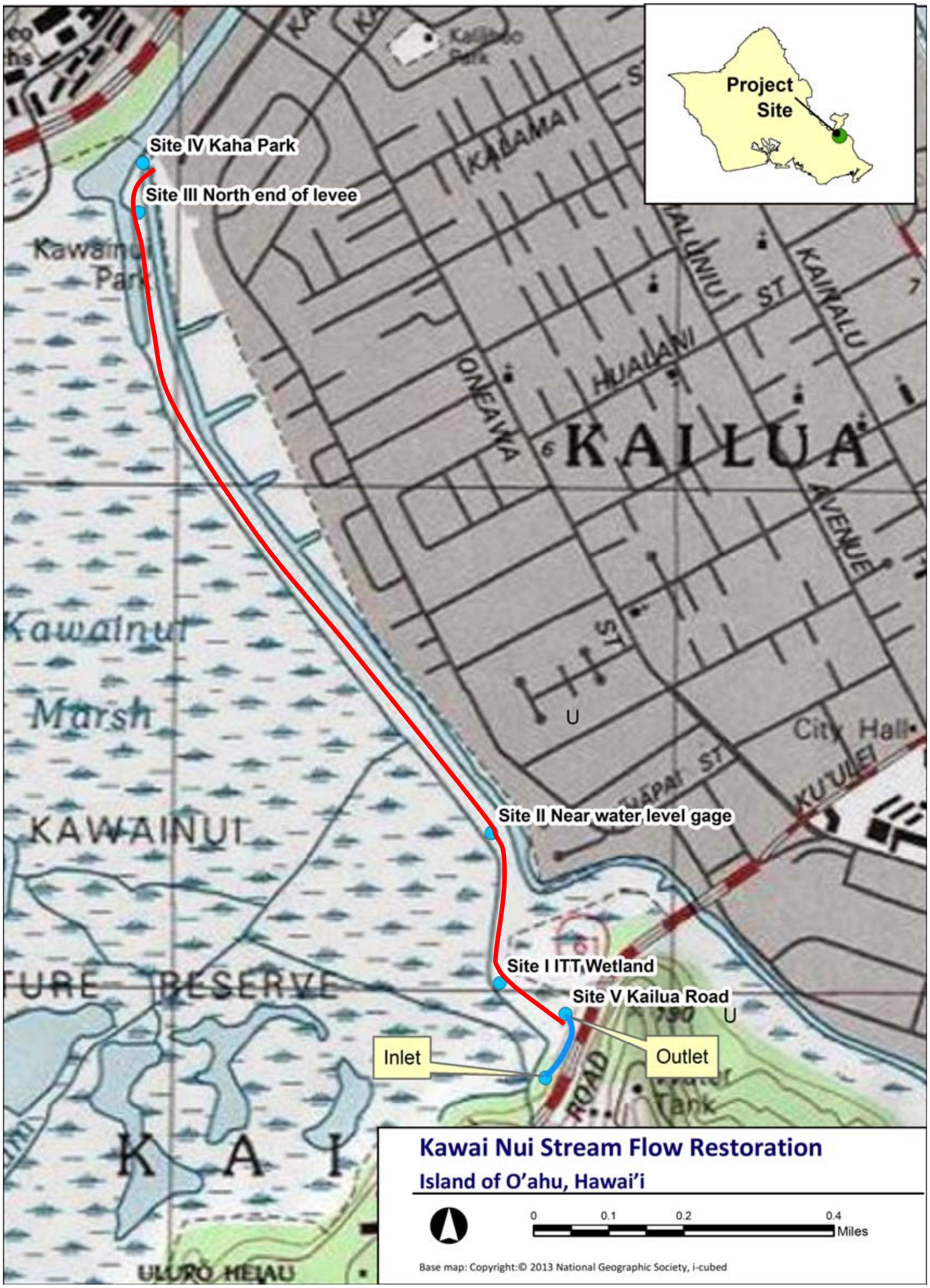

Figure 9. Location Map of the Proposed Project Alternatives along the Kawai Nui levee (red).

2 Project Description

2.1 Location of Project and Description

The proposed project is located at the eastern boundary of the Marsh in the town of Kailua, Koolaupoko District, on the northeast, windward coast of the Island of Oahu, Hawaii. The Marsh is located between the Koʻolau mountain range to the west and the town of Kailua and Kailua Beach to the east. The purpose of this PEA is to describe potential environmental impacts resulting from restoring partial water flow from the Marsh to Kawai Nui Stream and the larger KWS.

The project proposes to transfer 2 CFS of water from the the Marsh into the KWS to directly increase freshwater exchange and indirectly increase saltwater exchange at the stream mouth. This increased exchange is expected to improve water quality and restore lost aquatic ecosystem functions and services within the KWS. The 2 CFS water to be transferred is about 1/5th of the historical average (11 CFS) that flowed from the Marsh to KWS before construction of the Levee. The specific location of flow restoration is not critical, however restoring flow closer to the distal end of the Kawai Nui Stream will minimize areas that are subject to stagnation. Similarly the mechanism of water transfer (over, under, around or through the Levee) is not critical to the biological effect of the restored flow.

The Levee structure was designed by the USACE and is an important feature that protects a portion of Kailua town from flood damage. According to 33 USC 408 (Section 408) steming from the Rivers and Harbors Act of 1899, the Secretary of the Army must grant permission for the alteration or use of any USACE designed structure to insure that the proposed use will not injure the public interest or impair the usefulness of the USACE project. Any proposal for a flow restoration structure within the construction limits of the Levee would require a Section 408 evaluation. Any proposal for a flow restoration structure outside of the Levee construction limits would still require concurrence by the USACE because stopping this flow was the intent of the Levee structure, but this concurrence would not necessarily trigger the complete formal Section 408 process. The USACE generally discourages any action that might compromise a federally designed structure.

Five possible locations along the levee were considered for water transfer devices were proposed (Figure 9):

Site I (ITT Wetland); Levee distance: 100 ft
Site II (U.S.G.S Gauge Site); Levee distance: 1,500 ft
Site III (North end of the Levee Headwall); Levee distance: 8,000 ft
Site IV (Kaha Park) and Levee distance: 8,300 ft
Site V (Kailua Road, ITT Wetland). Levee distance: -10 ft

Construction footprints of the proposed project alternatives are relatively small, varying from about 4,000 square feet for the pipeways associated with the levee (options 1, II, III, and IV), or about 10,000 square feet for a directional drilled pipeline (option V) parallel to Kailua Road.

The proposed project would impact 894 acres of the Marsh from which the water would be withdrawn and 142 acres the KWS into which the water flow would be restored. A map showing the major waterbodies comprising the Kailua Waterways is shown in Figure 1.

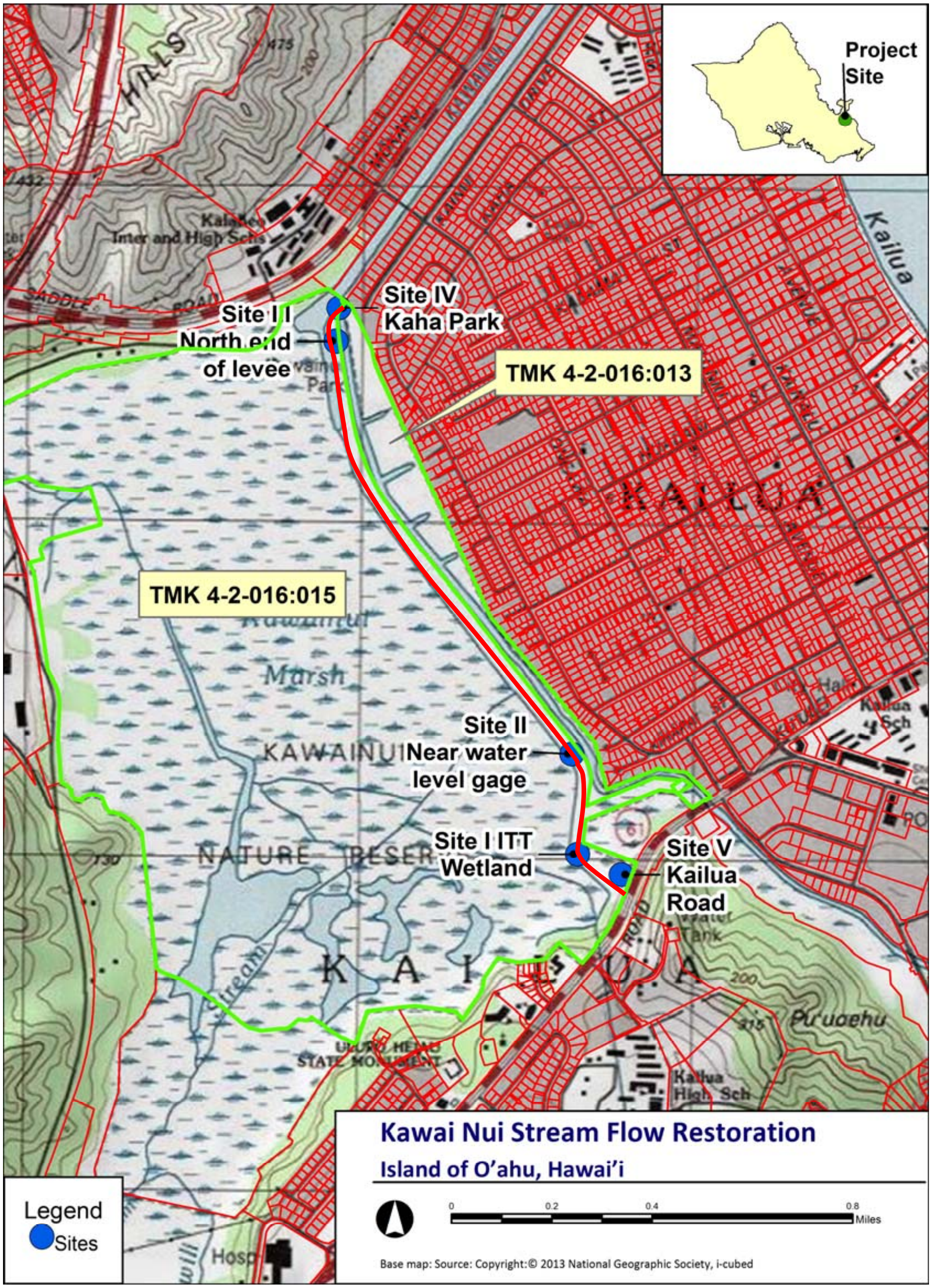

Figure 10. Tax Map Key of Proposed Project Site

2.2 Existing Land Use Classifications

Under the provisions of Hawaiʿi Revised Statutes (HRS) Chapter 205, the State Land Use Commission classifies all lands within the State of Hawaiʿi under one of four land use districts: (1) Agriculture; (2) Conservation; (3) Rural; and (4) Urban. The proposed project site lies within the State Conservation Land Use District (

Figure 11), and the proposed used is consistent with this land use designation.

The City and County Zoning designation is P-1 at the project site (Restricted Preservation District). Refer to Figure 12. The purpose of the preservation districts is to preserve and manage major open space and recreation lands and lands of scenic and other natural resource value. The project purpose and scope is consistent with activities associated with this zoning (Figure 12).

Figure 11 State Land Use Designations in vicinity of project.

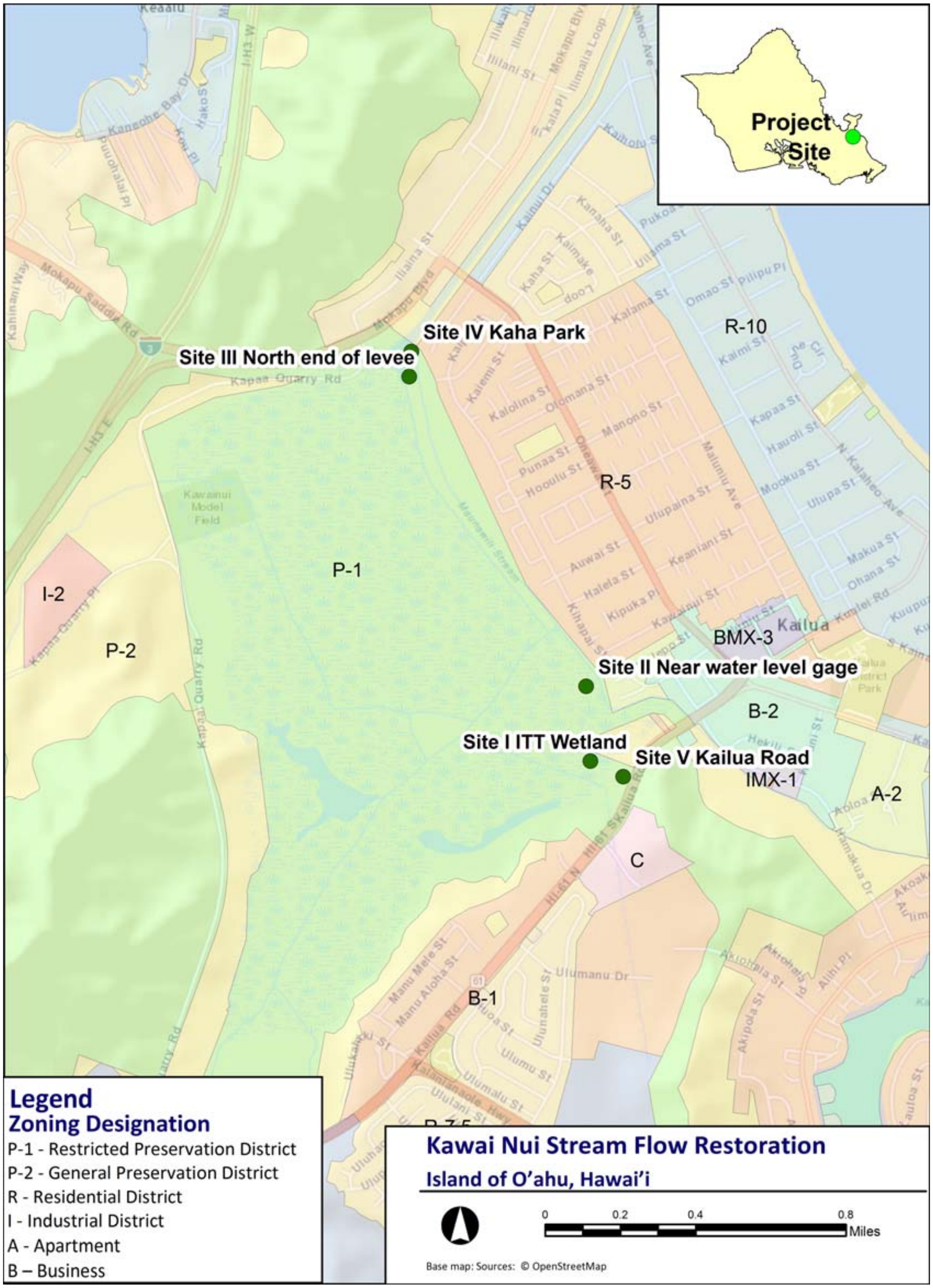

Figure 12. Kawai Nui Zoning Designation Map – P-1 Restricted Preservation District

3 Alternatives Considered

Alternatives are described in relation both to the possible locations and methods used to transfer the water. The Kawainui Stream runs along the entire mile-long eastern boundary of Kawainui Marsh from the ITT Wetland adjacent to the Kailua Road Bridge, to Kaha Park at the head of the Oneawa Canal. The levee wall is stamped with location markers at 100-foot intervals from Kailua Road (0:00) to Kaha Park (83:00) with the levee continuing along the Oneawa Canal to 9,470 feet. Water transfer could occur anywhere along the length of this levee. At the Kaha end of the levee, the water surface elevation of the Marsh varies tidally (~0 to 2 ft), but at the Kailua Road end, the water surface is typically elevated at about 4 ft mean sea level (MSL). Alternative locations selected along the levee will therefore provide different water head gradients between the Marsh and the stream.

For each potential location there may be several methods available to transfer the water from the marsh to the stream. Where the head difference is sufficient, gravity may be used to push the water from the Marsh to the stream in a siphon over the levee, a straight drain pipe through the levee, or a directionally drilled pipe below or around the end of the levee. Pumping the water using electric (or solar electric) pumps would allow water to be transferred at any location.

Four alternative water transfer methods (A,B,C,D) were considered at five locations along the levee yielding a total of 11 action alternatives, and the no-action alternative (F):

- Alternative A Gravity Flow Pipe through Levee
    - A-1 Site I Through levee base into ITT wetland
    - A-2 Site II Through levee base in Kawai Nui Stream
    - A-3 Site V Around end of levee into ITT wetland
- Alternative B Inverted Siphon Pipe Directionally Drilled under Levee
    - B-1 Site I Below levee into ITT wetland
    - B-2 Site II Below levee into Kawai Nui Stream
- Alternative C Siphon Pipes Over the Levee
    - C-1 Site I Over levee into ITT wetland
        - C-1a Over headwall
        - C-1b Through base of headwall
    - C-2 Site II Over levee into Kawai Nui Stream
        - C-2a Over headwall
        - C-2b Through base of headwall
- Alternative D Pump Controlled Pipe - Over Levee
    - Alternative D-1 Site IV Pump over levee from Oneawa Canal to Kawai Nui Stream near Kaha park
    - Alternative D-2 Site III Over levee wall to Kawai Nui Stream near Kaha park
- No Action Alternative

In addition to the above alternatives, the possible need for a separate project was identified to address an existing flood threat that was recognized as the data from the experiment was being analyzed. The Levee blocks all of the flow from the Marsh to KWS, and reduces the flow through the stream mouth by 95% of the historical flow. The reduced flow rate is no longer sufficient flow to keep the stream mouth open across Kailua Beach. In the absence of this flow the beach berm slowly increases in height, often reaching well above the flood elevation of 3.0 ft MSL. The lack of an overflow to the system, and the accumulation of sand at the stream mouth above the flood elevation allows the water elevation to rise, encroach upon the flood retention capacity of the system and thereby increase the flood threat to low-laying residences in the community.

The supplemental project was identified as an overflow to Oneawa Canal that would allow the KWS to drain to Oneawa Canal to maintain a contolled maximum elevation of 1.7 ft MSL and provide a 1.3 ft (8 MCF) flood retention buffer across the 142 acre KWS. While not intended as part of the flow restoration experiment, a potential solution to this flood threat is discussed in Appendix A:

- Supplemental Project. Pipe through levee at Site IV to drain water higher than 1.7 ft MSL elevation from Kawai Nui Stream to Oneawa Channel.

3.1 Alternative A: Gravity Flow Pipe through Levee

Alternative A would involve constructing a 12-inch diameter drain line pipe through or around the existing levee embankment. The pipe would be installed using either traditional trenching methods or directional drilling (Figure 13). At sites I (Alt A1) or site II (Alt A2) where the pipe passes through the levee, the levee width would be increased by 12 feet. This increase in width is intended to protect against the possibility of any weakening of the levee or leakage along the pipe alignment resulting from pipe installation. At site V (Alt A3), the pipe goes around the end of the levee through higher ground and would not impact the levee structure. Water restoration to the ITT Wetland (Alt A1 or Alt A3) would require additional improvements to the ITT wetland to properly manage the habitat change caused by increased water flow. Alt A2 would restore flow directly to Kawai Nui Stream at Site II.

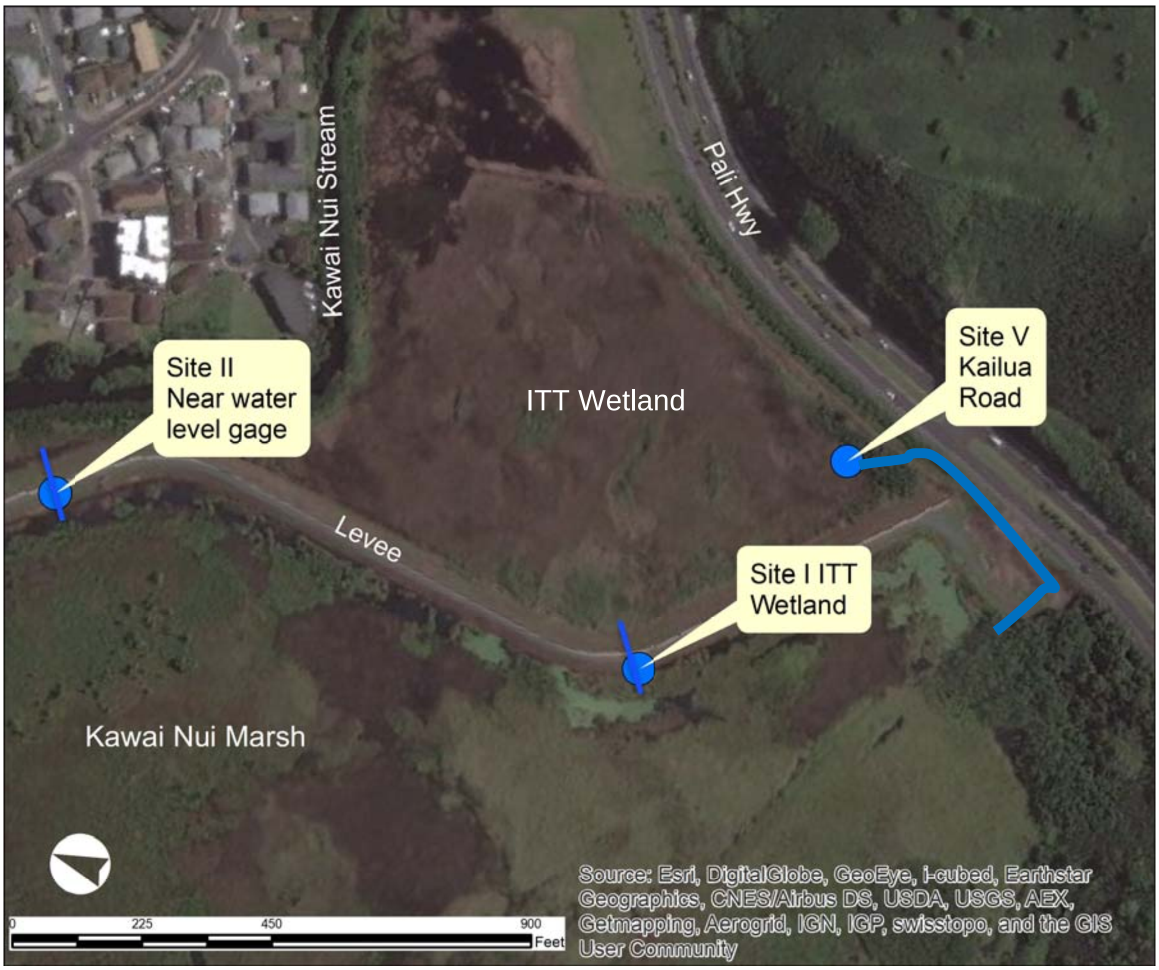

Figure 13 . Location Options for Gravity Pipe through or around Levee

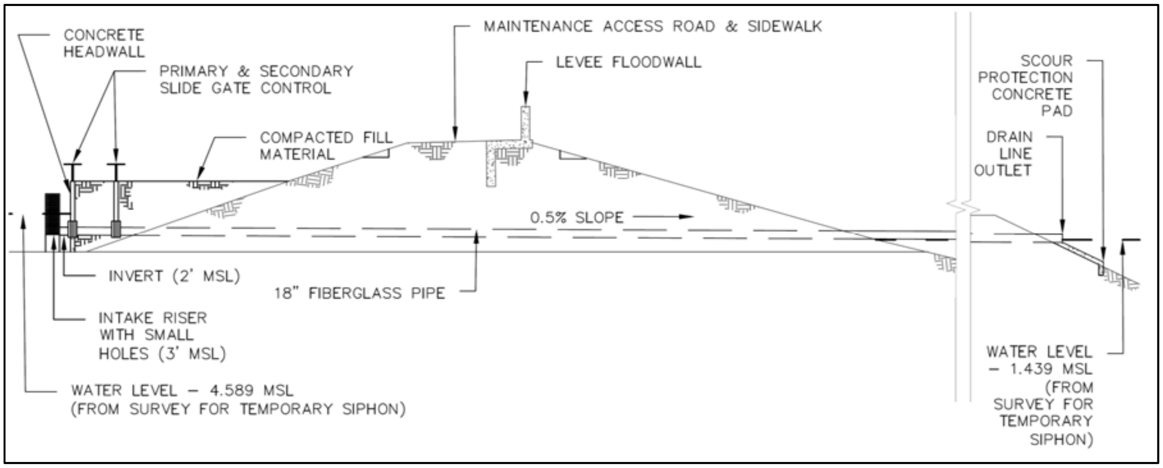

Figure 14. Gravity Pipe Placed through the Levee. Alternatives A1 or A2

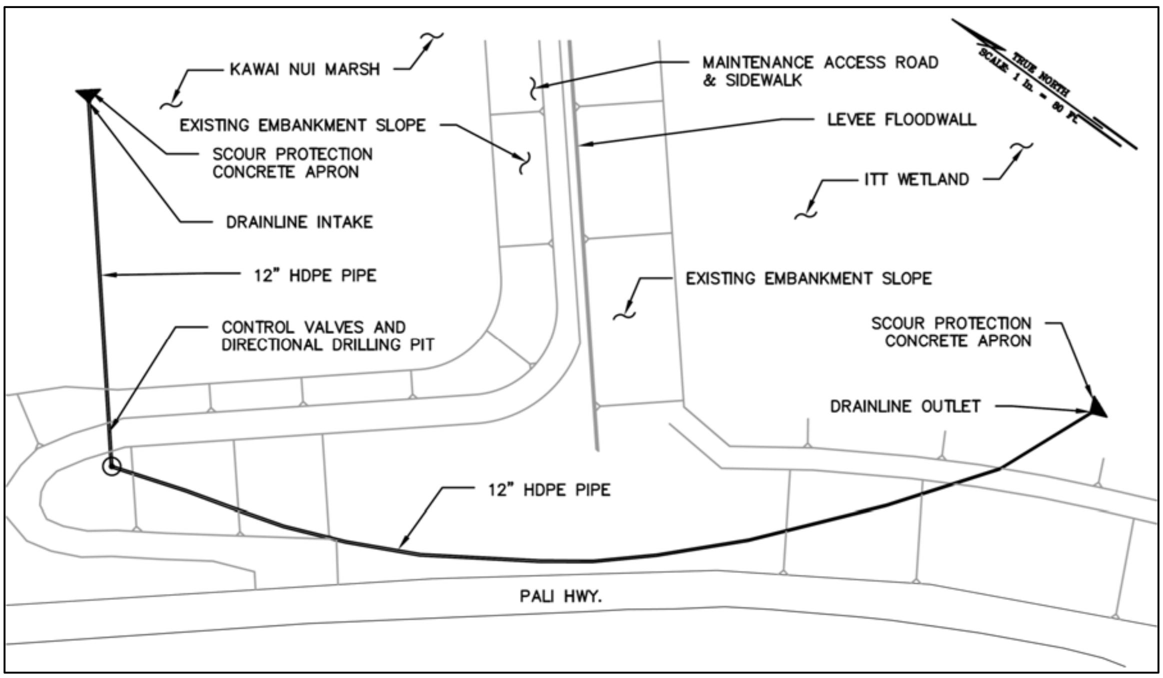

Figure 15. Alternative A3, directional drilling around levee within State DOT-highway right-of-way.

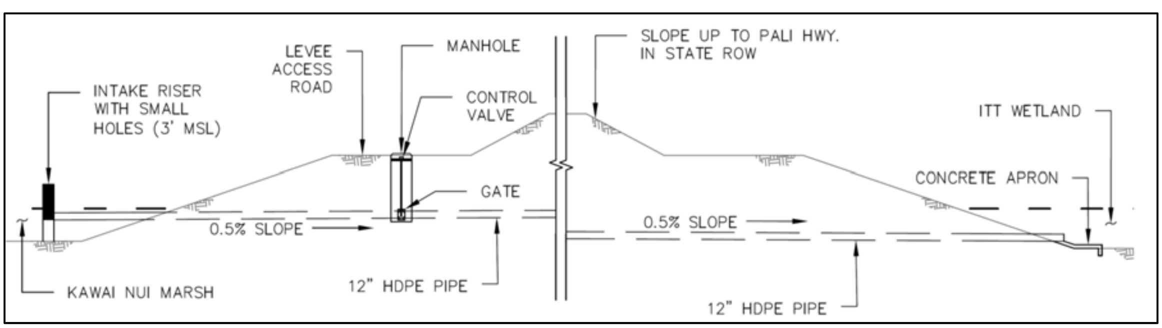

Figure 16. Alternative A3, alignment section of directional drilling around end of levee.

3.2 Alternative B: Inverted Siphon Pipe Directionally Drilled Below the Levee

Alternative B would consist of directional drilling and installing a 12-inch inverted siphon pipeline deep beneath the existing levee structure (Figure 17, Figure 18). To not impact the existing levee structure, the directional drilling would require the pipe inlet and outlet ends to surface 50 to 100 feet distant from the existing toe of the levee structure. The drilling operation requires a significant setup area about 100 feet from the levee. At Site I (Alt B1) this could be accommodated along the existing DLNR access road parallel to Kailua Road. At Site II (Alt B2), this could be accommodated on the mauka berm of the Kawainui Stream, although access to this berm may be difficult. Both alternatives would require construction of an intake structure inside the Marsh, 50 to 100 feet inside of the levee shoreline. Alternative B1 (Site I) would require the DLNR to make improvements to the ITT wetland so that it could accommodate the increased flow. One drawback of the use of an inverted siphon is the increased maintenance due to material settling at the lowest bend in the pipe and eventually restricting or blocking flow.

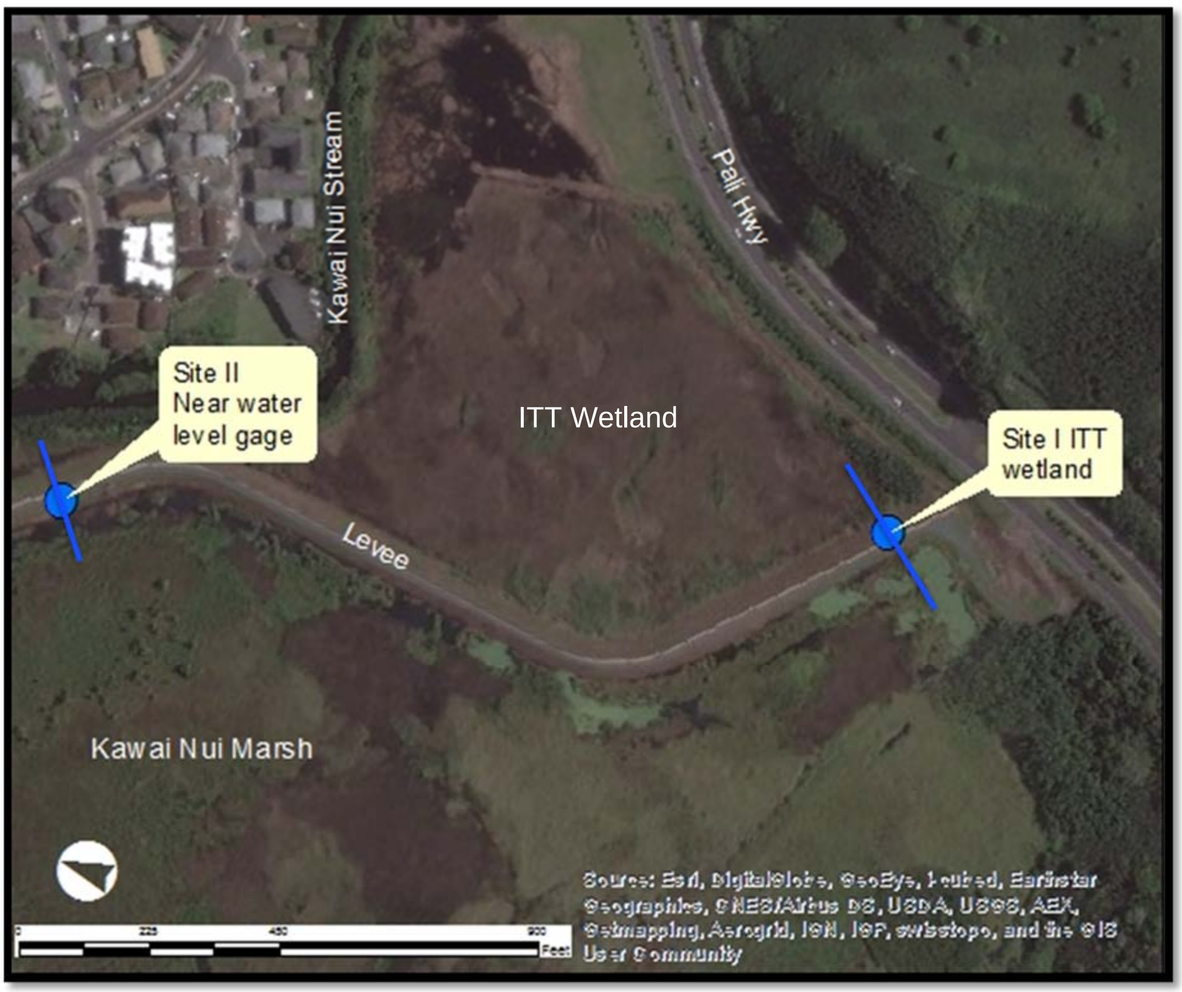

Figure 17. Location Options of Siphon Pipe Directionally Drilled under the Levee

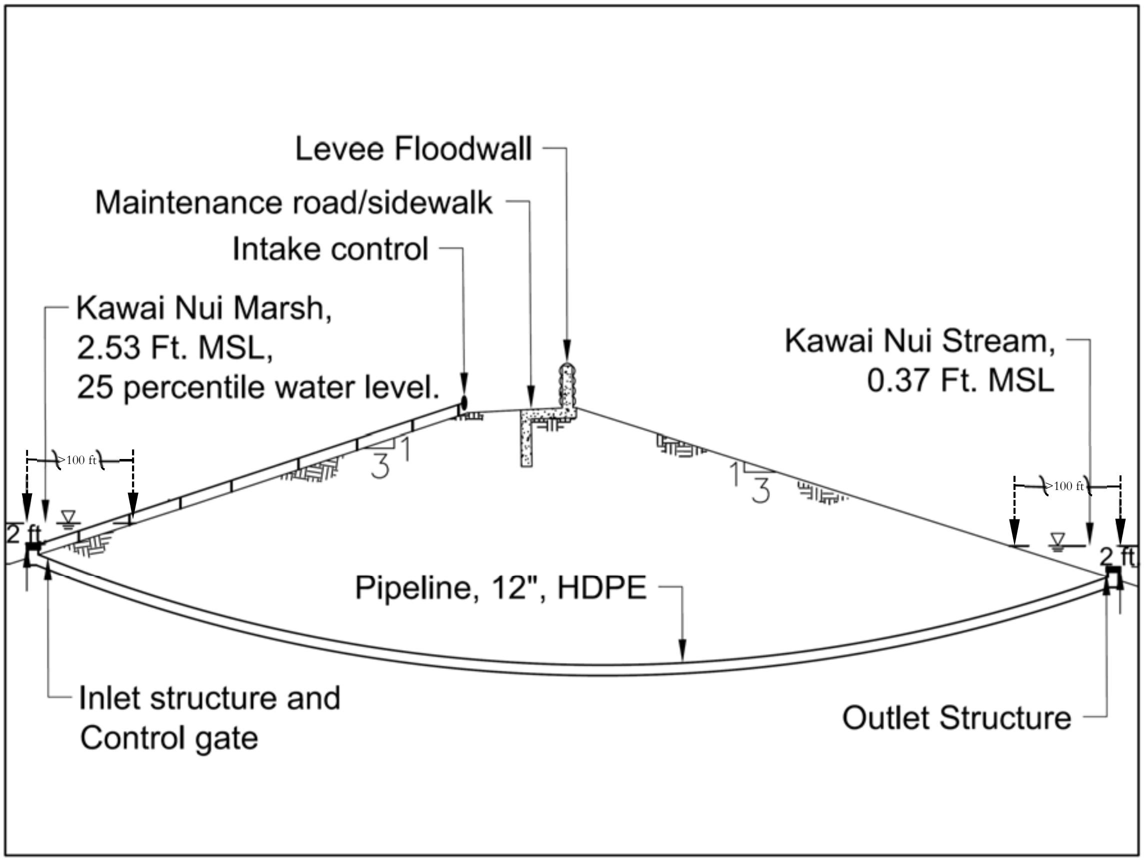

Figure 18. Siphon Pipe Directionally Drilled under the Levee. Drawing not to scale: intake and outflow ends of pipe would need to be 50-100 feet away from the base of the levee.

3.3 Alternative C: Siphon Pipes Over the Levee

Alternative C would consist of constructing four 6-inch siphon pipes or a single 12-inch pipe over the levee, similar to the construction and operation of the experimental siphon. The siphons could either be constructed just below grade and penetrate the foot of the concrete flood wall, or they could be above ground going completely over the concrete flood wall similar to the construction of the experiment. The siphon requires a hydraulic head difference to operate and so could only be constructed near the center or at the Kailua Road end of the levee (Site I or Site II) (Figure 19). Alternative C would require installation of a solar powered pump to suction air from the top of the siphon to maintain continuous water flow. Two construction methods at two possible sites results in four alternatives: C1a, C1b, C2a, and C2b.

Alternative C1a and b, would deliver the water directly into the ITT wetland, which would then drain to Kawai Nui Stream. These options may require DLNR to make planned upgrades to this wetland (dredging and water flow control features) earlier than anticipated.

Alternatives C2a and b, would deliver the water directly to the Kawai Nui Stream near the same location where the experiment was conducted.

Alternatives C1a and C2a (Figure 20) would be similar to the siphon used in the experimental with the pipes laid on grade and over the top of the walkway and wall. This would limit pipe diameter to 6-inches necessitating 4 pipes and require a permanent cover over the pipes on both sides of the wall to allow for the passage of vehicles, pedestrians and maintenance equipment.

Alternative C1b and C2b (Figure 21) would bury the pipes 2-feet below the existing grade, along the side slopes of the levee embankment, under the existing roadway and through the buried portion of the headwall. These options could replace the four 6-inch pipes with a single 12-inch pipe, which would decrease the total height of the siphon and lower the number of joints, and connections potentially causing air leaks that compromise operation of the siphon.

Figure 19. Location Options for Siphon Pipe Over the Levee

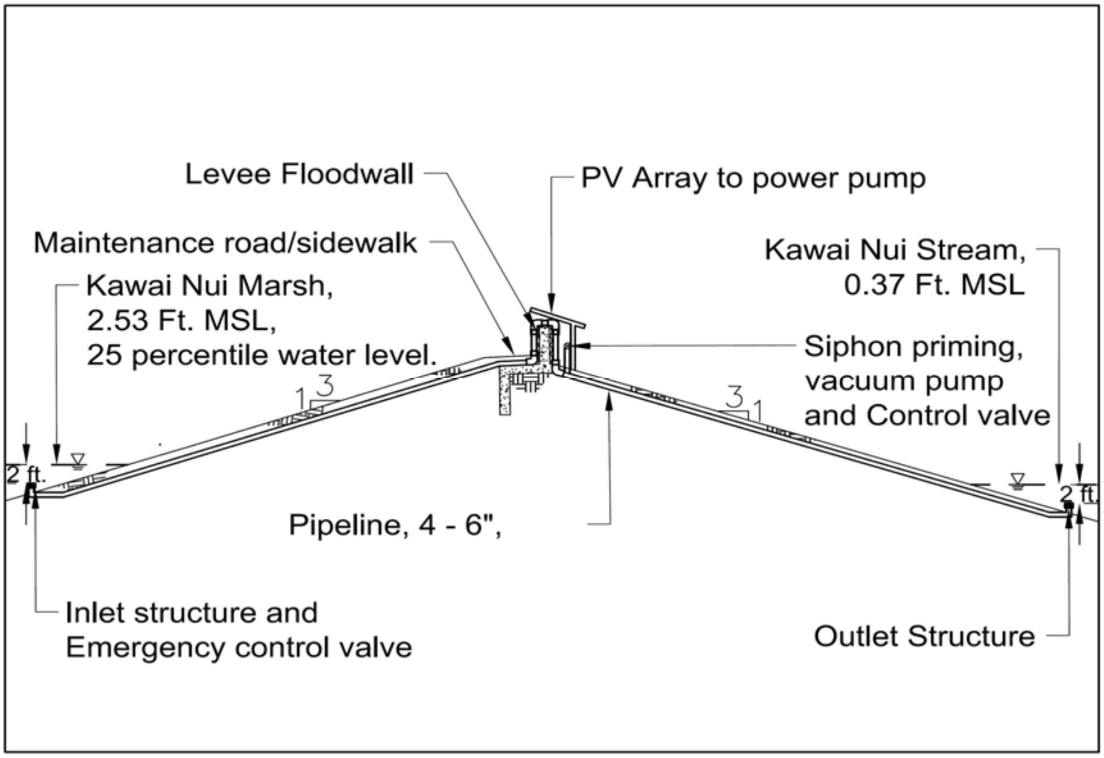

Figure 20. Siphon Pipe Placed over the Levee

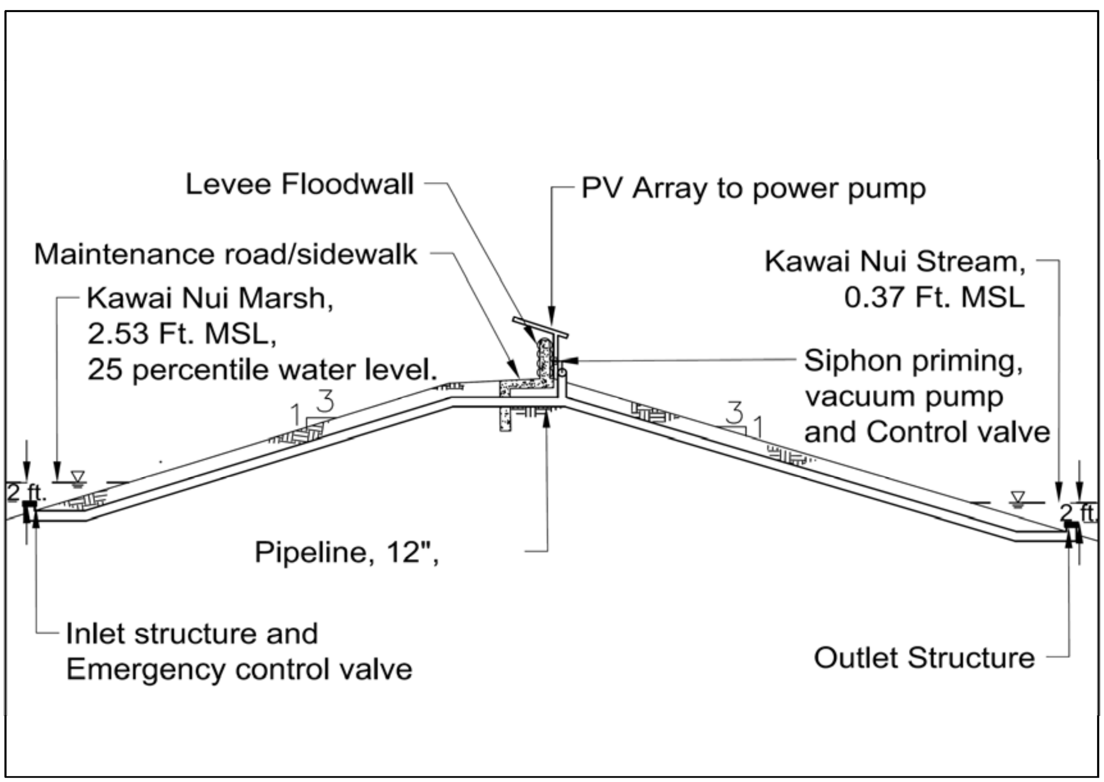

Figure 21 Siphon Pipe Placed through Levee Floodwall

3.4 Alternative D: Pump Controlled Pipe over or through Levee

Alternative D1 would consist of constructing a single 12-inch pipe at, or just below, grade, along the side slopes of the levee embankment and over (Alt D1)(Figure 22) or buried just below the surface of the levee (Alt D2)(Figure 23) at either Site III or Site IV. There is no concrete flood wall at these locations. A pump and power source would be required to be installed to move the water as there is insufficient head difference to promote flow at this end of the stream. Given the power requirement to move 2 CFS of water, either a large (16 ft x 20 ft) solar array would need to be installed (which would only power the pumps during the day) or a permanent electric service would need to be supplied to this location. This Alternative could be installed at any site but would be most appropriate at site III (Oneawa Canal) or site IV (Kaha Park) (Figure 22). At this end of the the Marsh system, the water is brackish and is tidally influenced through the Oneawa Canal. Site III would provide water with lower salinity than Site IV, but would require significantly greater distance to route electrical supply. Any water pumped into Kawai Nui stream from this source would likely increase the salinity of the Kawai Nui Stream.

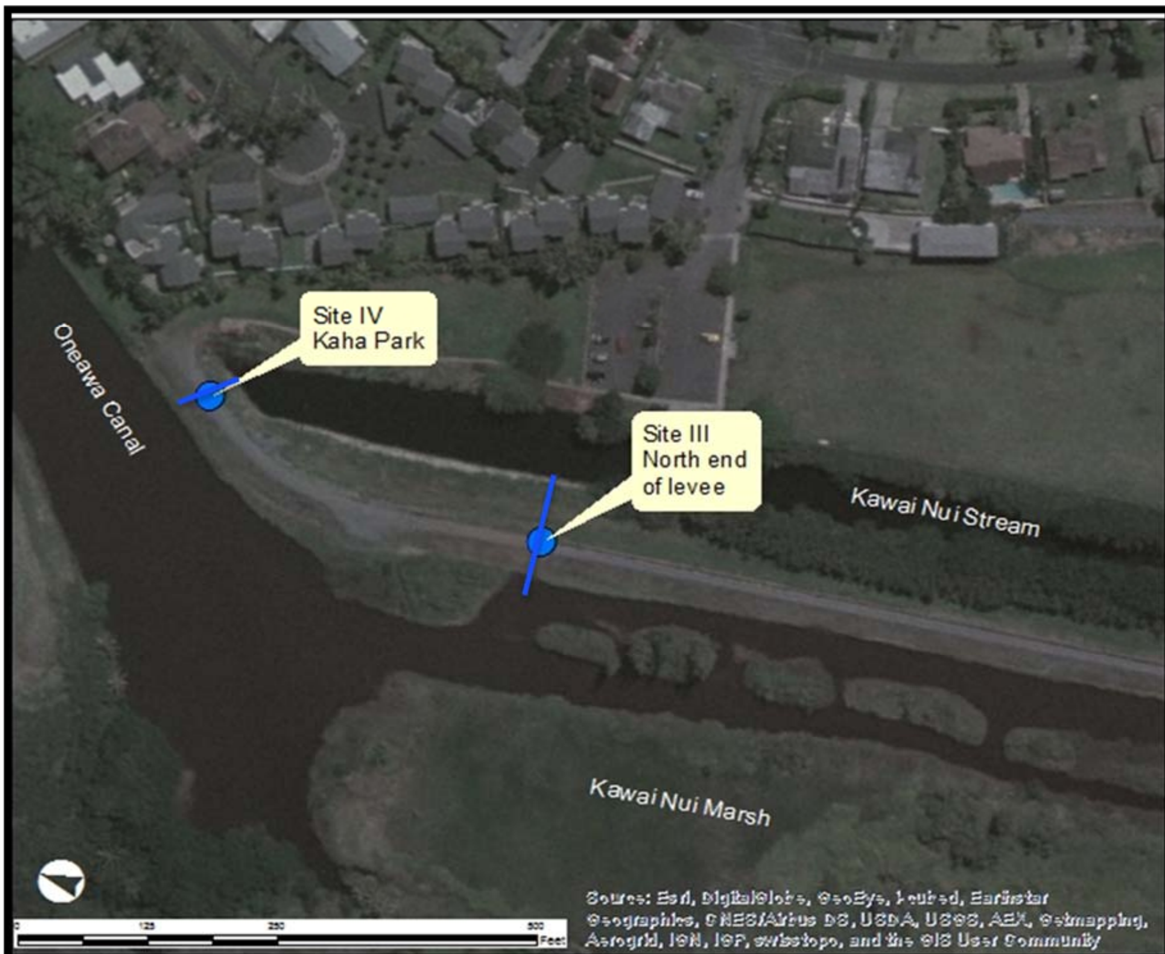

Figure 22. Location Options for Installing a Pump-controlled Pipe over the Levee.

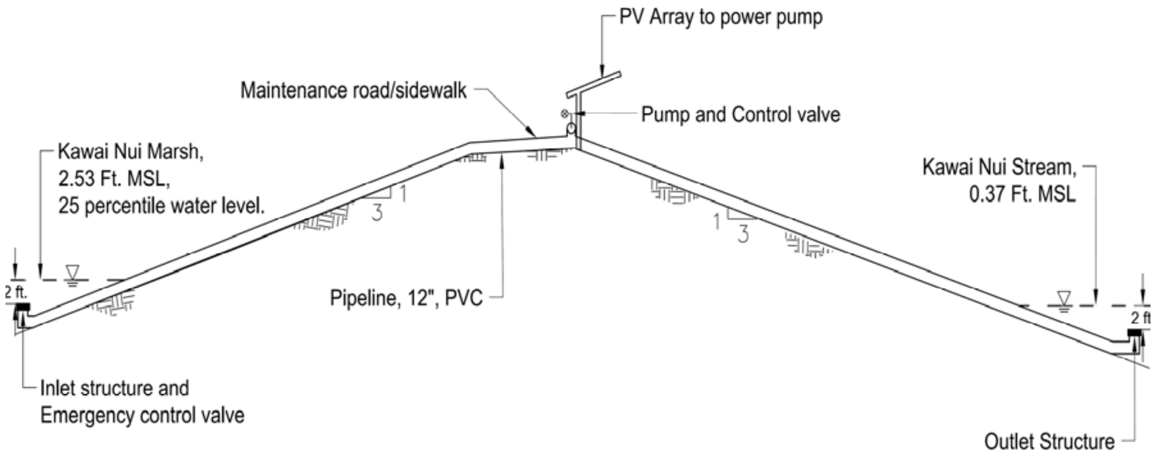

Figure 23. Alt D1, Pump Controlled Pipe over the Levee.

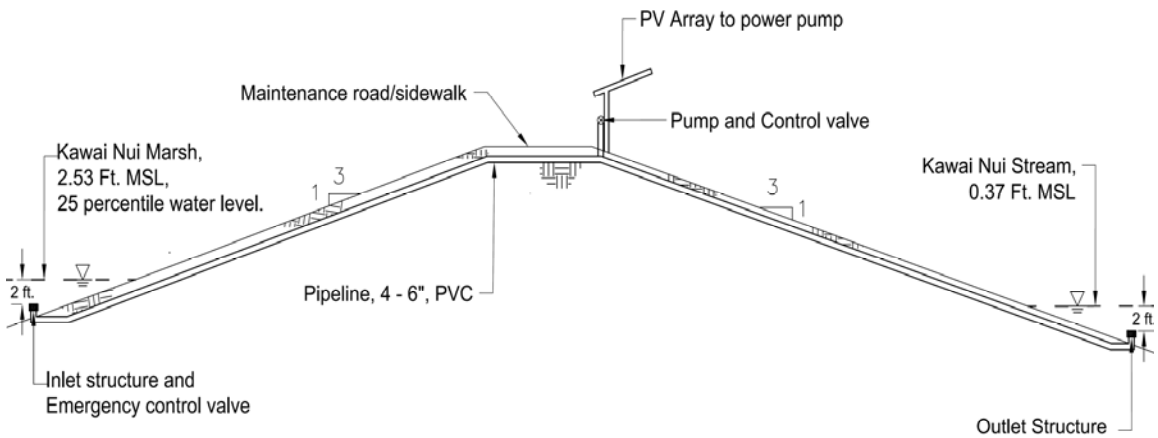

Figure 24 Alt D2, Pump Controlled Pipe Through Levee Floodwall.

3.5 No Action Alternative, E

The No Action Alternative would involve no improvements maintaining the status quo with no water passing from the marsh to the stream. Without installation of a water flow restoration structure, the existing conditions consisting of low water levels, poor water quality, and flood threat to low-lying properties on the shores of KWS would be maintained.

How much water is 2 CFS ?

A flow rate of 2 cubic feet per second (CFS) would:

- Fill three 5-gallon buckets in a second
- Fill a bathtub in about 3 seconds
- Fill a backyard swimming pool in about 10-15 minutes
- Fill the Kailua Park Olympic-sized swimming pool in about 7 hours
- Be equal to the water inflow rate from a rain storm event of 0.01-inch per hour over the 142-acre KWS.
- Raise the elevation of the 142-acre Kailua Waterway System 10-inches in a month, minus 7.5-inches evaporation for a total rise of 2.5-inches per month.
- = 7,200 ft^3/hr = 172,800 ft^3/da = 5,184,000 ft^3/mo = 5 MCF/mo
  142 acres = 6,180,000 ft^2

3.6 Evaluation of Alternatives

The advantages and disadvantages associated with each alternative are discussed below. All designs that impact the levee must follow the USACE Design and Construction of Levees Engineer Manual, Chapter 8, Section I Pipe and Other Utility Line Crossing Levees. The earth load acting on a pipe shall be determined as outlined in EM 1110-2-2902. The structure would be designed with a 50 year design life.

Alternatives which require a pipe to pass over the access road would require the installation of a ramp to allow for maintenance vehical and public access. Additionally, the siphon pipes shall be monitored regularly for seepage and structural integrity.

An evaluation matrix was developed to aid in the selection of an alternative. Table 3-1 below summarizes the practicality and feasibility of each of the five designated locations (Site I: ITT Wetland; Site II: Near USGS water level gage; Site III: North end of the levee; Site IV: Kaha Park, Site V: Kailua Road). The table shows a matrix of each alternative and the categories selected to compare each alternative. At this stage in the planning process, eight categories have been identified to compare the alternatives. A brief description of each category is described below. A value is placed in each category corresponding to the impact, 0 means there is negligable impact and 5 is the highest impact relative to the other alternatives. A negative number conotates a positive impact in this context. The alternative with less total points is more desirable.

Environmental Resources:

This category includes the following environmental resources:

- Climate, Topography, and Soils
- Wetlands
- Geology, Hydrogeology, Hydrology
- Coastal Resources
- Biology
- Infrastructure, Public Facilities and Utilities

All of the alternatives have been identified to have negligible negative impacts on: climate, topography, soils; wetlands, biology; infrastructure, public facilities and utilities. The primary alternatives have negligable impacts on the hydrology and hydrogeology, flooding and coastal resources. A possible supplemental project alternative, a drain pipe at elevation 1.7 ft MSL to the Oneawa Canal, would have a positive impact on flood prevention, but is not considered here as part of this project. These resources and the impacts the project may have are described in more detail in the following sections. All of the alternatives have the same impacts on the environmental resources, except the supplemental alternative, which has a lesser impact.

	Alternative A			**Alternative B**		**Alternative C**				**Alternative D**		**Alternative E**
	Gravity Flow Pipe Thru or Around Levee			Inverted Siphon Below Levee		Siphon Over Levee				Water Pump Over Levee		No Action
						Over Wall	Thru Wall	Over Wall	Thru Wall			
	A-1	A-2	A-3	B-1	B-2	C-1a	C-1b	C-2a	C-2b	D-1	D-2	S-1
Impacts	Site I	Site II	Site V	Site I	Site II	Site I	Site I	Site II	Site II	Site IV	Site III	Site IV
Environmental Resources	3	2	3	3	2	3	3	2	2	1	1	5
Visual Resources	1	1	0	1	1	2	1	2	1	3	3	0
Noise	0	0	0	0	0	0	0	0	0	2	2	0
Water Flows through ITT Wetland	1	0	1	1	0	1	1	0	0	0	0	0
Total Cost	4	4	4	3	3	2	2	2	2	3	3	0
Operation and Maintenance	1	1	1	3	3	5	4	5	4	4	4	0
Constructability	4	4	3	5	5	2	3	2	3	2	2	0
General Permits	4	4	4	4	4	3	3	3	3	3	3	0
USACE 408 Permit	5	5	0	4	4	2	3	2	3	1	1	0
Flood Threat	2	2	2	2	2	1	1	1	1	0	0	2
TOTALS	25	23	18	26	24	21	21	19	19	19	19	7
RANK	5	4	1	6	5	3	3	2	2	2	2	na

Table 3-1 Comparison of Alternative(s) Designs. Green shading indicates lowest rank per row. 5= worst 0=best

Visual Resources:

Each of the alternatives includes adding new structures to the levee and surrounding area. Each alternative will include a visible intake about outlet structure and access way. Alternatives C1 and C2 include photovoltaic panels located on stream side of the levee. Alternative C1 and D1 includes pipes running over the levee floodwall. Alternatives C1, C2, D1 and D2 all include visible pumps and appurtenances. The most visually impactful structure is the pipes running over the levee. These will obscure the views of the public as they use the levee walkway. There are no anticipated visual impacts on wildlife.

Noise:

The impacts from noise is a consideration for this project because this project is located in an area that is widely used by the public and wildlife. Several of the alternatives have pumps onsite. Alternative C1 and C2 will have a small siphon priming pump that will only run when an event occurs that causes the siphon to break. Therefore, there is little impact from noise. Alternative D1 and D2 will have a pump running at all times to move the water over the levee. The pump is estimated to emit a maximum of 70 decibels at its source. This equates to approximately 51 decibels at 30 feet away, which is the approximate lactation of the walkway at the top of the levee. This noise level is equivalent to a normal conversation volume and does not cause any damage from constant exposure, but does exceed the night time maximum noise levels and impacts the public experience of the area. Impacts from noise is further described later in this report specific to each alternative considered.

Constructability:

The ease of construction is a consideration when comparing alternatives. In this project, no issues with the ease of construction were identified. Two factors were considered when comparing the constructability: duration of constriction and specialty of construction methods. The use of directional drilling is more specialized than trenching, however is still a relatively common construction method. Trenching would likely require more time than using directional drilling so the ease of construction is less.

Permits:

All of the alternatives in this project require the same permits, with the possible exception of Alternative A-3, which may not require a Section 408 Army Corps permit because it is not on the levee structure. The USACE takes responsibility of determining wether or not this permit is required for this alternative. The permits required for this project are further described in Chapter 9 of this document.

Construction, Design and Permitting Costs

A budgetary cost estimate was itemized for each alternative. Table 3-2, shows the cost estimates for the design, permitting and construction of each alternative. These cost estimates may be modified as the designs are only conceptual at this point.

Alternative	Construction Costs	Design and Permitting Costs	Total	Cost Rating (0-5)
Alt A1 Site I - Drainline Through Levee	$274,000	$262,000	$536,000	4
Alt A2 Site II Drainline Through Levee	$274,000	$262,000	$536,000	4
Alt A3 Site V Drainline Around Levee	$333,000	$220,000	$552,000	4
Alt B1 Site I –Invert Siphon Under Levee	$276,000	$262,000	$538,000	4
Alt B2 Site II Invert Siphon Under Levee	$276,000	$262,000	$538,000	4
Alt C1a Site I- Siphon Over Levee	$312,000	$257,000	$568,000	4
Alt C1b Site I Siphon Through Levee Wall	$276,000	$260,000	$536,000	4
Alt C2a –Site II Siphon Over Levee	$312,000	$257,000	$568,000	4
Alt C2b Site II Siphon Through Levee Wall	$276,000	$260,000	$536,000	4
Alternative D1 - Pump Over Levee	$374,000	$260,000	$652,000	5
Alternative D2 - Pump Through Levee	$325,000	$272,000	$596,000	5
*Cost is based on being constructed in combination with another alternative. Should this design be selected alone the costs would increase.				

Table 3-2 Alternative Budgetary Cost Estimates

Army Corps Acceptability:
All but one of the alternatives will impact the levee designed by the USACE and will therefore require consultation with the USACE under Section 408 application process. The acceptance of the USACE is critical to this project and is an important criteria in the selection of an appropriate alternative.

The USACE conducted an informal evaluation of Alternatives A, B, C, and D, but did not review the Supplimental Project concept for a drain to Oneawa Canal (Appendix A). The USACE expressed concern of any pipe installation that physically penetrates the levee. The basis of concern relates to the potential for water seepage along any pipeline installed after initial construction of a structure and eventual levee failure at this point. Drainage pipes, water supply pipes, and pipes carrying a variety of infrastructure needs are regularly passed through USACE designed levees across the nation. Structural requirements for pipes through levees include consideration of inspection and maintenance needs, automatic and emergency shutoff, seepage along the exterior of the pipeline, and structural integrity with ground settlement. Potential increased flood threat is discussed in Section 4.4 of this report. While existing USACE guidance provides for methods to minimize seepage and to strengthen levees, where utility penetrations occur, the USACE would not likely be in support of proposed penetration for the purposes other than reducing risks to human life and/or property.

Penetration of any kind, to the foundation or levee embankment, is highly discouraged and not favored by the USACE. This is particularly so when the penetration is requested after completion of the USACE structure and the purpose of the penetration is other than for reducing risks to human life and/or property. Based on the alternatives descriptions provided informally to the USACE, the following alternatives would not likely be permitable under the Section 408 permit review process:

Alternative A-1, Straight pipe through levee into ITT wetland
Alternative A-2, Straight pipe through levee into Kawai Nui Stream
Alternative B-1, Inverted siphon into ITT wetland
Alternative B-2, Inverted siphon into Kawai Nui Stream

Penetration of the levee above the water level, while still not recommended, may be possible to permit through the Section 408 process and would include:

Alternative C-1b, Siphon through base of flood wall into ITT wetland
Alternative C-2b. Siphon through base of flood wall into Kawai Nui Stream

Alternatives that go over or around the levee would have a greater chance of being permitted through the Section 408 permit process and include:

Alternative A-3 Gravity flow pipe around south end of levee into ITT wetland:
Alternative C-1a, Siphon over flood wall into ITT wetland
Alternative C-2a, Siphon over flood wall into Kawai Nui Stream
Alternative D-1, Pump controlled pipe over levee from Oneawa Canal
Alternative D-2. Pump controlled pipe over levee from the Marsh

While Alternative A3 is specifically designed to avoid the footprint of the levee, its function is to pass water around a levee that was designed specifically to prevent the passage of this water. While this option may avoid the necessity of a 408 consultation it will be the USACE that must make this determination.

The USACE analyses will focus on two key elements: 1) impact of the proposed modification to the structural integrity of the levee, and 2) potential increase of flood threat resulting from the increased flow through the levee.

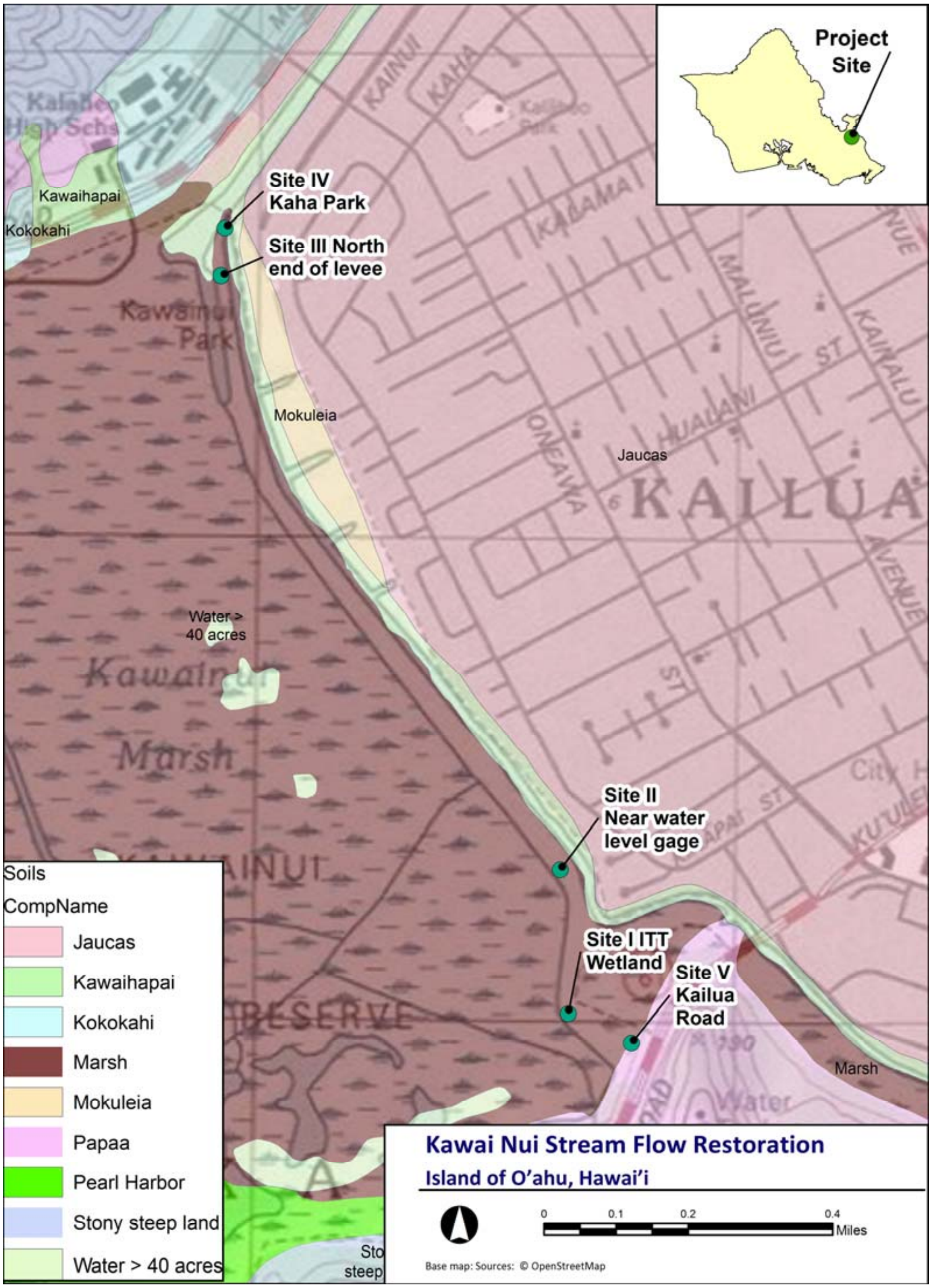

Figure 25 Soil types in project vicinity

4 Physical, Biological and Cultural Environment

4.1 Climate, Topography, and Soils

Oahu, Hawaiʿi has a mild semi-tropical climate that varies across the terrain primarily with altitude and orientation to trade winds. The proposed project site is located within a climatic region known as the windward lowlands. Average temperatures ranges from 77.4 degrees Fahrenheit (°F) (22 degrees Celsius [°C]) in the warmer months to 71.6°F (22°C) in the cooler months.

The Kawai Nui levee lays perpendicular to the prevailing flow of the northeast trade winds. Weather is moderately rainy, with frequent trade wind showers. In the proposed project area, average rainfall varies between 2 inches per month during the summer, to 5 inches per month during the winter. Mean annual rainfall at the site is approximately 40 inches (Figure 29). Mean annual rainfall increases in the mauka portions of the watershed to as much as 120 inches per year at the top of the Koolau Mountains.

Although the proposed sites are located on or adjacent to the Levee on the eastern edge of the Marsh; the project may affect 860 acres of the Marsh upstream of the water transfer site and 142 acres downstream of the water transfer site. The topography of the marsh is nearly flat with a slight upward gradient from sea level at the head of the Oneawa Canal (~ 1-ft.) to approximately 4.5-ft. elevation where the levee wall begins near Kailua Road. The community of Kailua is located on the mile wide sand barrier between the Kawai Nui Stream and Kailua Beach. The urban residential community was developed in the early 1940s replacing coconut groves, pasture lands, and a race track that previously occupied these lands.

Soil associations in the vicinity of the proposed project are comprised of marsh deposits (Foote et al, 1972). Marshes consist of wet, periodically flooded areas covered with grasses and other wetland adapted plants. Water in the Marsh varies from brackish near the head of the Oneawa Canal to fresh at elevations above about 2 ft.

4.1.1 Impacts

The proposed project will have negligible to no significant adverse impact upon climate, topography or soil.

4.2 Wetlands

The Marsh (894 acres) is roughly 6-times larger than the KWS (142 acres). Raising the elevation of the KWS by 6-inches should correspond to a one inch fall of the water surface level in the Marsh. In practice, the Marsh surface elevation regularly responds to water inflow from the mountains, outflow to Oneawa Canal and evaporation (Figure 30).

The KWS contains both the Hamakua and Kaelepulu Wetlands which serve as important habitat for 3 species of Native Hawaiian waterbirds on the endangered species list; Hawaiian Coot or ʻAlae keʻokeʻo (*Fulica alai*); Hawaiian Stilt or Aeʻo (*Himantopus mexicanus knudseni*) and Hawaiian common moorhen or ʻAlae ʻUla (*Gallinula chloropus sandvicensis*).

Hamakua Wetland is a 23-acre State DLNR managed water bird refuge, located on Kawai Nui Stream just below the the Marsh. This refuge is highly visible from downtown Kailua where it abuts Kawai Nui Stream . Although the wetland is hydraulically isolated from the Marsh (by the levee), it is considered to be part of the the Marsh complex. At a water surface elevation of 1.3-ft., the large majority of the Hamakua Wetland does not have standing surface water. At an elevation of 2-ft., approximately 90-percent of the wetland is flooded. The proposed project would restore a controlled hydraulic connection between the Marsh and Hamakua Wetland.

Kaelepulu Wetland is a privately owned 13-acre wetland located at the southern extent of Kaelepulu Pond. The wetland is managed as a bird preserve and presently hosts a healthy population of Hawaiian waterfowl. (Count as of 3/2013: 100+ Hawaiian Coots, 23 Hawaiian Gallinule, 22 Hawaiian Stilt, 10 Night Heron, plus miscellaneous ducks and geese). At a water surface elevation of 1.3-ft. approximately half of the 13-acre wetland is located above water level. At an elevation of 2-ft., about 80-percent of the wetland is submerged.

4.2.1 Impacts

Permanent water restoration would restore the aquatic ecosystem functions and improve water quality leading to higher quality wildlife habitat. The aesthetics of the waterway system would likely improve. Adverse impacts include the potential for drowning nests. Implementing a permanent water transfer method is intended to positively affect wetland resources associated with the proposed project site. The proposed project is likely to have a positive affect on the two managed waterfowl refuges within the receiving system.

Managers of the Hamakua and Kaelepulu wetlands have expressed concerns that rapidly raising the water level to a 2-ft. elevation could drown eggs that were laid during a period of low water elevation. This has occurred in the past when heavy rainfall or the inflow of sea water from the ocean results in rapid water rise. The rate of water level rise from siphon inflow would be a very slow process (~$^{1}/_{8}$th to ¼-inch/day) allowing managers more than adequate opportunity to contact project personnel to halt the inflow of water thereby protecting the nests.

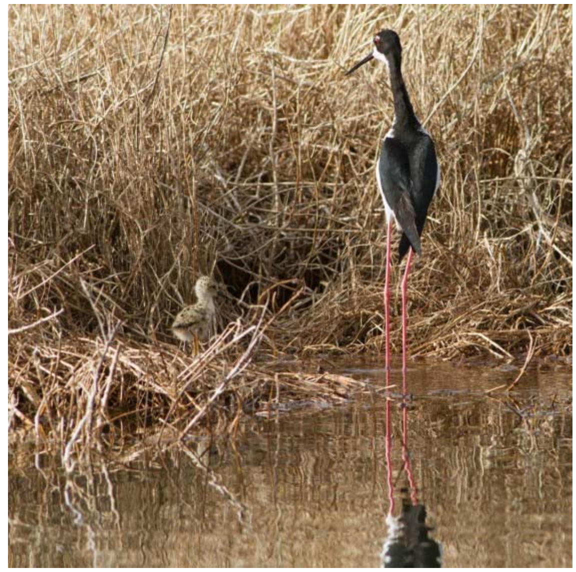

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Figure 26. Hamakua (right) and Kaelepulu Wetlands (above) provide excellent foraging, breeding, and nesting habitat for several species of native Hawaiian waterfowl on the endangered species list**.** (Photo Credit: H DeVries)

4.3 Geology

The Marsh and Levee are located on the windward coastal area of the Ko‘olau Volcano. The study area is directly underlain by Alluvium (Figure 27) but the underlying rock is Ko’olau Basalt, which erupted between 1.8 to 2.7 million years ago (Doell and Dalrymple, 1973). The Koolau lavas are divided into the Ko‘olau Basalt and the Honolulu Volcanics. Both of these formations play an important role in the vicinity of the study area. Koolau Basalt is found just north and south of the levee and Honolulu Volcanics are also found south of the levee. The Ko‘olau Basalt primarily consists of Pliocene aged shield stage tholeiitic basalt. The Honolulu Volcanics are composed of Quaternary and Pleistocene aged alkalic basalt, basanite, and nephelinite (Macdonals, et al,.1983). Alluvium, called Older Alluvium in Hawaii, is found in parts of the study area.

The rocks of the Ko‘olau Basalt can be divided into three groups, lava flows (a‘a and pahoehoe), pyroclastic deposits, and dikes. The lava flows of the Ko‘olau basalt are usually thin bedded with an average thickness of about ten feet (Wentworth and MacDonald, 1953). These beds are composed of a‘a and pahoehoe flows and pyroclastic deposits. A‘a contains a solid central core between two gravely clinker layers. Pahoehoe flows are usually characterized by a smooth ropy texture. Pyroclastic deposits originate from explosive volcanism. They are composed of friable sand-like ash and indurated tuff deposits. Dikes are thin near vertical sheets of rock that intruded or squeezed into existing lava flows or pyroclastic deposits.

The Honolulu Volcanics erupted much later than the Ko‘olau Basalt and overlay the deeply eroded Ko‘olau Volcano and its associated alluvial deposits. Near Kawai Nui, they are composed mostly of lava flows of approximately 0.6 million years old (Sherrod and others, 2007). The lava flows have flow structures similar to the Ko‘olau Basalt.

Alluvium is composed of unconsolidated deposits of silt, sand, and gravel along streams and in valley bottoms. The alluvium in Kawai Nui was deposited due to the eustatic changes in sea level in marsh area. Eustatic changes in sea level have alternatively left the Kawai Nui area submerged and emergent. A higher stand of sea level and subsequent submergence resulted in the deposition of both consolidated and unconsolidated marine sediments within the Marsh. Re-emergence of the area to nearly its present level allowed for the formation of the barrier beach dunes (Stearns and Vaksvik, 1935) separating the marsh from Kailua Bay. The Coconut Grove area of Kailua just makai of the project site now occupies a portion of the beach dunes that formed across the mouth of the shallow bay.

Core samples collected from underneath the Marsh reveal marine coral and calcium carbonate containing deposits underlying shallow clays and organic sediments (Takasaki et al., 1969). Previous researches have suggested that from approximately six thousand to about four thousand years before the present, Kawai Nui was an open marine bay, similar to present day Kane`ohe Bay. Coral sands washed up on the silty beaches along the inland portion of the bay, while the peripheral slopes supported a tropical forest.

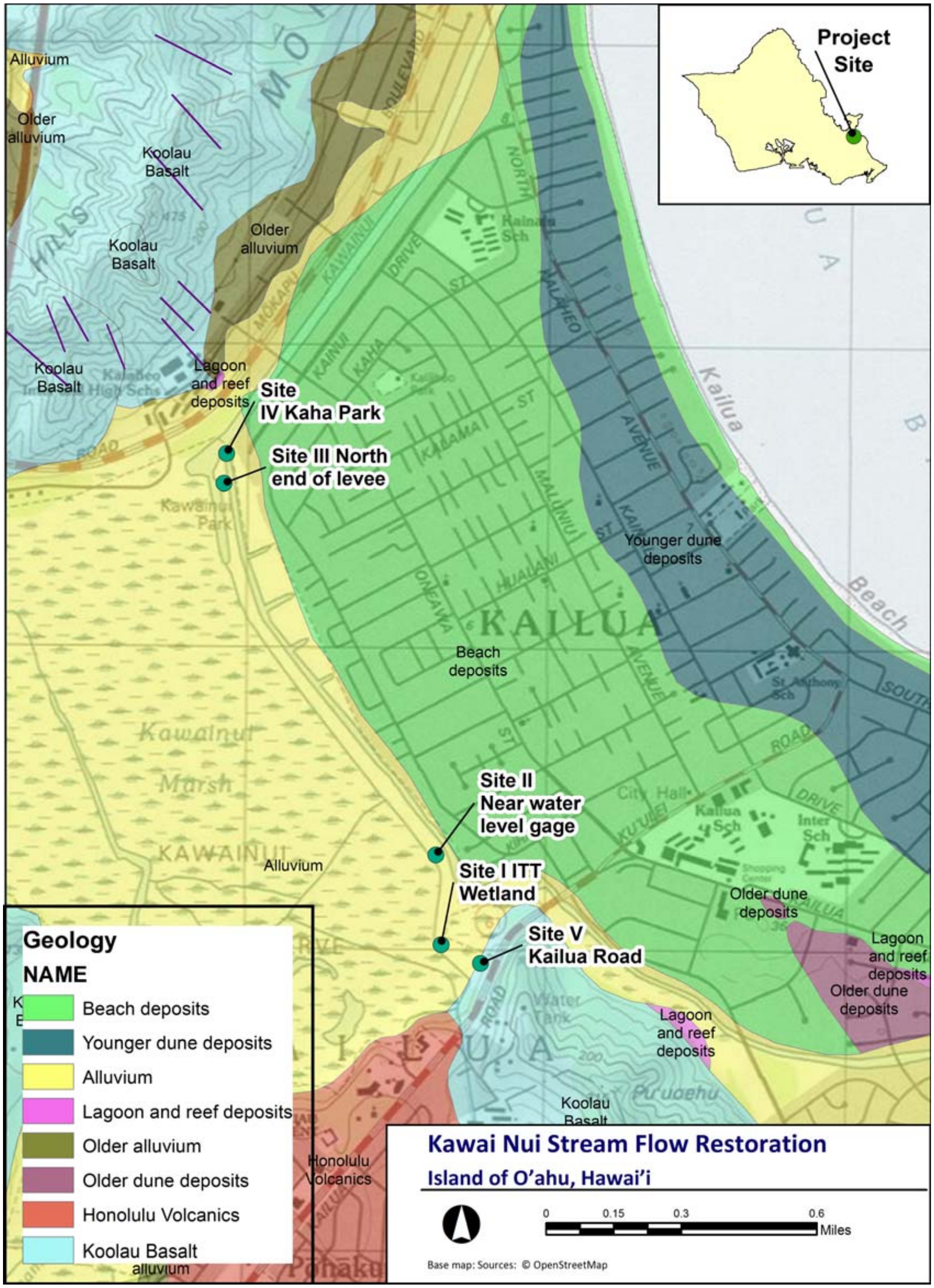

Figure 27 Geology of project vicinity

4.3.1 Hydrogeology and Hydrology

The principal reservoirs of groundwater in O'ahu are in basaltic lava flows that were extruded above sea level. Lava extruded above water is generally thinly bedded alternating layers of clinkers that result in rock units that are highly permeable. Because of isostatic readjustment and associated subsidence, these subaerial flows are now at depth below sea level throughout Oahu. The regional permeability of the basement lavas is significantly reduced when they are intruded by dikes. The reduction in permeability is a function of the number and volume of the dike intrusions and the geometry of the dikes (Takasaki and Mink, 1985). At Kawai Nui, the basement rock is composed of heavily altered basalt that is intruded with between 10% to 80% dike intensities (Walker, 1988) and is thus poorly permeable and not considered a viable source for developing significant quantities of groundwater.

The Marsh receives drainage from an area of about 9.7 square miles within the Kailua Watershed (Wilson Okamoto & Assoc., 1994). Most of the input is from the sub-basins of Maunawili Stream (5.6 square miles), Kahanaiki Stream (1.9 square miles), and Kapa`a Stream (1.2 square miles). The total freshwater input to the Marsh is estimated at 16 CFS from the Maunawili basin streams with a monthly variation from about 6 CFS to 25 CFS (Figure 28). Additional input from direct rainfall to the Marsh is about 4 CFS. Discharge to Kailua Bay through the Oneawa Channel is estimated at about 11 CFS (Wilson Okamoto & Assoc., 1994) and an additional 7 CFS lost to evapotranspiration (at evaporation of $^1/_5$"/day over 894 ac of the Marsh). These values are overall averages that are subject to seasonal variations. A mass balance of water flow in the system based upon monthly flows is shown in Figure 5. The upper streams and remnant ponds in the marsh are fresh water; while the salinity of water within Oneawa Canal as it drains the Marsh is affected by tidal influence. Patterns of water flow and circulation beneath the floating vegetative mat within the Marsh are poorly understood. The amount of open water in the Marsh varies considerably with patterns of rainfall runoff. Sharp or sudden rises in Marsh water level always correspond to heavy rainfall periods.

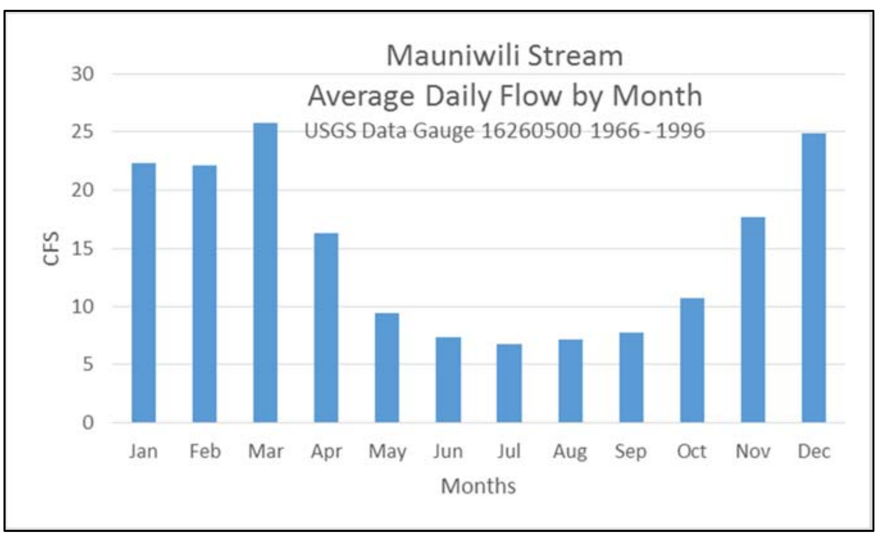

Figure 28. Average Daily Flow into the Marsh from Maunawili Stream

Kaelepulu Watershed, a subset of the larger Ko'olaupoko Region, covers approximately 3,450 acres, or roughly 25-times the water surface area of the entire KWS estuary. The upper reaches of the watershed extend to the top of Mount Olomana, approximately 3 miles north of Kailua Bay (EPA, 2015). The majority of the watershed is separated from the Koolau Mountain ridge and is therefore not typically subject to diurnal orographic rainfall or to the intense rainfall associated with the uplift of the storm systems as they meet this mountain range. Annual rainfall averages 41-inches, with winter rainfall of 5-6 inches per month and summertime rainfall between 1 and 2 inches per month (Figure 29).

The large majority of water flow enters the estuary through the City's storm drain system with minor inflows through the remnants of natural stream systems, overland and potentially groundwater flow. Significant rainfall events result in an average rise of pond elevation at a ratio of approximately 1:3. For large or intense rainfall events with significant antecedent rainfall, the rates are often 1:4 (Bourke, 2016) Evaporation from the system in the absence of rainfall averages about 0.25-inch per day, or roughly 7.5-inch per month. At a 1:3 rain:rise ratio, 2.5-inches of rain are required per month to offset evaporative losses (Figure 29).

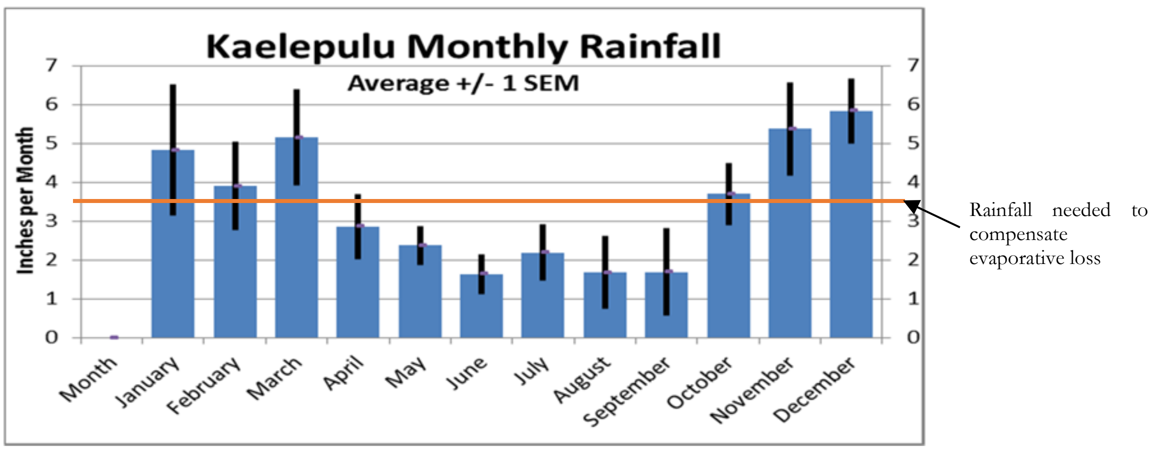

Figure 29. Monthly average rainfall compensation required to match evaporative loss

4.3.2 Impacts on Geology, Hydrogeology and Hydrology

The proposed project would likely positively affect coastal resources because it would improve patterns of water flow and circulation thereby restoring aquatic ecosystem functions within the 142-acre downstream KWS estuary.

The geology of the area would not be impacted by the proposed project. There would be impacts to the hydrology but these impacts would be negligible and are intended to improve the water quality and ecosystem. Impacts to hydrogeology would also be negligible, as there would be a directly proportional increase in groundwater surface elevation. Water flows would be increased in Kawai Nui and Kaelepulu Streams with an equal decrease to flow in the Oneawa Canal draining the Marsh. No adverse impact is anticipated from the flow increase. The decreased flow to Oneawa Canal is not anticipated to result in any decrease to water quality because flow quantity in this channel is tidally influenced.

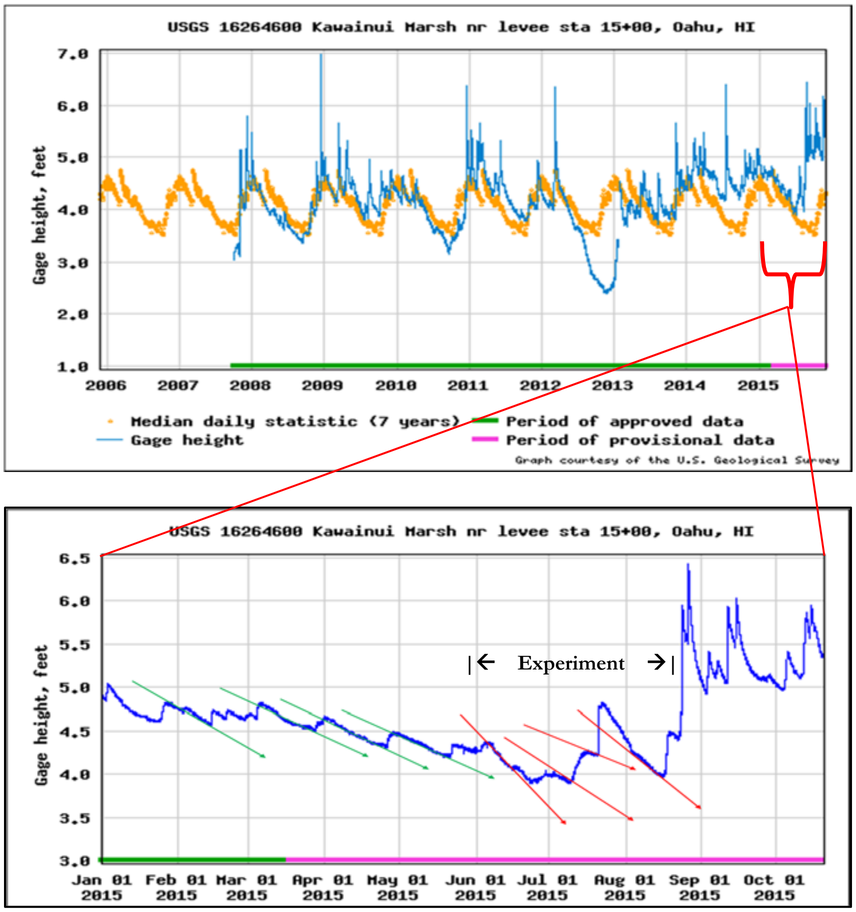

Figure 30 Top: 9-year record of Kawainui Marsh surface elevation compared to long term average. Bottom: Elevation of Kawainui Marsh during 2015 only, prior to and during siphon experiment. Arrows show rate of surface elevation decline.

4.4 Flooding

The primary purpose of the Levee is to control flooding. Therefore allowing water to flow past the levee into the floodplain is an issue deserving serious consideration. According to the Federal Emergency Management Agency (FEMA), Flood Insurance Rate Map (FIRM), the Project area's flood zone designation is Zone A (1% chance of flooding), on the Mauka (Marsh) side of the levee and Zone AH (1% chance of shallow flooding, protected by levee) on the makai (Kawai Nui Stream) side of the levee (Figure 31). The Project is not in a tsunami evacuation zone and will not be adversely impacted by tsunami.

The volume of water proposed to be transferred past the levee (2 CFS) is insignificant in comparison to the volume of runoff inflowing to the 894 acres of the Marsh or 142 acres of Kailua Waterways during any significant rainfall event. A flow rate of 2 CFS is equivalent to rainfall directly into the 142-acre surface of KWS from a 0.014-inch per hour or $^{1}/_{3}$-inch per day rainfall. Although there would be no measurable increase to public safety, the flow could be quickly and easily disconnected during any flood conditions by closing one of two valves at the intake to the flow pipe.

4.4.1 Impacts on Flooding

Implementing a permanent water transfer method would likely have negligible to no significant adverse impact on floodplains nor result in any measurable increase in a flood threat. The proposed project area could be inundated by flooding during a major storm event; however it is highly unlikely that the project could adversely impact flooding to other areas. In any flooding situation, the water flow through the pipe can be discontinued by closing a valve. The size of the proposed diversion from the Marsh to the Kawai Nui Stream would not contribute enough water to produce or significantly increase the threat of flooding to downstream areas.

The Levee and Oneawa Canal were designed to contain an inflow of 18,100 CFS from the watershed, and transfer 6,700 CFS from the Marsh to Kailua Bay (ParEng, 1993). The Marsh has an area of over 1 square mile (~ 30 million square feet) with a storage capacity above high tide (1.7 ft) and below the lowest point on the levee berm (10.8 ft, not including the 4-foot flood wall) of 245 MCF of water. The Kawainui Stream and Kaelepulu watershed have a designed inflow capacity of 5,055 CFS and transfer flow capacity of 2,840 CFS to Kailua Bay through Kailua Beach (ParEn, 1993). The flood storage capacity of KWS (142 acres between 1.7 ft and 3.0 ft) is 7.6 MCF of water. The 2 CFS flow proposed to be transferred between these two systems is insignificant in comparison to the above flood flow rates and volumes.

Residential parcels in Kailua along the KWS shoreline begin to be threatened by flood when the water surface elevation of KWS reaches 3.0 ft (Figure 31). At this water surface elevation the banks in low laying areas (such as by Buzzes near the Lanikai Bridge) start to overflow and inundate adjacent property. The ParEn flood study (1993) lists a slightly higher flood elevation (3.7 ft MSL), but acknowledges that at this elevation flooding is already occurring in a number of low lying lots.

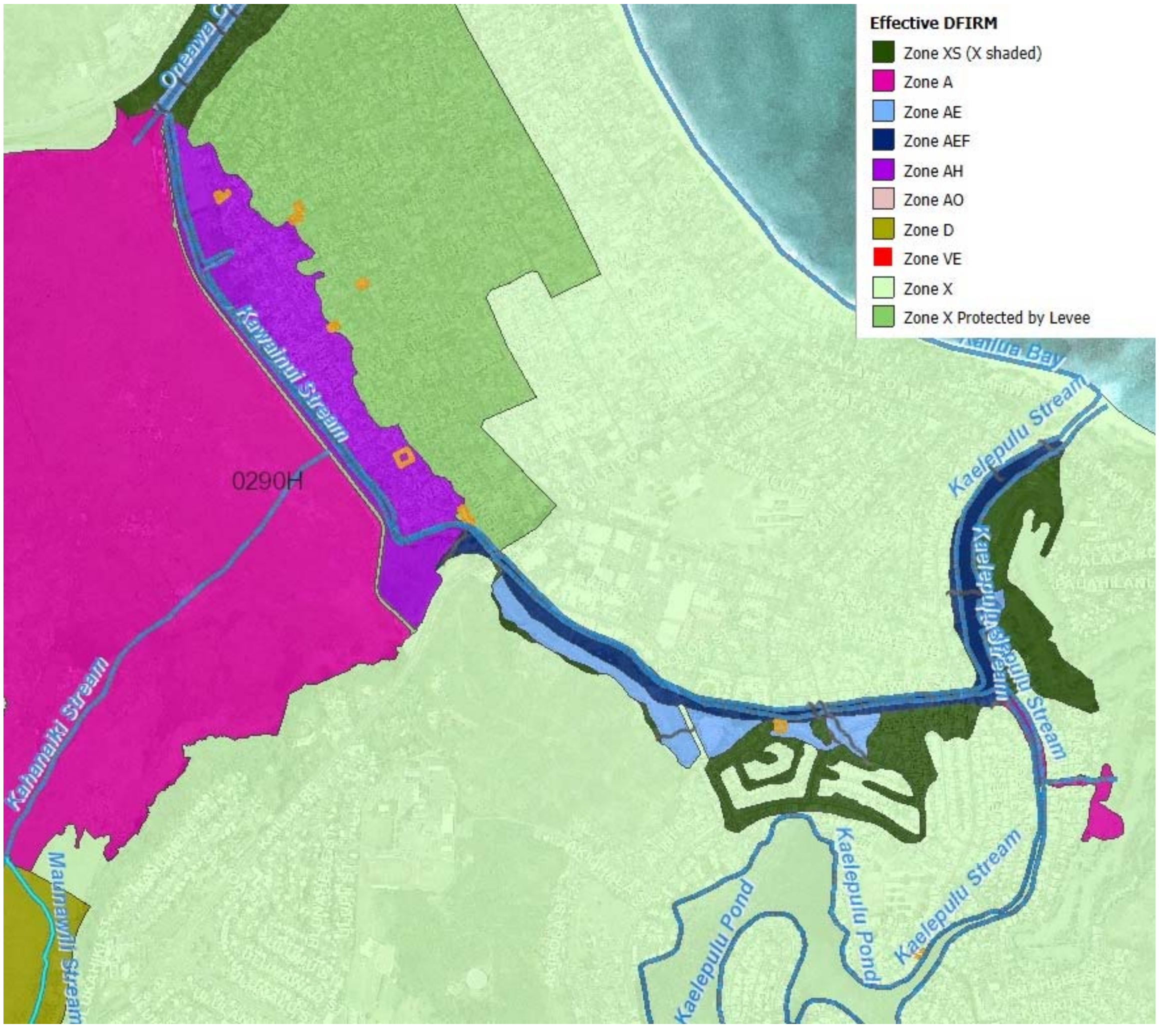

Figure 31. FEMA flood zone map of Kailua and Kawai Nui.

If the preferred alternative (a 300-foot long, 12-inch pipe beyond the Kailua end of the levee) were to be constructed and a worst case scenario is presumed (when the Marsh is at flood stage of 12-ft. and Kailua Waterways is very low at 1.0-ft) a 12-inch pipe at 11-foot head pressure would be capable of transferring about 16 CFS from the Marsh to the Stream. 16 CFS is 0.5% of the design outflow capacity of the Kaelepulu system through the Lanikai Bridge (2,840 CFS) expected from a 100-year storm (ParEn, 1993). This 16 CFS flow would result in an additional rate of rise of a 1/8th inch per hour in the 142 acre Kailua Waterway System. Presuming that this flow continued for 8 hours unabaited it would raise the Kaelepulu system by 1-inch. For comparison purposes, this is the same rate of rise that would be expected from a rainfall of about 1/3-inch during this same time period across the 142 acre Kailua Waterway System. would not be an adverse flooding impact because the pipe is not physically large enough to transmit a quantity of water that could measurable impact flood levels on the time scale during which floods occur. The proposed pipeline is not capable of carrying suffient water to cause any measurable increase flood risk to the residents of Kailua. The 16 CFS inflow rate from the pipe under a worst-case scenario is insignificant compared to any direct rainfall or watershed runoff that would likely accompany such an event.

Another concern may be that by raising the elevation of the system from 1.2-feet to 1.7-ft. may limit the City DPW's response time to open the stream mouth when threatened by rapidly rising water during an extreme rainfall event. Flooding in the system has been determined to be controlled primarily by the height of the sand berm at Kailua Beach (ParEn, 1993). The stream system was determined to be of adequate size to convey 100-year flood flows at an elevation of 3.8 ft MSL which would result in minor flooding to a small number of home lots near the Lanikai Bridge..

The elevation where minor flooding begins to occur at streamside homes in Kaelepulu Stream has been observed to occur at 3.0-ft. MSL. The ParEn report (1993) states a flood elevation of 3.7-ft, but acknowledges that at this elevation "several" home lots are inundated. If the elevation of the sand berm is lower than 3.0 ft then the stream overtops the berm and rapidly creates a discharge channel before flooding occurs. If the elevation of the sand berm at the mouth of Kaelepulu Stream is greater than 3.3 feet, then the City must lower the berm with heavy equipment to prevent flooding before the flood water level rises above 3.3 feet. Therefore the difference in response time is the difference in the time it takes for water levels in the system to rise from 1.7-ft. to 3.0-ft. as compared to the more typical 1.2-ft. to 3.0 ft. Under existing conditions, the water surface elevation often exceeds 1.7 ft (Figure 32) several times during the year and is a flood threat not previously recognized.

How much time do City crews have to respond to an emergency stream opening event before flooding occurs? As an example, during a 20-year 6-hour rainfall event the total rainfall is 6-inches, or about 1-inch per hour (Rainfall Atlas of Hawai'i 1986). Under this extreme rainfall rates, the Rain : Rise ratio in the Kailua Waterways system has been measured to be as high as 1:8, so the system may be expected to rise at a rate as fast as 8 inches/hr (0.66 ft./hour) during this heavy rainfall. The average water level is 1.2-ft. with a normal range of 0.8 to 1.6-ft. and the flood water level is 3.0-ft. During a 20-year 6 hour rainfall event the City crews have a theoretical response time of about 2.7 hours to open the Kaelepulu Stream mouth and prevent flooding ([3.3-1.5]/0.66). Comparatively, due to the elevated water level during this experiment of 1.7-ft., the City crews would only have a 2.0 hour response time. This 45-minute difference may be significant and bears discussion with the response agencies. However, it should be noted that during the 2014-15 winter, the natural (not managed) stream elevation was above 1.7-ft. for at least 6 weeks with no reported adverse comments from the community.

A long term, appropriate solution may be to maintain the beach sand berm at an elevation lower than 3.0-ft through regular monthly stream mouth openings. Another alternative would be to provide a surface drain from the end of Kawai Nui Stream to the Oneawa Canal that would allow water above the 1.7-ft elevation to drain through the levee back to the Canal. A Possible Additional Project (E) was analyzed to address the concern of overly high water surface elevations by allowing the water to drain down to a maximum elevation of 1.7-ft. This concept is discussed in Appendix A.

If the proposed project is not implemented there would be no adverse impact to floodplains in the short term. However, over the long term, not restoring water flow to the Kaelepulu Watershed system would decrease the opening frequency of the stream mouth thereby allowing the sand bar to build to greater heights. The increased height of the sand bar across the mouth of Kaelepulu Stream would likely become a perceived flood threat factor affecting up-stream low-lying residential properties.

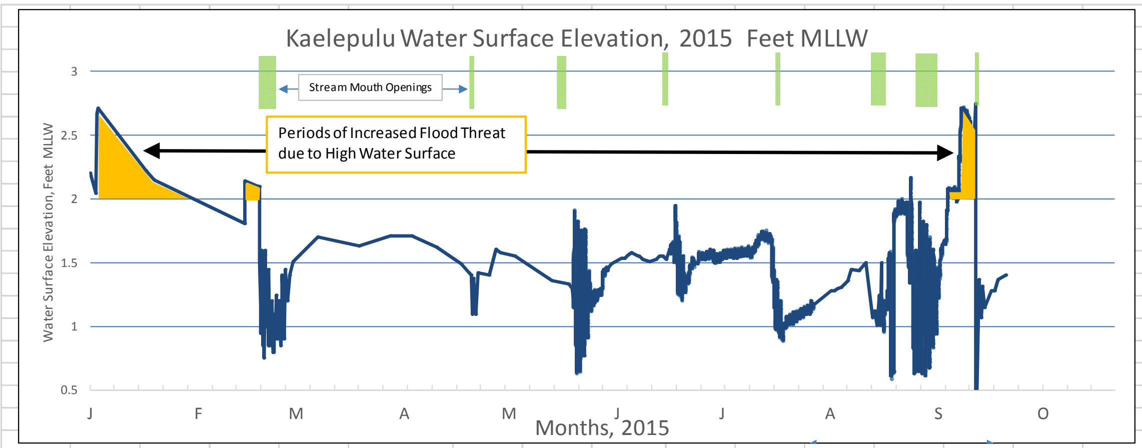

Figure 32. Water surface elevation of Kawainui Stream and Kaelepulu system during 2015, showing periods of previously unrecognized increased flood threat when water surface elevation remains above 2.0 feet MLLW (1.7 ft MSL).

4.5 Coastal Resources

Natural coastal resources are plentiful within Kawai Nui and Kaelepulu Watersheds. The Marsh was designated as a Ramsar Wetland of International Importance. The Marsh and two wetlands in the adjacent Kaelepulu system support the foraging and breeding of migrating waterfowl and three species of endangered Hawaiian waterbirds. Both the Marsh and KWS drain to Kailua Beach. Kailua Beach is world famous for its white sand beach, offshore reefs, windsurfing, and many other tourist and recreational activities. The Marsh drains into the Pacific Ocean at the northwest end of the beach through the USACE constructed Oneawa Canal, and Kaelepulu drains to the ocean at the south east end of the beach. The project would shift 2 CFS of the total 11 CFS water flow away from the Oneawa Channel and the northwest end of Kailua Bay, and restore it to the Kaelepulu Stream mouth at the south-east end of the Bay.

4.5.1 Impacts on Coastal Resources

The proposed project would likely have negligible to no significant adverse impact upon coastal resources. It is surmised that the proposed project would likely positively affect coastal resources because it would restore historic flow patterns and improve circulation thereby improving water quality in KWS.

Implementation of the project would result in a shift in water inflow to Kailua Bay from the Oneawa Canal, to the Kaelepulu Stream at opposite ends of the bay. As a first estimate the volume of fresh water shifted from the north to the south end of the bay at a flow rate of 2 CFS would be approximately 4.75 MCF per month. This is the volume difference resulting from raising the elevation of the 142 acre estuary by 6 inches (~ 3 MCF) plus the additional flow volume that occurs during the period the stream mouth is open to flow to the ocean. This will impact the distribution of salinity within the bay, although the impacts from this change in distribution are not believed to be significant.

If the proposed project is not implemented then future water quality conditions are likely to be the same as present water quality conditions. Over the long term (50 years), the Kaelepulu Watershed system would continue to infill with sediments and precipitated organic material, experience an increased incidence of low water levels, low dissolved oxygen levels, and associated fish die-off and avian botulism events.

4.6 Biology

The proposed project would serve to re-connect the the Marsh with the Kawai Nui Stream which controls water elevations within both the Hamakua Wetland, and the Kaelepulu Wetland.

The most abundant plant species present on the marsh side of the levee include California grass (*Brachiaria mutica*), Hilo grass (*Paspalum conjugatum*), honohono (*Commelina diffusa*), and Indian pluchea (*Pluchea indica*). In drier areas of higher elevation Sensitive plant (*Mimosa pudica* var. *unijuga*), Wedelia (*Wedelia trilobata*), Kamole (*Ludwigia octovalvis*), and Bamboo (*Phyllostachys nigra*) are also found (U.S. Army Corps, 2009).

The Marsh and adjacent wetlands are essential habitat for many birds including four federally listed endangered waterbirds. These four species, which are endemic to Hawaii and non-migratory, include the Hawaiian Coot (*Fulica alai*), Hawaiian Stilt (*Himantopus mexicanus knudseni*), Hawaiian common moorhen (*Gallinula chloropus sandvicensis*), and Hawaiian duck (*Anas wyvilliana*). Waterfowl located within the natural flooded portion of the Marsh are limited due to the floating overgrowth covering 98% of the water surface area. Migratory geese and ducks found at various times throughout the year include Northern pintails (*Anas acuta*), Northern shovelers (*Anas clypeata*), Mallards (*Anas platyrhynchos*), Canada geese (*Branta collaris*), Lesser scaup (*Aythya affinis*), Geen-winged teal (*Anas crecca*), American wigeon (*Anas Americana*), and Redheads (*Aythya Americana*) (Shallenberger, 1997, Conant 1981, and Engilis, 1988). Shorebirds reported in the area include Pacific golden plover (*Pluvialis dominica*), Ruddy turnstones (*Arenaria interpres*), Sanderlings (*Calidris alba*), and Wandering tattlers (*Heteroscelus incanus*) (Shallenberger, 1997, Conant 1981, and Engilis, 1988). Other common birds observed are Black-crowned night heron (*Nycticorax nycticorax*), Spotted doves (*Streptopelia chinensis*), Red-vented bulbuls (*Pycnonotus cater*), House sparrows (*Passer domesticus*), Cattle egrets (*Bulbulcus ibis*), and Common mynas (*Acridotheres tristis*).

Land animals present include non-native mongoose (*Herpestes auropunctatus*), feral cat (*Felis cattus*), feral dog (*Canus familiarus*), mouse (*Muss* sp.), pig (*sus scrofa*) and rat (*Rattus* sp.) species.

The most abundant fish species identified in the Kawainui marsh include tilapia (*Oreochromis mossambica* and *Sarothorodon melanotheron*), mosquitofish (*Gambusia affinis*), guppy (*Poecilia spp.*), carp (*Cyprinus carpio*), Chinese catfish (*Clarasfuscus*), swordtail (*Xiphophorus heller*), bronze catfish (*Corydoras aeneus*), and smallmouth bass (*Micorpterus dolomieui*). Native fish species found in the marsh are endemic goby (*Awaous guamensis*), indigenous goby (*Stenogobius genivittatus*), endemic eleotrid (*Eleotris sandwicensis*). Native invertebrates include shrimp (*Atyoida bisculata* and *Macrobrachium grandimanus*) and introduced invertebrates include Tahitian prawn (*Macrobrachium lar*), crayfish (*Procambarus clarkii*), damselfly (*Ischnura ramburii*), apple snail (*Pomacea sp.*), and pond snails (*Melanoides sp.*).

Kawai Nui Stream has been cut off from the marsh since 1966 and the waters are now brackish as compared with the mostly freshwater content of the marsh. Marsh water salinity is typically close to 0 ppt although it is possible that some salt intrusion from Oneawa Canal may be occurring at depth. The Kawainui Stream water is stratified with salinity near the bottom commonly measured between 3 and 14 ppm. Typical nearshore ocean salinity is about 34 ppt. The most abundant species present within the Kawai Nui Stream are tilapia (*Oreochromis mossambica* and *Sarothorodon melanotheron*). In the lowest reach of Kawainui Stream and the Kaelepulu system additional species become more prevalent including milkfish (*Chanos chanos*), mullet (*Mugil cephalus*), lai (*Scromboides lysan*), papio (*Caranx ignobilis*) pufferfish (*Diodon hystrix*) and barracuda (*Sphyraena barracuda*).

Insect species are abundant within the marsh and wetland areas surrounding the streams and canals. Common species found include damsel fly (*Megalagrion sp.*), dragon fly (*Anax sp.*), grasshopper (*Schistocerca sp.*), water boatmen (*Corixidae sp.*), earthworms (*Lumbricus sp.*), dipterean flies (*Ephydroidea sp., Ephemeroptera sp., Trichoptera sp.*), polychaete worms (*Polychaetes sp.*), and several species of beetle (*Coleoptera spp.*). Cane toads (*Rhinella marina*) are common in and around the marsh and wetlands and feed on local insect species.

4.6.1 Managed Wetlands

The lower Kawai Nui Stream and upper Kaelepulu Pond contain the Hamakua and Kaelepulu Wetlands which are managed to benefit native endangered waterbird species. Water elevations are critical to the management of wetlands. Water elevations that are too low do not support waterbird habitat, and water elevations that are too high either drown wetland plants or may be too deep to allow the birds to forage. Water elevations that rise too quickly can be a danger to birds that nest on the ground. Water elevations that are overly stable do not induce the variations in aquatic invertebrate and flying insect populations upon which the birds rely as a food source.

Hamakua Wetland is a 23-acre State DLNR managed water bird refuge, located on Kawai Nui Stream just below the Marsh (Figure 1). The refuge is highly visible from downtown Kailua where it abuts the stream. The wetland is hydraulically isolated from the Marsh by the Levee, but is considered to be part of the Marsh complex. At water surface elevation of 1.0 feet, the major portion of the Hamakua Wetland does not have standing surface water. At an elevation of 1.7-ft., approximately 90-percent of the wetland is flooded. In the past when water surface elevations have been allowed to remain very low (<1.0 ft) for extended periods of time, Hawaiian Stilts would occasionally lay nests on the dried mud flats. Then when the stream mouth is opened, incoming tidal waters can flood these lowlying flats resulting in the loss of the eggs or fledglings.

Kaelepulu Wetland is a privately owned 13.7-acre wetland at the southern extent of Kaelepulu Pond (also referred to as Enchanted Lake). 5.8-acres of the property is a USACE designated constructed wetland, and 7.9 acres is wetland and shallow open water contiguous with Kaelepulu Pond. The wetland is managed as a bird preserve and presently hosts healthy population of Hawaiian waterfowl. (Count as of 3/2013: 100+ Hawaiian Coots, 23 Hawaiian Gallinule, 22 Hawaiian Stilt, 10 Night Heron, plus miscellaneous ducks and geese). At a water surface elevation of 1.3 feet about half of the 13.7-acre wetland is above water level. At an elevation of 2-ft., approximately 80-percent of the wetland has surface water with much of this area at a depth of 0 to 9-inches considered ideal for Hawaiian Stilts.

4.6.2 Open Water Estuary

Kaelepulu Pond and Wetland is the 100-acre remnant of a 180-acre natural pond once owned by Kamehameha Schools. Following urbanized development that greatly modified the pond, both ownership and management were transferred to the surrounding home owners in 1987. The “pond” is actually a dynamic estuary that responds to freshwater inflows from storms and saltwater flows from the Pacific Ocean during periods when the sand dune located at the mouth of Kaelepulu Stream is open to water flow. The pond supports a broad range of fish stocks including: mullet (Awa awa); jacks (Papio); barracuda (Kaku). Unfortunately, the KWS is also subject to urban pollution and subsequent overgrowth of algae (*Gracilaria tikvayhae*) and occasional bouts of low dissolved oxygen levels.

4.6.3 Impacts on Biology

Implementing a permanent water transfer method may affect, but would not likely adversely affect the biology resources associated with the proposed project site. Restoring water flow and improving water circulation would improve aquatic ecosystem functions and preserve habitat for endangered Hawaiian waterbirds and migratory bird species. Potential adverse impacts to actively nesting birds would be mitigated by coordination with wetland managers to avoid increasing water surface elevations when nests are present.

If the proposed project is not implemented; future conditions would remain the same over the short term. The conditions that would remain the same include: poor water quality; poor water circulation; no control over water elevations which threaten the habitats of endangered waterfowl species.

Removal of a limited amount of water from the Kawai Nui system is unlikely to have any measurable impact upon the limited open water features of the marsh, but is likely to positively impact the two managed waterfowl refuges within the receiving system. Other flora and fauna are not likely to be adversely impacted.

4.7 Visual Resources

During project construction machinery and stockpiled materials will partially block views of the Marsh from Kailua Road near the southern end of the Levee. The completed preferred alternative woud be primarily below grade, within only a narrow walkway extending out into the Marsh about 40-feet to the intake screen and would not adversely imnpact visual resources. Outfalling water into the ITT wetland will likely result in a larger ponded water surface within this park. The flow of 2 CFS into this reed-dominated habitat will slowly change the character of the reed bed into sinusoidal flow channel(s) leading to the existing pond within the park.

4.7.1 Impacts

Implementing a permanent water transfer method would likely have negligible to no significant adverse impact on visual resources.

4.8 Air Quality and Noise

The State Department of Health, Clean Air Branch, monitors ambient air in the State of Hawai ʻ i via 14 air quality monitoring stations on three islands. Oahu has six monitoring stations, Big Island has seven monitoring stations and there is one monitoring station located on Maui. The Environmental Protection Agency has set standards for six pollutants: 1) carbon monoxide; 2) nitrogen dioxide; 3) sulfur dioxide; 4) lead; 5) ozone; and 6) particulate matter ($PM_{2.5}$ and PM_{10}). The State has set standards for nitrogen dioxide (70 $\mu g/m^3$) and carbon monoxide (10,000 $\mu g/m^3$). According to the 2006 annual summary, none of these pollutants exceeded State or Federal standards in the last 3 years from 2006 to 2008. Ambient air quality in the State of Hawai ʻ i continues to be one of the best in the nation.

Kailua is a small coastal town on the windward side of the island of Oahu roughly 2,000 miles from another land mass. As such the air quality is typically deemed as “good”. There are three wetlands associated with the proposed project site, the Kawai Nui Marsh, Hamakua Wetland, and Kaelepulu Wetland. Wetlands do produce “marsh gas” – typically a mixture of methane and hydrogen sulfide – The production of these odors is associated with periods of little or no rainfall which results in a lack of flow, stagnation, lower water surface elevation, and low dissolved oxygen levels in the water. On occasion, the low dissolved oxygen events also lead to fish die-offs which can adversely impact air quality down wind. Methane and hydrogen sulfide gas are produced during anaerobic metabolism of bacteria within the mud, with these gasses typically released in response to the lowering of pH that occurs when runoff is formed during a rainfall event.

Prior to the removal of the major stands of mangrove from Kaelepulu Pond around 1990 the community on the leeward side of the pond was faced with almost continual episodes of anaerobic rotten-egg odors. Following removal of the mangrove, the incidence of malodorous events dramatically decreased. During the past decade malodorous events have been associated with rare sewage spills into the pond, with slightly more common low-oxygen fish die-offs (likely the result of nutrient enrichment) and annual episodes of low water surface elevations that exposed mud flats for extended periods. Malodorous events associated with low water levels extend up the Kawai Nui Channel and are associated with each area of significant mangrove growth. Increasing the average elevation of the streams and pond is likely to further reduce episodes of malodorous events, particularly along the Kawai Nui Stream channel. During the period of the experiment (May – August) when water levels were higher than seasonally expected, there were no incidents of malodorous events.

4.8.1 Impacts

Implementing a permanent water transfer method would likely have a negligible to slightly positive impact on air quality. The existing air quality conditions would not differ from post construction air quality conditions except that the frequency of summertime low-water events often associated with episodes of bad odors from mangrove stands would be expected to decrease.

Under the no action Alternative, the proposed project would not be conducted and there would be no change from present ambient conditions. However, if a permanent water transfer method is not implemented, then it is likely that air quality downwind of the Kaelepulu Pond and Wetland would experience increasing incidence of marsh gas odors associated with low water stagnation, low dissolved oxygen, and fish die-off events as the system continues to slowly become more eutrophic.

5 Infrastructure, Public Facilities, and Utilities

This section describes the existing infrastructure, public facilities, and utilities in the vicinity of the proposed project site and any adverse impacts that the proposed project would incur. Water, wastewater, drainage, solid waste, transportation, power, communications, medical, schools, police, and fire will be addressed in this section.

5.1 Transportation

The main roadway arteries that pass in close proximity to the Marsh include Kailua Road (Pali Hwy), Mokapu Boulevard and Oneawa Street. Kailua Road runs along the southeast portion of the Marsh. Oneawa Street runs the northeastern portion of the Marsh and Mokapu Boulevard runs along the northern end of the Marsh. Kihapai Street is the local through street located closest to the levee. Kaha Street, Kainui Drive and Kahoa Drive are also adjacent to the levee.

5.1.1 Impacts

Implementing a permanent water transfer method would likely have negligible to no significant adverse impact on transportation. During testing and construction, access to the site will be from either Kailua Road or Kaha Street. It is not anticipated that the flow of traffic would be impeded along Kailua Road or Kaha Street.

5.2 Power and Communications

Electricity is provided by Hawaiian Electric Company HECO, and telephone communications are provided by several private companies. Oceanic Time Warner Cable provides cable TV service. Only one of the options would require electric service to run the pumps required to transfer water.

5.2.1 Impacts

Implementing a permanent water transfer method would likely have negligible to no significant adverse impact on power and communications.

5.3 Schools

A private pre-school, The Sunshine School, located off of Kainui Drive backs up onto the Kawai Nui Stream. Other private preschools and a grade school associated are associated with the four churches along Kailua Road above the site of the preferred alternative. Kailua Highschool is located about ½ mile up Kailua Road from the south end of the Levee and site of the preferred alternative. Le Jardin is a private middle and high school located off of the Quarry Road just inland of the Kawai Nui Marsh and about a mile from the project.

5.3.1 Impacts

Implementing a permanent water transfer system would likely have negligible to no significant adverse impact on schools in the area. Improvements to water quality within the Kawai Nui Stream could have beneficial impacts to The Sunshine School as it is immediately adjacent to the stream. However, because this lots is well fenced off from the stream, any positive impacts are not likely to be noticed.

5.4 Medical, Police and Fire

Kailua is served by the Castle Hospital, located approximately 1 mile up Kailua Road and is afforded a limited view of Kawai Nui Marsh. The Kailua Police Department and the Kailua Fire department are located on Kuulei Road, a continuation of Kailua Road approximately 1 mile towards the beach from the site of the preferred alternative.

5.4.1 Impacts

No adverse impacts or increased need for medical, police, or fire prevention services are anticipated as a result of project implementation.

6 Conformance with Plans and Policies

This section describes the relationship of the proposed project to applicable State and County policies related to the proposed project.

6.1 Kawa Nui Marsh Resource Management Plan (1983)

The *Kawainui Marsh Resource Management Plan (1983)* specified objectives, policies, and a comprehensive list of recommended actions to manage and use the Marsh. The primary recommended use is as a flood control facility. Secondary uses includes taking advantage of the area's intrinsic beauty by encouraging continued public use. Recommended actions include the creation of safe hiking paths and jogging trails in perimeter areas of the marsh; creation of access routes and trails to connect principal culture features and for nature studies.

6.2 Kawa Nui Master Plan (1994)

The *Kawai Nui Master Plan (*1994) was completed by the State of Hawaiʽi, Department of Land and Natural Resources (DLNR) to supplement the conceptual framework set forth in the *The Kawainui Marsh Resource Management Plan*. The main focus of the plan is to preserve public use and appreciation by ensuring continued preservation of the marsh's resource values. Neither the Hamakua Marsh nor the Kawainui Stream are considered in this master plan.

6.2 Kawai Nui – Hamakua Complex Master Plan Update (2014)

The draft of the updated master plan does not mention the concept of water transfer between the marsh and the stream. It does, however, consider the Hamakua Wetlands as part of the Kawai Nui system and stresses the importance of controlling the flow of water to benefit all the natural systems supported by Kawai Nui. There is nothing in the draft plan that would classify the water transfer automatically as either a positive or an adverse impact.

6.3 Ko'olaupoko Sustainable Communities Plan (2000)

The *Ko'olaupoko Sustainable Communities Plan* is one of several community-oriented plans on the Island of Oahu intended to help guide public policy, investment, and decision making through the 2020 planning horizon. It addresses areas of development, vision for the future, land use, public facilities and infrastructure, and implementation. The proposed project specifically aligns with the guidance of the Plan with regard to the following recommendations:

- Modifications needed for flood protection should be designed and constructed to maintain habitat and aesthetic values, and avoid and/or mitigate degradation of stream, coastline and nearshore water quality;
- Select natural and man-made vegetated drainageways and retention basins as the preferred solution to drainage problems wherever they can promote water recharge, help control non-source pollutants, and provide passive recreation benefits;

6.4 Kailua Waterways Improvement Plan (2003)

The Kailua Waterways Improvement Plan (2003) covers the watershed system for the Kailua ahupua'a including the ridges above Maunawili, the Marsh, Kaelepulu Pond, Coconut Grove, Kailua Town, Lanikai, the area beaches and Kailua Bay. Some long term solutions recommended in the plan include building a wetland to filter water above The Marsh, redesigning storm drain systems, and restoring flow from Kawainui Marsh to Kawainui Stream to reduce stagnation.

6.5 Koolaupoko Watershed Restoration Action Strategy Kailua Bay Advisory Council (KBAC)

The purpose of this plan is to serve as a master plan for KBAC and provide direction for the implementation of best management practices, restoration, moinitoring, education and outreach in the Koolaupoko area.

The plan refers to three water quality problems in the Kailua watershed: nutrients, turbidity, suspended solids, metals and trash. The plan does not specifically mention the project addressed in this EA but the intent of the plan is to improve water quality. One of the purposes of this project is also to improve water quality.

6.6 City and County of Honolulu General Plan 1992 (amended 2002)

The General Plan for the City and County is a comprehensive statement of objectives and policies which contain the long-range goals of Oahu’s residents and strategies to achieve them. Section III. Natural Environment has two pertinent Objectives.

Objective A To protect and preserve the natural environment.

- Policy 2: Seek restoration of environmentally damaged areas and natural resources.
- Policy 6: Design surface drainage and flood-control systems in a manner which will help preverve their natural settings.
- Policy 7: Protect the natural environment from damaging levels of air, water, and noise pollution.
- Policy 8: Protect plants, birds, and other animals that are unique to the State of Hawaii and the Island of Oahu.
- Policy 10: Increase public awareness and appreciation of Oahu's natural resources.

Objective B To preserve and enhance the natural monuments and scenic views of Oahu for the benefit of both residents and visitors.

- Policy 1: Protect the Island's well-known resources: its mountains and craters; forests and watershed areas; marshes, rivers, and streams; shoreline, fishponds, and bays; and reefs and offshore islands.

The proposed water quality restoration project aligns with the objectives and goals in the City and County General Plan.

7 Preferred Alternative

Alternative A-3, in which a single 12-inch pipe is placed below water level around the south (Kailua road) end of the levee is the preferred alternative. Implementation of alternative water transfer methods A, B, or C would achieve the desired positive impact to the ecosystem but each method has different positive and negative impacts. While method D (pump) would achieve water transfer, the long term maintenance and energy costs are significant and transfer of water at location III or IV would add salt water to the stream system which is not preferable. Method B (inverted siphon) would require structures to be built at a significant distance (~100+ ft) away from the foot of the levee, which is likely to be costly. In addition the likely accumulation of material at the bottom of the inverted siphon pipe poses a long term maintenance problem. Alternative B (siphon) would likely provide a viable option, particularly Alternative B-2 in which the siphon is buried 2-feet below the surface of the levee and passes below (not over) the flood wall. However, the difficulties experienced in keeping the siphon primed make this alternative less desirable than Alternative A. In Alternative A a single level pipe below the water surface passes water from the marsh to the stream with no energy consumption, no priming necessary, and with minimal opportunity for pipe clogging. Alternative A-2 is the most preferable in that it is the simplest, shortest pipe route and transfers water directly to the stream. However, the USACE has expressed concern about passing a pipeline through the levee below the water surface elevation or even just below the surface of the levee itself. Alternative A-3 has a longer pipeline, and is more expensive than either A-1 or A-2, but it also avoids the levee structure completely. Outfalling water directly to the ITT wetland before it flows to Kawai Nui Stream may be a drawback because long term plans to improve (i.e. dredge) this wetland to provide open water bird habitat have not yet been implemented. The placement of Alternative A-3, immediately adjacent to the Kailua Road is a positive factor as it provides easy access to the flow control structures. The USACE would prefer an alternative that did not physically impact the levee structure, and would be most likely to support alternatives that completely avoid the levee (Alt. A-3), or go over it using pumps (Alt D-1, or D-2), or a siphon over the top of the wall (Alt C-1b or C2-b).

Examination of stream elevation data from the experiment (Figure 32) brought us to the realization that the Kawainui Stream and Kaelepulu system was often at an elevation of more than 1.7-ft for extended periods of time. During these times, if another significant rainfall event were to occur, and if the sand dune and the mouth of Kaelepulu Stream is higher than 3.0-ft, then the threat of flooding is greatly increased because the City crews may not have adequate time to respond and lower the sand dune. For this reason a concept for a supplemental project, the overflow pipe, is being discussed here with plans provided in Appendix A. The pipe would allow any water in excess of 1.7 feet surface elevation to flow to the Onceawa Canal, thereby reducing the flood threat to residents along the Kawai Nui Stream and Kaelepulu system. This alternative does violate the USACE’s caution about retrofitting utilities through existing levees below the water line, however, as the primary purpose of this alternative is to minimize flood threat, this alternative may deserve additional consideration by the USACE. In addition to flood threat reduction the overflow would improve the flow characteristics at the dead-end of the Kawai Nui Stream and allow the water to flow continuously from the marsh to the stream without fear of filling the KWS to above the 1.7 foot desired water surface elevation.

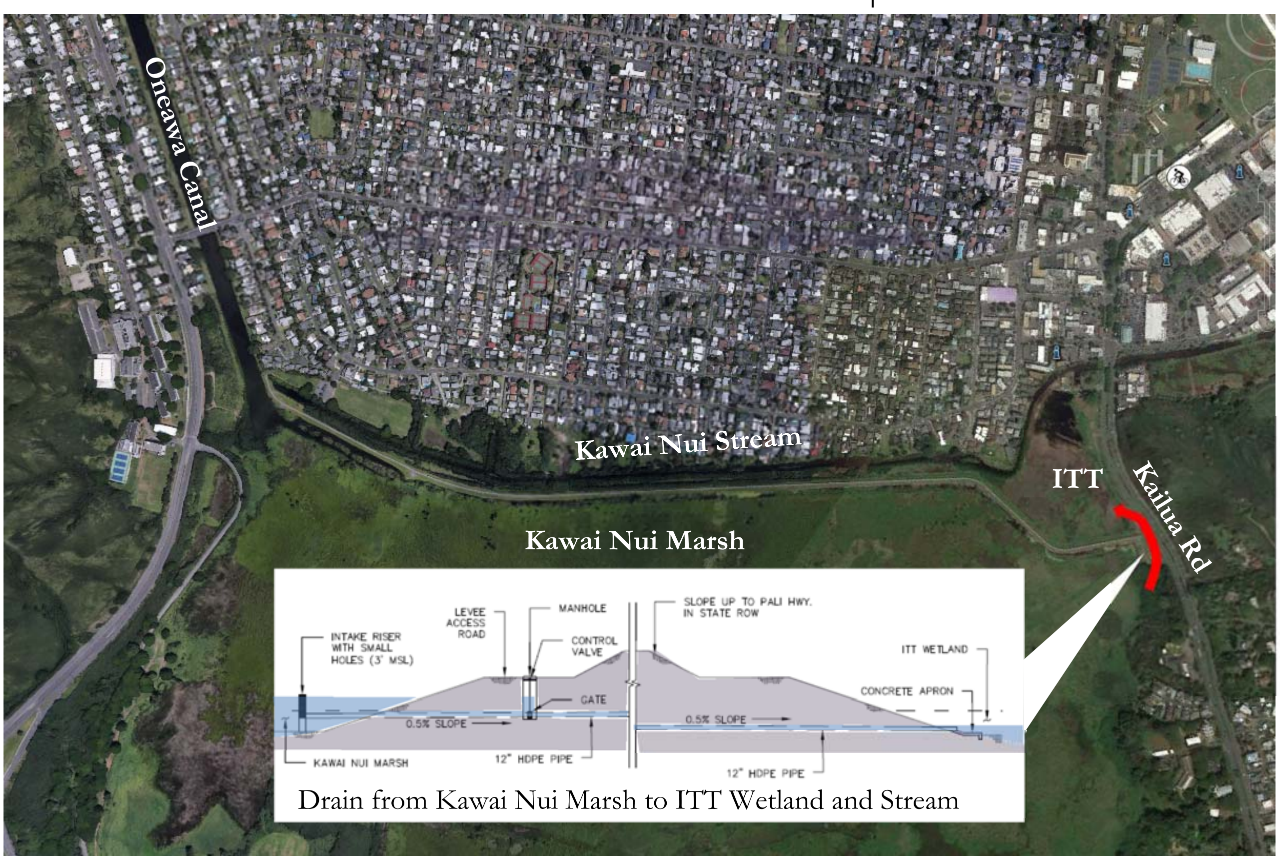

Figure 33 The Preferred alternatives is the straight 12-inch drain pipe around the south end of the levee.

8 Significance Criteria

To determine whether a proposed action may significantly affect the environment, one needs to consider every phase of the action, the expected primary, secondary, and cumulative consequences, as well as the short and long-term effect of the action. Therefore, evaluation of the significance criteria determines if there are any significant impacts on the environment. The following criteria are used to determine significance of the proposed project activities.

(1) **Involves an irrevocable commitment to loss or destruction of any natural or cultural resource;**
The proposed project would not result in the irrevocable loss or destruction of any natural or cultural resource.

(2) **Curtails the range of beneficial uses of the environment;**
Implementing a permanent water transfer method would restore water flow from the Marsh to Kawai Nui Stream which would also improve water circulation for Hamakua Marsh and Kaelepulu Pond and Stream. Restoring water flow and improving water circulation would restore aquatic ecosystem functions thereby helping to preserve habitat for endangered Hawaiian waterbirds and migratory bird species. Higher water surface elevations and improved water quality would also increase the recreational services offered by the KWS.

(3) **Conflicts with the state's long-term environmental policies or goals and guidelines as expressed in Chapter 344, HRS, and any revisions thereof and amendments thereto, court decisions, or executive orders;**
The proposed project would not conflict with the State's long-term environmental policies or goals and guidelines as expressed in Chapter 344, HRS. It would address in a positive manner the central purpose of Chapter 344 HRS relating to "promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of humanity, and enrich the understanding of the ecological systems and natural resources important to thepeople of Hawaii."

(4) **Substantially affects the economic or social welfare of the community or state;**
Implementing a permanent water transfer structure would not directly affect the economy but would improve the social welfare of the community or state. The proposed project would affect the social welfare of the community by improving water quality associated with health and safety benefits.

(5) **Substantially affects public health;**
Implementing a permanent water transfer method would improve water quality and has shown to decrease the incidence of noxious odors emanating from the system which have direct positive affects on public health.

(6) **Involves substantial secondary impacts, such as population changes or effects on public facilities;**
Implementing a permanent water transfer method would not result in any substantial secondary impacts.

(7) **Involves a substantial degradation of environmental quality;**
Implementing a permanent water transfer method would not degrade environmental quality. The proposed project aims to restore aquatic ecosystem functions and services through improving water quality and increasing flow rates within the downstream estuary.

(8) **Is individually limited but cumulatively has considerable effect upon the environment or involves a commitment for larger actions;**
The proposed project is not part of a larger action and would not contribute to cumulative adverse environmental effects on the environment. The water restoration measure would require periodic maintenance to ensure it is running properly.

(9) **Substantially affects a rare, threatened, or endangered species, or its habitat;**
The potential for drowning nests of endangered waterbird species does exist and will continue to exist under the "no change" alternative. Under any of the water restoration alternatives the rate of water level rise from designed inflow would be a very slow process (~1/8th to ¼-inch/day) allowing managers more than adequate opportunity to contact project personnel to halt the inflow of water thereby protecting the nests. It would also tend to keep the wetlands wet to higher elevations which would limit opportunities for birds to nest at abnormally low elevations subject to flooding. The objective of the proposed project is to benefit habitat for species dwelling within the area. The proposed project would improve wildlife habitat by restoring the aquatic ecosystem functions and improving water quality.

(10) **Detrimentally affects air or water quality or ambient noise levels;**
Short-term impacts on air quality would not occur during construction. However, there would be low to negligible effects on noise levels during construction. After construction is completed no long-term effects on air quality or noise level are anticipated. After implementing a permanent water transfer method water quality would improve because the aquatic ecosystem functions would be restored through improving water quality and increasing flow rates within the downstream estuary.

(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;**
The proposed project is located in a flood plain, estuary and fresh water area. The purpose of the proposed project is to restore aquatic ecosystem functions through improving water quality and increasing flow rates within the downstream estuary. The attributes from the proposed project would benefit the environmentally sensitive area.

(12) **Substantially affects scenic vistas and view planes identified in county or state plans or studies;**
The proposed project would not adversely affect view planes. The proposed structure is a low profile and would not affect any view planes. The proposed project does not conflict with county or State plans or studies.

(13) **Requires substantial energy consumption.**
The proposed project would not require substantial energy consumption.

8.1 Final Determination

An Anticipated Finding of No Significant Impact (AFONSI) determination for the proposed project preferred alternative is based upon the information provided in the Preliminary EA document. The results of the assessments conducted have determined that there would be no significant adverse impact in accordance with HRS Chapter 343 from the restoration of 2 CFS water flow from the Marsh to Kawai Nui Stream in Kailua, Oahu. Restoring water flow to the Kawai Nui Stream would improve water circulation and would result in an overall positive impact on the Kawai Nui Stream, Hamakua Marsh, and Kaelepulu waterways.

9 Permits and Approvals

This section lists the anticipated permits and approvals that will be required to test the impact of partial water restoration from Kawa Nui Marsh to Kawai Nui Stream across the Levee in Kailua, Oahu. Refer to Table 9-1 below.

The proposed project is in a coastal zone as defined by the State's Coastal Zone Management (CZM) Program. For Hawai‘i, the coastal zone management area (CZM) encompasses the entire state. The proposed project is consistent with the State's CZM Program. The proposed project is located over 5,000-ft. from the Pacific Ocean at Kailua Beach and is located within the City Special Management Area (SMA Status 1) as part of the coastal flood plain. The proposed project does not involve the placement, erection, or removal of materials near the coastline and would not adversely impact coastal resources. The proposed project is consistent with the State's CZM Program objectives of protecting, preserving, and restoring historical resources and providing public facilities and improvements important to the State's economy. Restoration of partial flow from the the Marsh to its historical outflow along Kawai Nui Stream is consistent with this intent.

Table 9-1. Permits Required

Permit	Agency Approval
National Pollution Discharge Elimination System (NPDES), General Form C	State of Hawai‘i Department of Health(HDOH), Clean Water Branch
CWA Section 401 Water Quality Certification (WQC)	State of Hawai‘i Department of Health (HDOH), Clean Water Branch
Stream Channel Alteration Permit (SCAP)	Commission on Water Resource Management (CWRM)
Section 408 Permit	U.S. Army Corps of Engineers (USACE)
Section 10 / 404 Clean Water Act (CWA) Permit	U.S. Army Corps of Engineers (USACE)
Coastal Zone Management (CZM) Certification	State of Hawai‘i Department of Business & Economic Development & Tourism (DBEDT)
Special Management Area Permit (SMA)	City, Department of Planning and Permitting

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APPENDIX A

POTENTIAL SUPPLIMENTAL PROJECT

OVERFLOW PIPE TO ONEAWA CANAL

Flood Threat Minimization Project

Supplemental Project, to Minimize Residual Flood Risk and Improve Water Quality

A Supplemental Project, is considered to provide a mechanism to lower the base water surface elevation to 1.7 ft to decrease the residual flood threat in the KWS. When the sand bar blocking the mouth of Kaelepulu Stream is higher than the base flood elevation (3.0 ft) and the water surface elevation is higher than 1.7 ft, then it is possible for a 1-year rain storm (3.9” rain) to raise the elevation of the KWS to above the base flood elevation. A secondary benefit of a drain at the terminus of the Kawai Nui Stream would be the improved circulation at this dead end of the channel. If the stream mouth is closed and excess water enters the system (either from rainfall or the siphon), this overflow pipe would provide a mechanism to automatically lower the elevation of the estuary to 1.7 ft. Under these conditions the flood threat is lowered and flow and water quality would improve in a stagnant area of the stream.

Figure 34. Location of the Supplemental Alternative Overflow Drain.

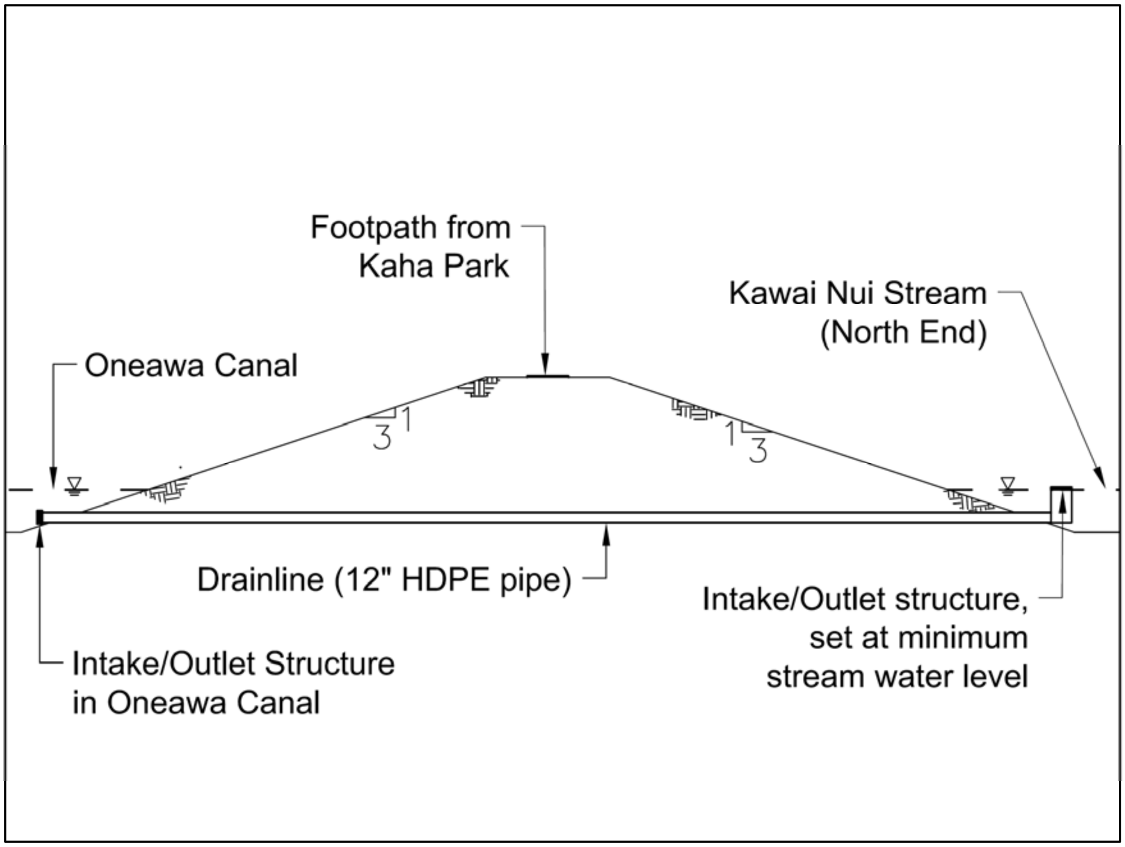
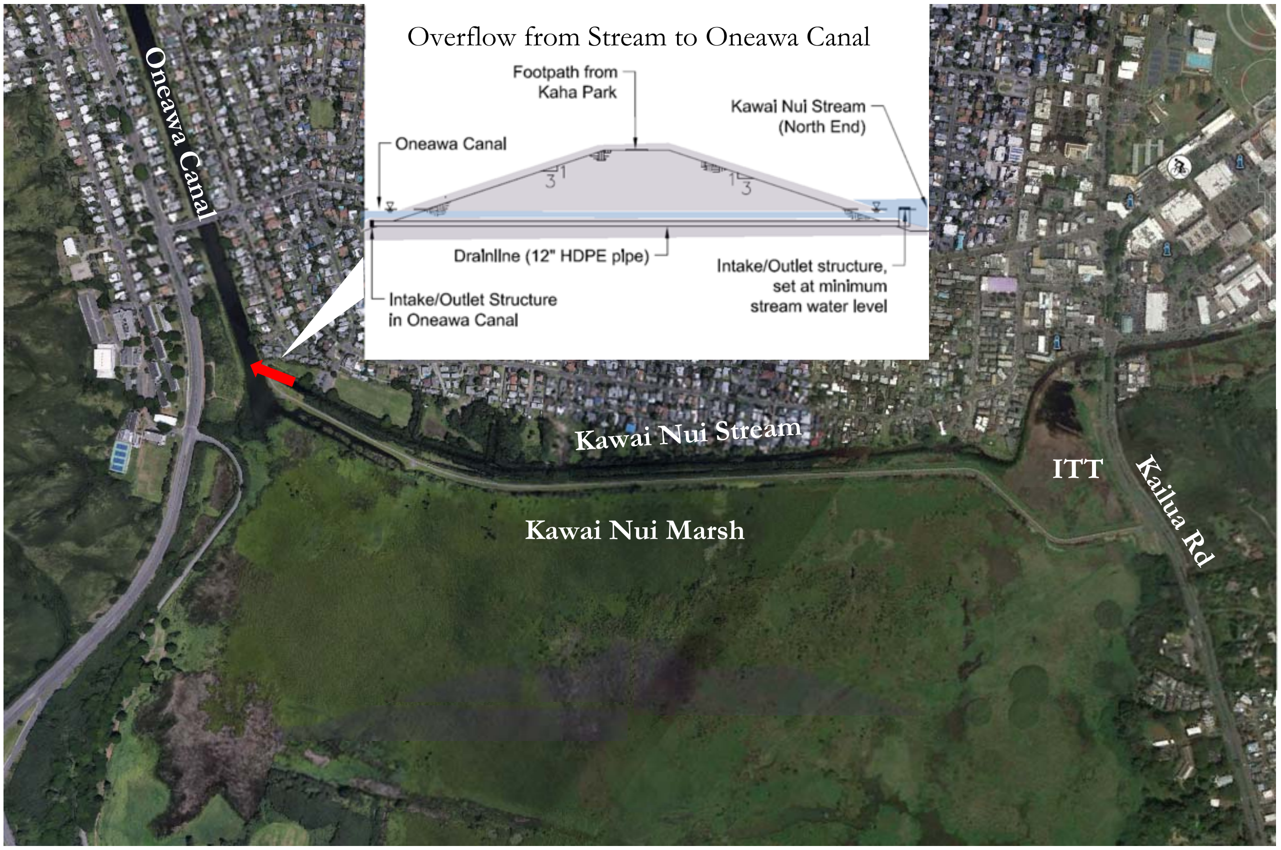


Figure 35. Supplemental Alternative to Improve Water Quality.

Figure 36. Levee where it separates Kawainui Stream (right) from Oneawa Canal (left).



Location of overflow from Kawai Nui Stream to Oneawa Canal proposed as a possible supplemental project.

APPENDIX B

KAWAI NUI STREAM FLOW RESTORATION PROJECT

Sipyon Flow Restoration Experiment Report