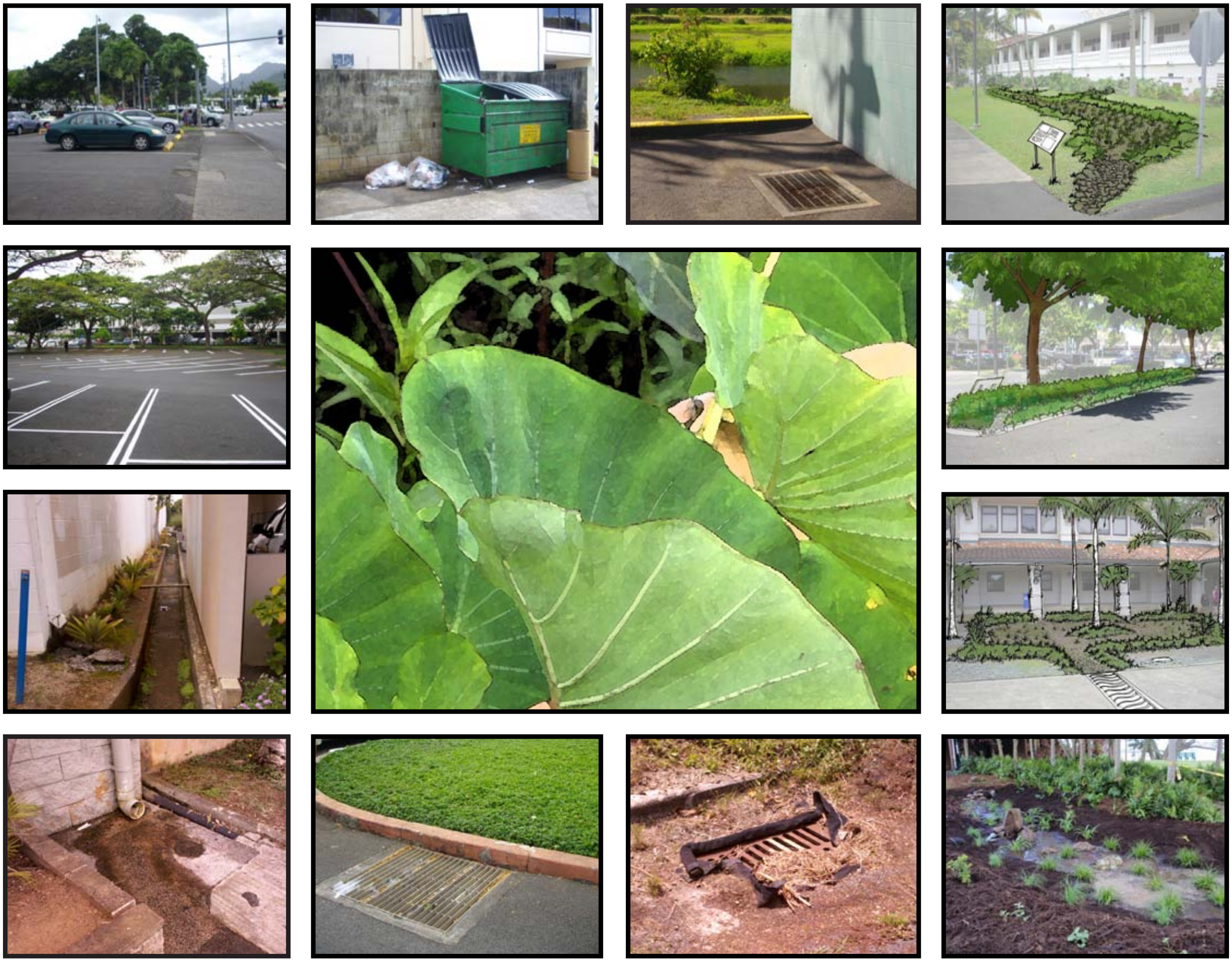

Ko‘olaupoko Urban Sub-basin Action Plan

hui o ko‘olaupoko

September, 2011

Acknowledgements

This work and final document would not have been possible without the generous support and grant funding from the Harold K. L. Castle Foundation. Additionally, there are many individuals who deserve acknowledgement for providing direction, input, advice and volunteer time, they include:

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Hudson Slay, Hawai‘i Watersheds Coordinator, Environmental Scientist, U.S. Environmental Protection Agency; and

Lauren Roth Venu, President, Roth Ecological Services.

The Technical Advisory Council provided insight, guidance, direction and technical review to the overall document. Additional thanks are extended to Jamie Carter and Christine Feinholz as well as Adam Stein of NOAA for their involvement of this project and in-depth GIS data sets. A big mahalo to Neil Berg for his work on rainfall analyses and historic data sets.

Additionally, Hui o Ko‘olaupoko thanks Cate Cullison and Etsuyo Kila, both provided much needed GIS mapping services, help with data presentation and document edits. HOK thanks Dave Hirschman from the Center for Watershed Protection and staff from Horsley-Whitten Group, including Rich Claytor, Anne Kitchell and Michelle West, all whom provided technical advice throughout this project. Lastly HOK thanks Maria Cahill of Green Girl Land Development Solutions in Portland, OR. for her retrofit tour, countless e-mail replies and technical assistances.

Credits: Co-written by Merrick Patten, D.Arch and Todd A. Cullison; illustrations by Merrick Patten, D.Arch.

hui o ko'olaupoko

HAROLD K.L. CASTLE FOUNDATION

Executive Summary

The urban areas of Koʻolaupoko have sub-watersheds which are covered with impervious surfaces ranging from one percent (1%) to nearly sixty-percent (60%). Research from the Center for Watershed Protection and others suggest as impervious surfaces increases, associated water quality problems also increase and water bodies have less ability to support aquatic functions. The Center for Watershed Protection estimates that watersheds covered with between 10-25% impervious surfaces have impacted watershed health, watersheds with 25-40% impervious surfaces results in non-supporting watersheds and over 60% coverage with impervious surfaces are considered Urban Drainages. Similar issues are apparent within the watersheds of Koʻolaupoko Streams with significant urban surroundings have a suite of water quality problems that include nutrients, phosphorus, total suspended solids and other pollutants associated with non-point sources.

Analyses in Koʻolaupoko have highlighted areas that can be retrofitted to capture and infiltrate storm water ultimately reducing the amount of pollutants that enter storm drains and flow into receiving waters.

Two-hundred twenty (220) sites were indentified and groundtruthed resulting in a total of sixty (60) sites being ranked candidates for Low-Impact Retrofitting. Low Impact Retrofit projects are defined as landscape features which use green infrastructure principles and ideas to manage stormwater within a confined urban space. Low Impact Retrofits are intended to address NPS pollution by capturing and treating stormwater on-site. Waimānalo had the fewest opportunities with the smallest developed urban areas with a total of six (6) candidate sites. In the Kailua area which includes the Kaʻelepulu and Kawainui sub-basins, twenty-four (24) sites were prioritized for retrofitting. The urban areas of Kāneʻohe present the most opportunity for retrofits with twenty-eight (28) sites prioritized. Several of these sites are located within close proximity to each other and can be implemented concurrently for a comprehensive approach to urban pollution reduction. This will prove more effective than implementing geographically isolated projects based on ranking alone.

Cumulatively, it is estimated if all ranked projects were implemented, the following pollution reduction could be reduced annually:

- ✓ **Total Suspended Solids: 6187 lbs.**
- ✓ **Total Phosphorus: 53.68 lbs.**
- ✓ **Total Nitrogen: 191.69 lbs.**
- ✓ **Annual Runoff Reduction: 25,257 inches**

Implementation will be addressed by working with the priority sites' landowners, learning about current and future land use plans and providing presentations as part of an overall restoration strategy. Additionally, a comprehensive education and outreach program will be developed to address pollution prevention on other urban sites where LIR are not feasible because of site constraints.

Along with individual site retrofits, HOK assessed opportunities for Green Street implementation to deal with non-point source pollution. Green Streets can be an effective tool to deal with both street runoff as well as runoff exiting adjacent developed sites. In addition to the water quality benefits, Green Streets can add aesthetics to the streetscape, improve pedestrian safety and traffic calming measures.

HOK will work with the City and County of Honolulu Environmental Services to identify and contact landowners, help further prioritize areas for work, share resources and deliver a consistent message for pollution prevention practices.

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Introduction

In 2006, Hui o Koʻolaupoko (HOK) formally the Kailua Bay Advisory Council (KBAC) completed an U.S. Environmental Protection Agency (EPA) based watershed plan titled, *Koʻolaupoko Watershed Restoration Action Strategy* (WRAS). The document addressed all nine-elements of EPA's requirements for watershed plans. The Urban Sub-Basin Action Plan (USBAP) builds upon information contained within the WRAS with a focus on urban areas to address non-point source pollutants such as Total Phosphorus (TP), Total Nitrogen (TN), Total Suspended Solids (TSS), and prioritize projects for retrofitting. The following guidelines were used while developing the USBAP:

> ***Goal****: Assess urban areas and other developed lands that contribute to non-point source (NPS) pollution in Koʻolaupoko using ecologically-based metrics and social inputs to identify and prioritize opportunities for Low-Impact Retrofits (LIR) implementation.*
>
> ***Objective****: The USBAP shall inform and guide the implementation of projects that shall restore to the fullest extent possible a site's pre-development hydrology and address pollutants by using design techniques that infiltrate, filter, store, evaporate and detain runoff as close to its source as possible.*
>
> ***Guiding principle****: To produce a plan which provides a course of action for Hui o Koʻolaupoko (HOK) over the next several years to address storm water and NPS pollution in a prioritized effort within the Koʻolaupoko moku.*

Figure 1 Natural vs. Altered Stream Environments

Organization Background

Hui o Koʻolaupoko is a community-based 501 (c) 3 non-profit organization whose mission statement is to*: protect ocean health by restoring the āina: mauka to makai*. Organizational efforts are focused in three main program areas:

- *Watershed/ahupuaʻa restoration and monitoring;*
- *Natural resource coordination/stakeholder involvement; and*
- *Scientific data and information dissemination.*

History

In 1995, KBAC was established to study non-point source pollution in the Koʻolaupoko region, recommend and oversee implementation of best management practices (BMPs) and support a volunteer water quality monitoring program. KBAC implemented several projects including production of the Watershed Restoration Action Strategy (WRAS). In 2008, KBAC changed its name to Hui o Koʻolaupoko adopting a very similar approach to watershed management. Hui o Koʻolaupoko fulfills its mission via partnerships with stakeholders including interested citizens, non-governmental organizations (NGO), government, educational institutions and businesses through the use of sound ecological principles, community involvement and cultural heritage.

Koʻolaupoko moku

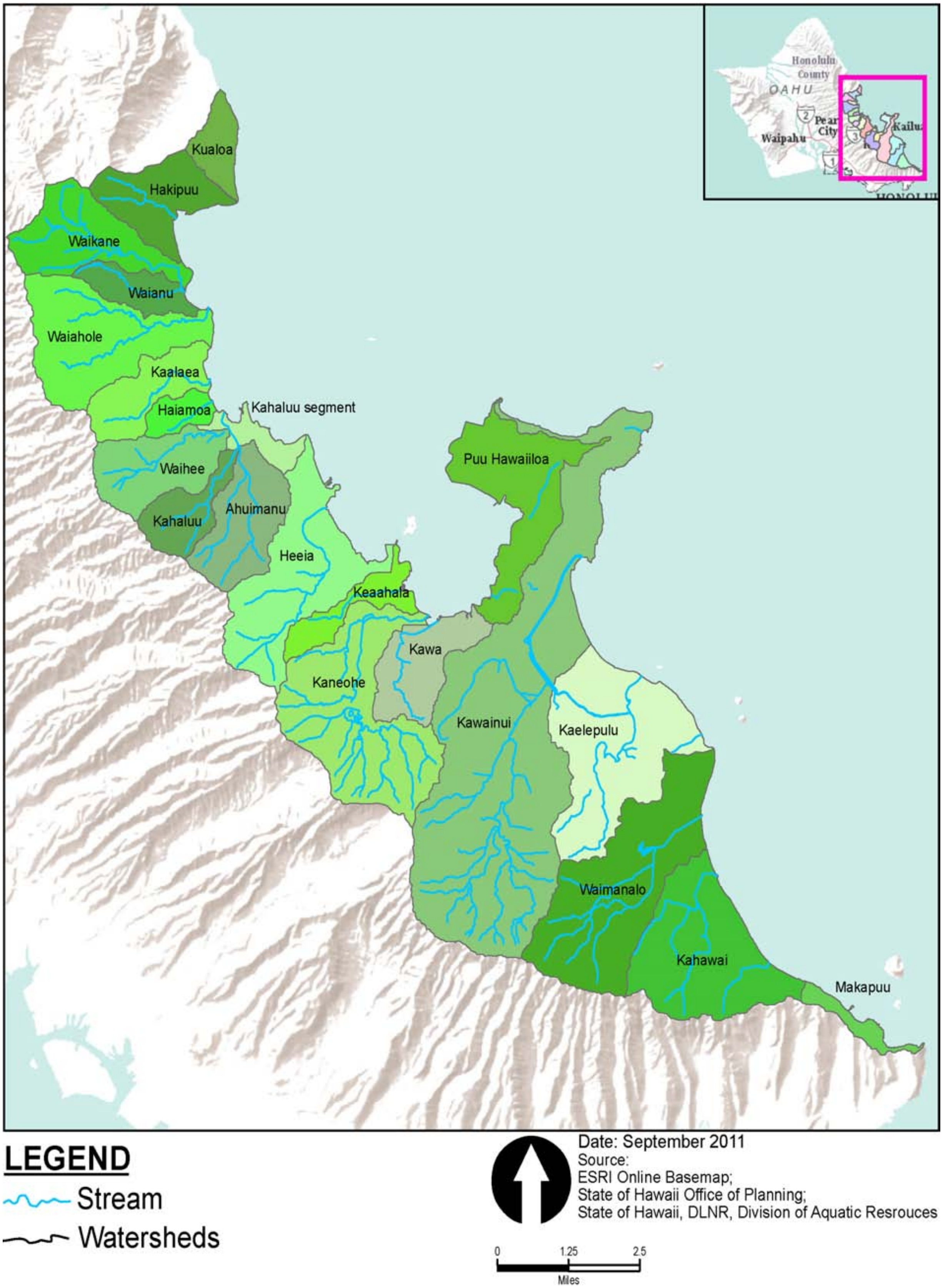
Located on the windward side of the island of Oahʻu, Koʻolaupoko moku is comprised of eleven ahupuaʻa and roughly 43,557 acres. Figure 2 shows the watersheds found within Koʻolaupoko moku. Contemporary management practices divide the Koʻolaupoko moku into three major drainage areas: Waimānalo, Kailua, and Kāneʻohe comprising twenty sub-watersheds.

- **Waimānalo Watershed**: 7,147 acres in size, drains into Waimānalo Bay, composed of Waimānalo, Kahawai, and Makapuʻu sub-basins. Agriculture and Residential developments compose a majority of the land-use in this area.

- **Kailua Watershed**: 12,910 acres in size, drains into Kailua Bay, composed of Kawainui and Kaʻelepulu sub-basins. Residential land-uses compose a majority of this area.

- **Kāneʻohe Watershed**: 23,500 acres in size and drains into Kāneʻohe Bay composed of sixteen sub-basins. the northern portion of this area remain as open space, low density residential land-use and agricultural lands, a majority of the urban development found within Koʻolaupoko is concentrated in the Kāneʻohe town region.

Figure 2 Ko‘olaupoko Moku: Watersheds



USBAP Rationale

Increasingly, HOK is focusing on non-point source (NPS) pollution and urban runoff as an important component for watershed restoration. As such, HOK realized the need to prioritize opportunities for future implementation of projects. The purpose of creating the USBAP is to clearly identify and prioritize Low Impact Retrofit (LIR) projects and assess urban areas for improved pollution prevention within the Koʻolaupoko moku. The document is not meant to replace the responsibilities of local government to comply with federal National Pollution discharge Elimination System (NPDES) regulations. However, HOK believes it can play a role in the assessment and implementation of projects that will have both a positive impact on water quality and further advance the state of the art work in Hawaiʻi.

Higher density urban environments such as the type found around the various town centers located within the Koʻolaupoko region are commonly associated with increased imperviousness caused by wide streets, parking lots, and minimal building setbacks. These types of features create a majority of the urban character found in the Koʻolaupoko region and have altered the natural environment impacting its ability to retain natural hydrologic site functions.

Low Impact Retrofit projects are defined as landscape features which use green infrastructure principles and ideas to manage stormwater within a confined urban space. Low Impact Retrofits are intended to address NPS pollution by capturing and treating stormwater on-site. The use of LIR can effectively reduce NPS pollution loading on receiving waters. Nearly all components of an urban environment have the potential to incorporate LIR projects, while the selection of appropriate and effective practices depends on the variety of site-specific factors. There are two major ways in which to deal with storm water, 1) Capture rain fall (e.g. green roofs) or 2) Capture runoff (e.g. rain gardens) or other practices that infiltrate runoff. Low Impact Retrofit features can be integrated into rooftops, streetscapes, parking lots, driveways, sidewalks, medians, and open spaces of residential, commercial, industrial, and civic land uses. Existing urban stormwater conveyance and landscape features present opportunities to direct runoff into LIR areas for storage, infiltration, and treatment. Using LIR, it becomes possible to reduce pollution loads on receiving waters and reduce problems associated with *peak runoff volumes* during rainfall events. HOK is promoting LIR within the urban environment as a vehicle to capture pollutants before they enter into local receiving waters.

Urban and suburban environments share many of the same characteristics associated with the creation of impervious surfaces and NPS pollution. Additionally, suburban residential neighborhoods[1] contribute to high amounts of NPS pollution in the Koʻolaupoko region.

However, retrofitting privately owned residential dwellings and landscapes is beyond the scope of the HOK USBAP at this time. Continued education and outreach programs have been established by HOK to address this issue in its own right. Most notably at the time of the creation of the USBAP document, HOK is concurrently developing a statewide *Hawaiʻi Rain Garden Manual* specifically tailored towards reaching single-family residential dwellings and associated landscapes to install rain gardens.

[1] According to the United States Environmental Protection Agency (EPA) website "Pollution Prevention Management Measures" a non-point source loading analysis conducted in 1991 by Cahill & Associates, found 512.7 tons (10 percent) of the nitrogen and 49.9 tons (4 percent) of the phosphorus applied annually within a 193 square mile residential development was found in adjacent surface waters.

LIR Restoration Objectives

Setting restoration objectives early in the retrofitting process was extremely important. Restoration objectives define the purpose of retrofitting and target the specific sub-basin watershed problems to be solved. Restoration objectives help identify what pollutants need to be treated, how much storage is needed and where the most cost-effective locations are in the sub-basin watershed. HOK has identified and defined the following five LIR objectives.

- *Fix Past Mistakes & Maintenance Problems:* LIR are used to improve the existing stormwater infrastructure (e.g., to fix drainage problems, protect stormwater conveyance systems threatened by erosion or to address maintenance problems within individual stormwater practices). These types of infrastructure retrofits are localized to address a specific problem. The type of LIR usually is tailored to solve the site specific problem.

- *Stormwater Demonstration and Education:* LIR can demonstrate stormwater practices on public lands or promote stormwater education and stewardship. Well-designed and highly visible demonstration retrofits are a good tactic to garner greater support to finance more widespread retrofitting efforts in the future.

- *Reduced Runoff Volumes to Receiving Waters:* LIR can reduce stormwater inputs to receiving waters, thereby reducing the frequency and size of stormwater outflow. The objective is to reduce the amount of non-point source pollution from reaching receiving waters. Disconnection is the most common approach to reduce runoff volumes.

- *Reduce Pollutants of Concern*: Pollution reduction may be driven by a TMDL, a local watershed restoration plan or regional directive to reduce pollutant loads. The pollutant of concern may include sediment, nutrients, bacteria, metals and toxins.

- *Support Stream Restoration:* LIR can potentially provide means of regulating the peak volume, duration, frequency, discharge of stormwater runoff, thereby creating a more stable and predictable hydrologic regime for a particular stream. Not that *LIR are not designed or intended to function as BMPs for flood control.*

Ideally a given LIR should address each of the five LIR objectives within one retrofit. Due to the characteristics of the urban environment it often becomes impossible to achieve each of the five restoration objectives within a single solution. The intent is such to maximize the positive impact of a given LIR with respect to the LIR objectives, while acknowledging each and every potential project site is associated with common yet unique site constraints driven by zoning classifications, land-use practices, topographic and geologic variations which affect hydrologic site functions.

LIR Restoration Objectives in Action

The Heʻeia State Park Rain Garden is a good example of a restoration objective in action. The demonstration and education site was joint effort between HOK, University of Hawaiʻi Sea Grant, Mālama Maunalua and Kamaʻāina Kids. As a rain garden demonstration site, the project provides an opportunity to educate visitors on the method and means of restoring a healthy and productive hydrologic site. Another important aspect of this particular project is the community's involvement in the construction as shown in Figure 3. Before the construction of the rain garden, roof generated runoff flowed across the grassed area and on to a parking lot before draining in nearby Kāneʻohe Bay. Figure 4 demonstrates how a rain garden functions, detaining runoff and infiltrating water.

Figure 3 Rain Garden construction at He'eia State Park

Figure 4 Completed Rain Garden at He'eia State Park

Urbanization of Koʻolaupoko Watersheds

Magnitude of Problem

The Koʻolaupoko moku and its eleven ahupuaʻa is the largest water producing area on the island of Oahʻu[2]. Human activities along with urbanization and other types of development in each of the three major watersheds within Koʻolaupoko have severely altered the natural landscape. Roads, houses, parking lots, and other impervious surfaces have reduced the ability of the ground to absorb rainfall and recharge aquifers. Additionally, storm water collection pipes, gutters, and drains, associated with urban development have concentrated pollutants and reduced the effectiveness of the watershed's natural ability to keep streams and coastal waters clean. Table 1 highlights the various streams on the EPA 303 (d) list, their pollutant type and percentage of total impervious surfaces associated with the watershed.

Table 1 Koʻolaupoko Moku: Stream Pollutants

Region	Sub-Basin	303d	Nitrite/Nitrate	Nutrients	Turbidity	TSS	Total N	Total P	Metals	Trash	Dieldrin	TMDL	%Imperviousness
Kāneʻohe	*Kawa*	X		x	x	x						X	40.17
	Kāneʻohe	X		x	x						x	X	22.77
	Keaʻahala	X	x		x		x	x		x			56.99
	He'eia	X	x										18.41
	Kahaluʻu	X			x								13.06
Kailua	*Kaʻelepulu*	X		x	x							X	49.82
	Kawai Nui	X		x	x	x			x	x		X	19.67
Waimānalo	*Waimānalo*	X		x		x	x					X	9.17

Impervious Cover

Urban development including impervious coverage such as roads, paved parking lots, sidewalks, roof tops, individual driveways and other hardscape surfaces convey stormwater pollution into storm drains and result in the direct conveyance of nonpoint source (NPS) pollution and excess levels of runoff into streams[3] and eventually the ocean. Figure 5 graphically illustrates the relationship between percent impervious surface coverage and the alterations of the natural hydrologic cycle. Along with impervious surfaces, in urban areas of Koʻolaupoko, streams are channelized with concrete to control flooding at the cost of eliminating important natural features that maintain healthy streams and their associated ecosystems. In such cases where streams are channelized and lined, the rapid delivery of increased volumes of freshwater causes a near-instantaneous decrease in salinity and temperature. The result can adversely affect coral and other marine life[4].

[2] KBAC. WRAS. Chapter II: Watershed Summaries. 2-1. 2007
[3] "Impervious cover fundamentally alters the hydrology of urban sub-watersheds by generating increased storm water runoff and reducing the amount of rainfall that soaks into the ground." (Center for Watershed Protection, 2005)
[4] Watersheds and Coral Reefs: Conservation Science, Policy and Implementation. Richmond Robert, et al 2007, BioScience, pp.598 - 607.

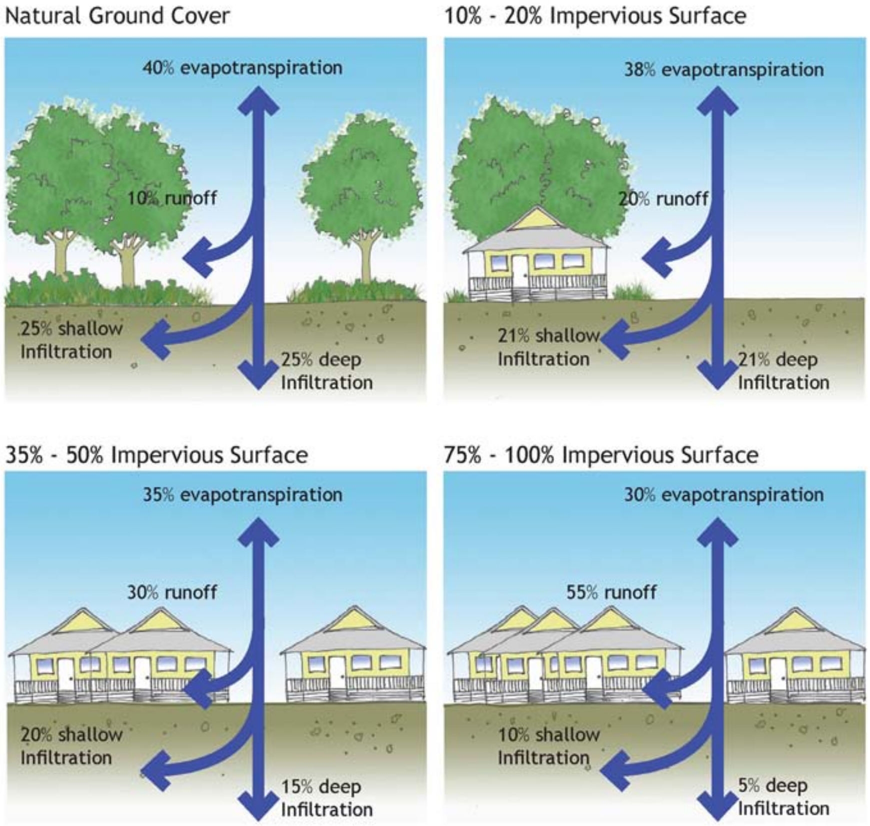


Figure 5 Natural vs. Impervious Coverage

Adapted from Environmental Protection Agency 1993.

Impervious cover is often used as a general index of the intensity of sub-watershed development. For example, the Ka‘elepulu sub-basin in Kailua has approximately 50% impervious surface, the Kea‘ahala sub-basin in Southern Kāne‘ohe has approximately 57% impervious surface. Both are listed for NPS pollutants on the EPA 303 (d) list. With factors such as this, HOK is focusing attention in these areas. Figure 6 graphically illustrates the relationship between degraded stream quality and impervious coverage per watershed within Ko‘olaupoko moku. Notably, as impervious surfaces increase, the amount of pollutants increase as well as the overall number of streams on the EPA 303(d) list. Figure 7 shows the total impervious cover (roads, parking lots, driveways, buildings) found within Ko‘olaupoko moku.

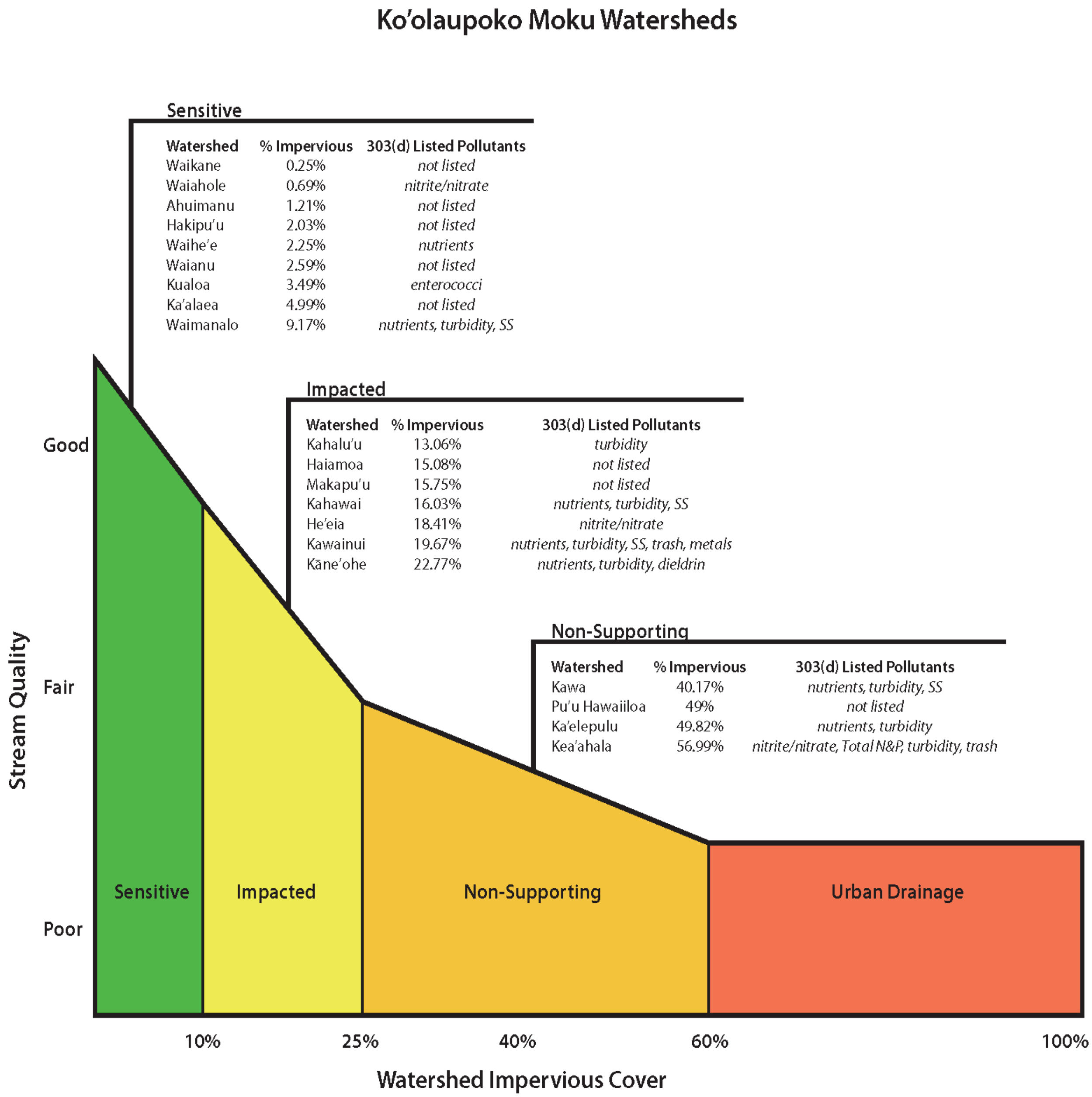
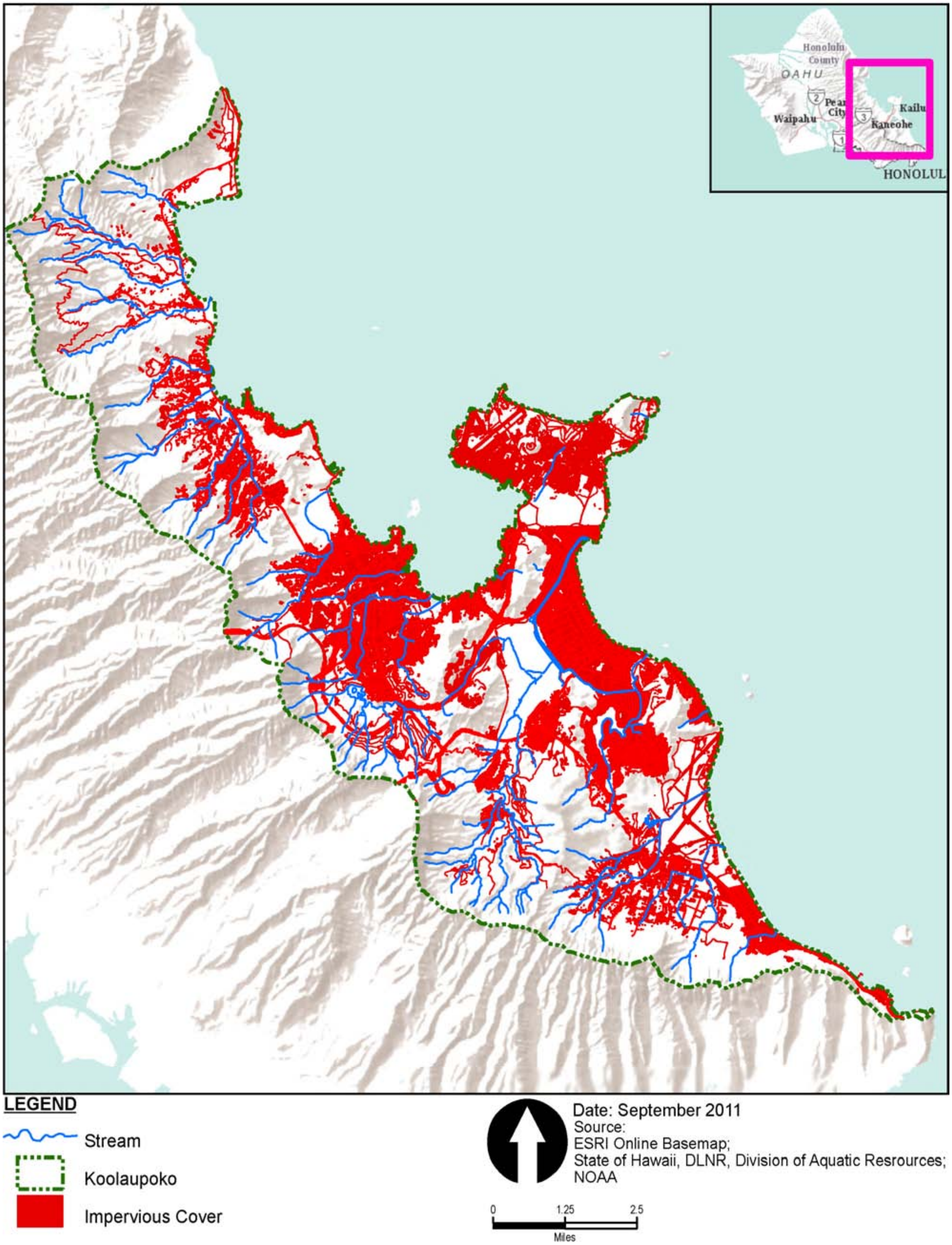


Figure 6 Effects of Impervious Coverage on Stream Quality

Adapted from Center for Watershed Protection, Urban Stream Repair Practices.

Figure 7 Koʻolaupoko Moku: Impervious Cover



Non-point Source Pollution

The EPA has estimated that NPS pollution is now the single largest cause of the deterioration of water quality (United States Environmental Protection Agency, 2000). As previously stated, an increase in impervious surface area has a direct correlation to a decrease in water quality. In areas where storm water runoff flows from altered natural surfaces, whether from a storm event, car washing, or the irrigation of lawns, runoff picks up an array of contaminants including hydrocarbons from roadways, agricultural chemicals from farmland, sediment, and nutrients from urban and suburban areas. Contaminated surface water runoff will eventually enter either a conventional stormwater conveyance systems or flow directly into the receiving waters with negative consequences. NPS pollution types of particular concern associated with the urban environment are found to be Total Suspended Solids (TSS), Total Phosphorus (TP), Total Nitrogen (TN), and total annual runoff volumes. Figure 8 shows the various known NPS pollutants found within Ko'olaupoko streams.

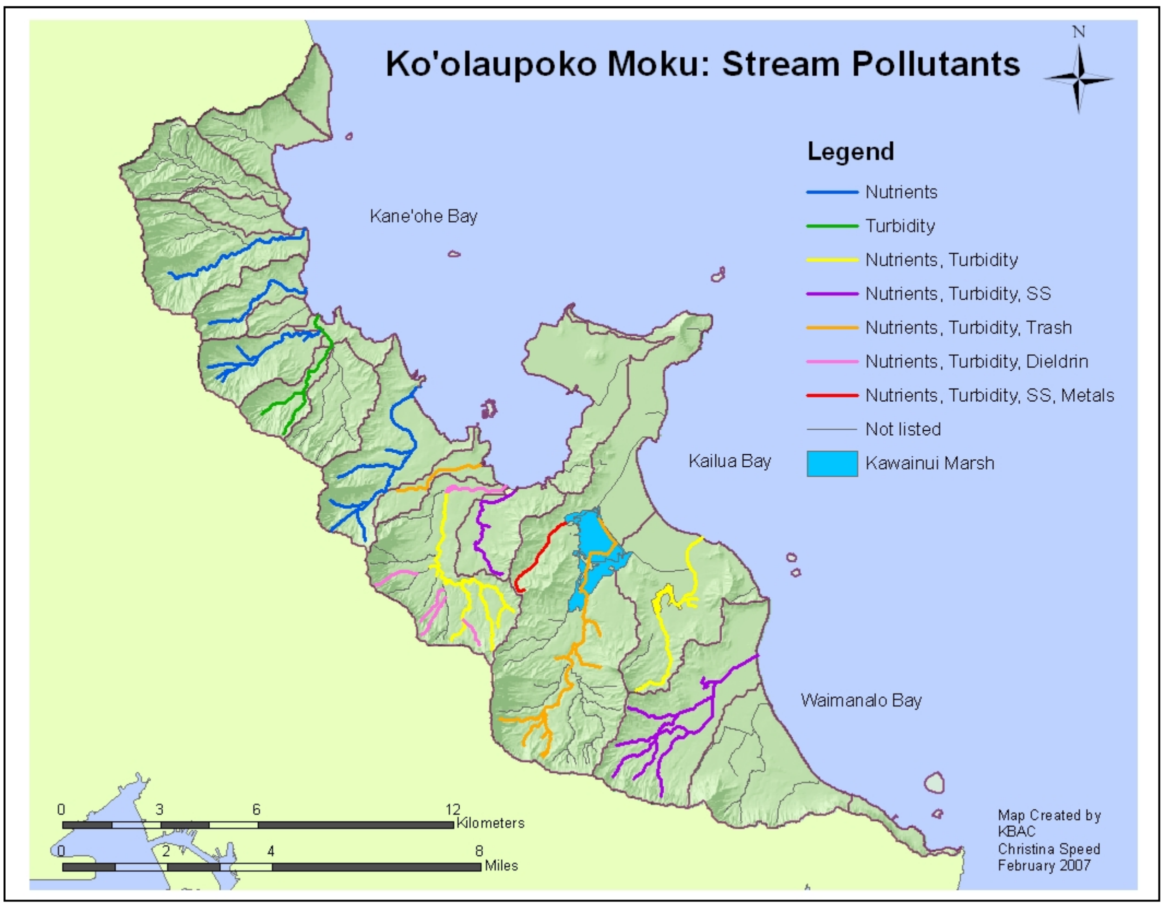


Figure 8 Ko'olaupoko Moku: Stream Pollutants

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Green Infrastructure

Low Impact Retrofits

Low Impact Retrofits are designed to maximize restoration objectives within a confined space. Figure 9 graphically illustrates conventional stormwater conveyance systems vs. LIR stormwater best management practices (BMPs). Typically LIR are constrained by specific site characteristics such as limited space, utilities, stakeholder participation and funding. Each LIR project must meet high standards for performance (NPS pollution load reduction, operation and maintenance), community benefit and aesthetics.

Additionally, on Oah‘u, there are limited, if any, incentive programs for private landowners to implement LIR. Property owned by the City and County of Honolulu (CCH) falls under its NPDES permit. As such, the CCH should be implementing retrofits in priority watershed areas with completed total maximum daily loads (TMDL). For other private landowners, their participation will likely be encouraged through incentives such as grant funds or a desire to be good land stewards.

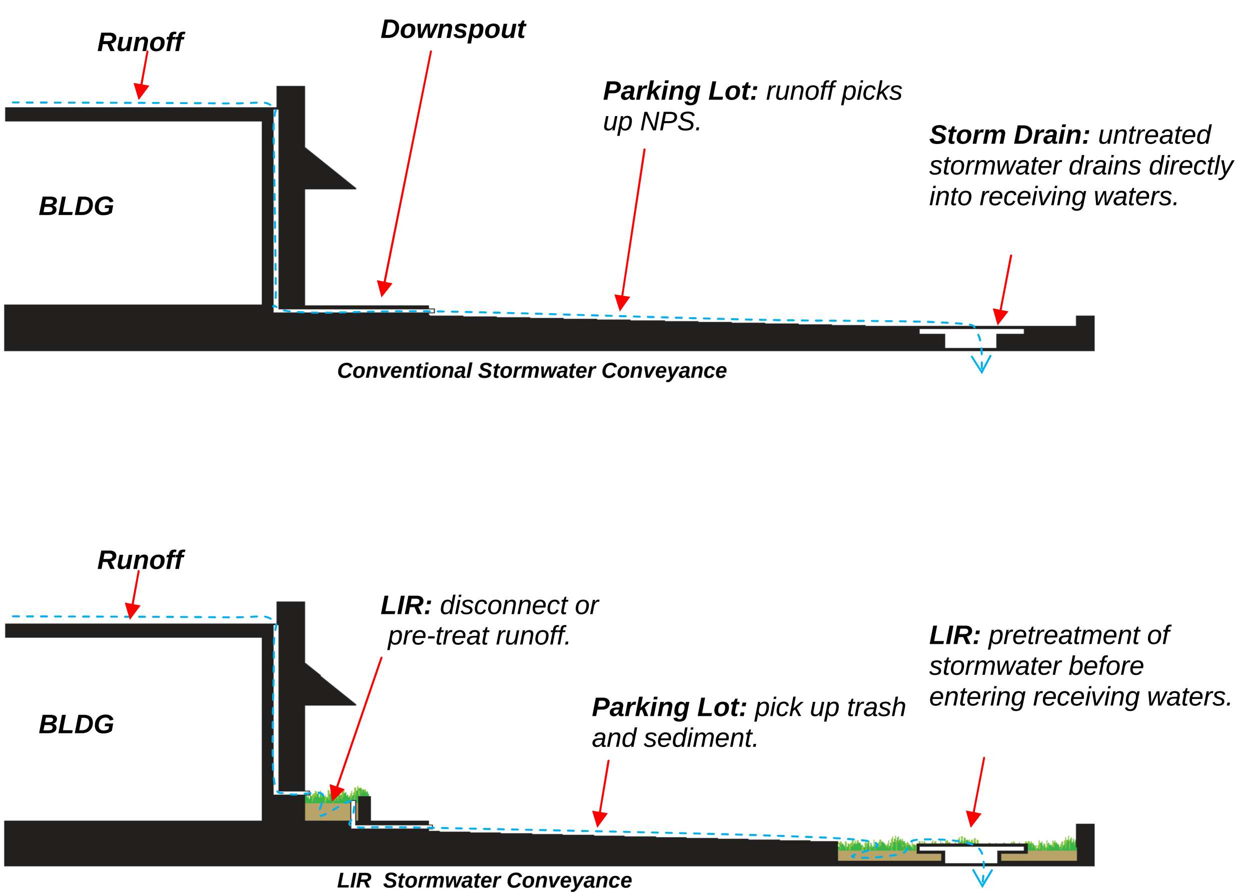


Figure 9 Conventional Stormwater Conveyance System vs. LIR Stormwater BMPs

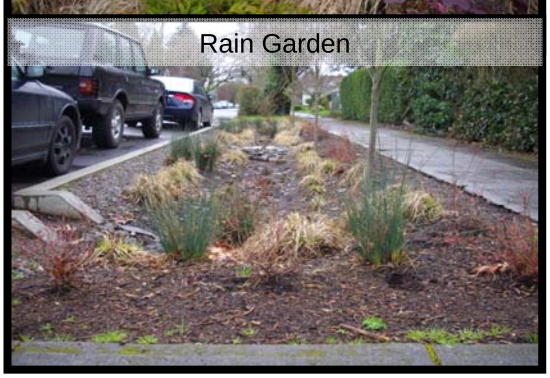
State of the Art LIR Projects: Case Studies

Within the State of Hawai‘i, few examples of LIRs exist. For this reason it becomes necessary to develop a number of brief case studies, or summaries and samples of retrofits to illustrate specific examples of projects in other regions. The City of Portland, Oregon is widely known for its progressive application of LIRs. Portland also shares many characteristics of highly urbanized environments found within Ko‘olaupoko. HOK traveled to Portland to learn from and document first hand LIR projects in action. Below are examples that can be replicated, with the proper design adjustments, in Ko‘olaupoko.


Rain Garden & Check Dam


Street Bump Out


Rain Garden


Rain Garden


Road Side filtration Planters


Rain Garden & Curb Cut

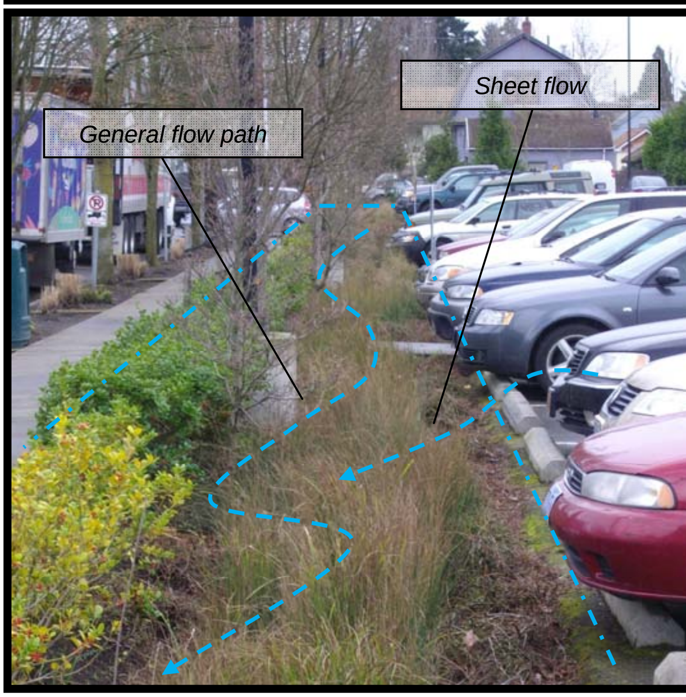
New Seasons Market; Portland, Oregon

<u>**Average Annual Rainfall:**</u> *37.5"*

<u>**Retrofit:**</u>

Disconnect Downspouts & Rain Garden: *In this particular case, the designers have chosen to express the interaction between built form and environmental functions (rainwater runoff). The roof generated runoff is directed into a rain garden where filtration and infiltration processes are allowed to treat runoff vs. being directed immediately towards conventional stormwater conveyance systems.*

Rain Garden: *Sheet flow generated by the parking surface is directed towards the depressed area where stormwater is treated by the plantings and soil media. Tree plantings also provide shade for parked vehicles and reduce overall "heat island" effects. The use of vegetated swales allows for greater on site infiltration, effectively reducing overall stormwater discharge rates and volumes. This is a simple yet extremely effective potential retrofit requiring a limited amount of space and construction effort.*



General Maintenance: *Periodic inspection for erosion, removal of sediment buildup and debris from the bottom of channel. Occasional watering, weeding and pruning is required to keep plants healthy and maintain the overall aesthetic appeal. Selecting climate appropriate native plantings can reduce the overall irrigation requirements.*

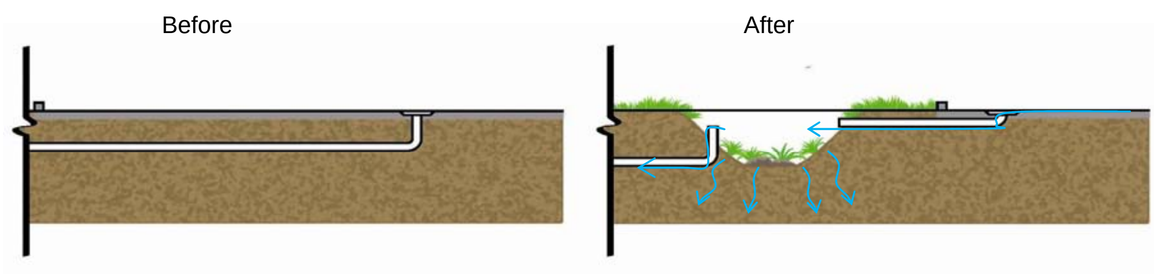
Church Parking Lot; Portland, Oregon

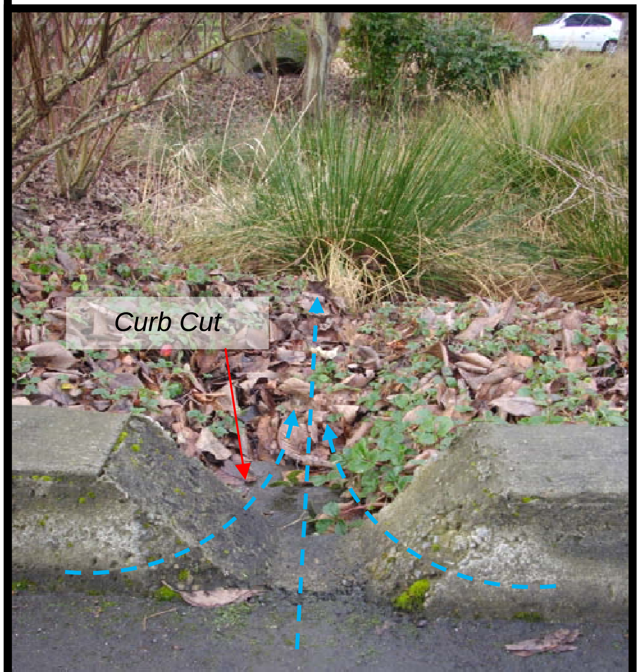
Average Annual Rainfall: 37.5”

Retrofit:

Rain Garden: *Space permitting, this type of application is able to treat larger amounts of stormwater runoff. This technique is useful for detaining stormwater runoff before entering conventional conveyance systems at a strategic location. The rain garden is designed and sized to treat a specific amount to stormwater. Once rainfall exceeds the designed parameters (soil infiltration rates determine storage capacities), the pre-existing stormwater outlet is used to convey water safely away from the site.*

Curb Cuts: *In cases where existing curb systems are in place it becomes necessary to open the curb to allow stormwater runoff to enter at a desired location. The size and shape of the opening should reflect the amount of site generated runoff that will be serviced by the particular LIR application.*





Green Streets; Portland, Oregon

Average Annual Rainfall: *37.5"*

Retrofit:

Green Streets: *As a method of addressing the impermeable surfaces associated with infrastructure, Green Streets are designed to perform specific functions such as filtration and pre-treatment of street generated runoff. Often connected to conventional storm drain systems, the specific design may very dependent on site conditions.*

Located either in the designated right-of-way (ROW) or within the confinements of on street parking stalls, these applications are effective at mitigating stormwater runoff, improve lines of sight for pedestrian crossings, reduce aquifer withdraws (lower irrigation needs commonly associated with grassed areas).

Rain garden located in the ROW. Storm water enters through curb cuts and is directed through the rain garden allowing for filtration before either infiltrating on site or entering conventional storm water conveyance systems.

The image above provides a good illustration of the proposed retrofit compared to a typical ROW configuration.

He'eia State Park; Kāne'ohe, Hawai`i

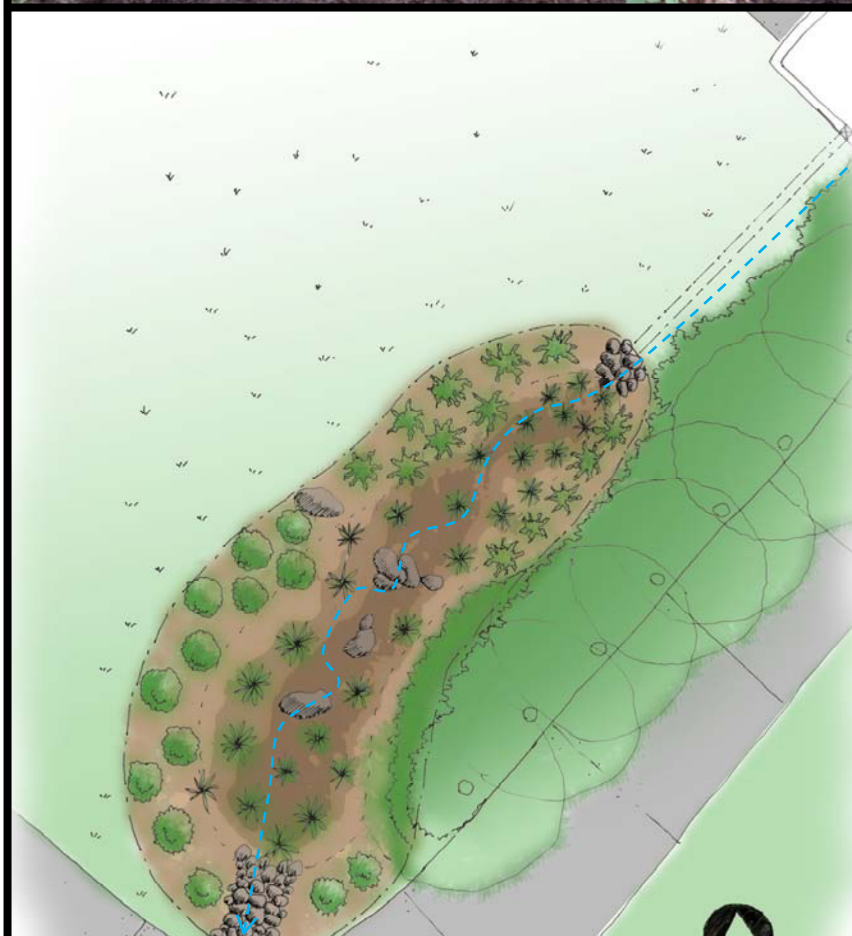
<u>**Average Annual Rainfall:**</u> *50"*

<u>**Retrofit:**</u>

Rain Garden: *Roof generated runoff is directed into a Rain Garden where filtration and infiltration processes are allowed to treat runoff.*

A collaborative effort between HOK, University of Hawai'i Sea Grant Program, and Kama'āina Kids, this project serves multiple purposes. The first and foremost goal of any LIR is to retain on site hydrologic functions and maintain water quality, secondly the location of the rain garden within the state park allows for greater education and outreach opportunities.

Native Plantings: A number of climate appropriate local plant species were selected which include; 'Ae'ae Bacopa Monnieri,'Akulikuli Sesuvium portulacastrum, Carex Wahuensis, Uki'uki Dianella sandwicenses,'Ohai Sesbania Tomentosa, 'Ahu'awa Mariscus javanicus



Popoia Rd; Kailua, Hawai`i

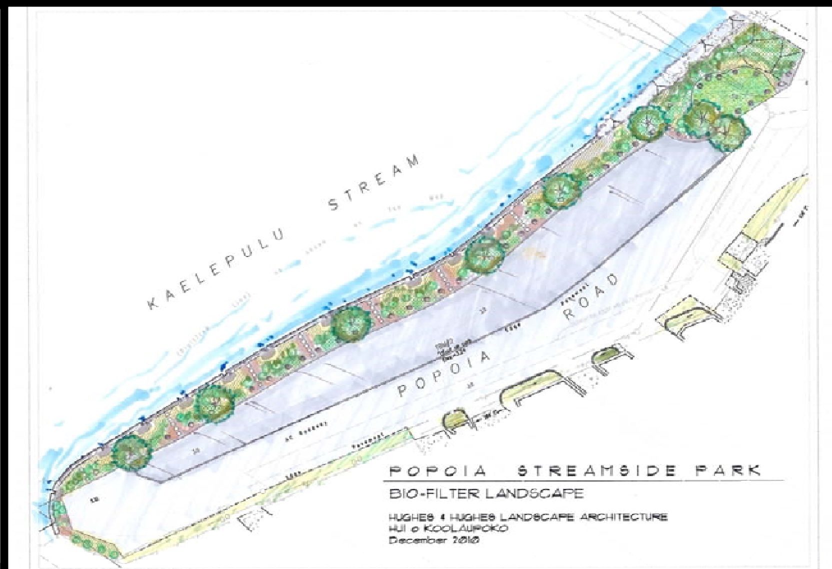
Average Annual Rainfall: *40"*

Retrofit:

Rain Garden/Filtration Swale: *Runoff generated by the parking lot and road surface is directed into a Rain Garden where both filtration and infiltration processes are allowed to pre-treat runoff before it enters Ka'elepulu stream.*

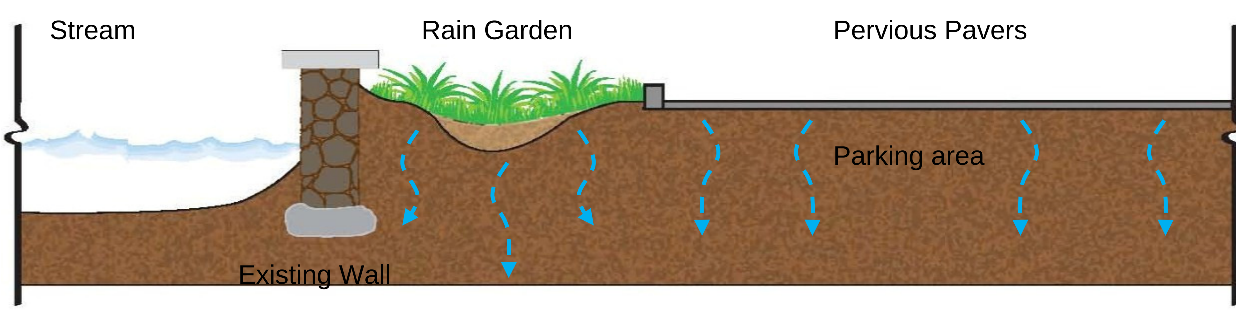
The LIR also provides a physical and biological buffer between the stream and the road.

Pervious Surfaces: *The parking surface was replaced with pervious pavers. This allows greater infiltration setback from the edge of the stream.*



Native Plantings: *A number of climate appropriate local plant species were selected which include; Milo (Thespesia populinea), Hinahina Ewa (Achyranthes splendens rotunda), Maipilo (Capparis sandicensis), Mau aki aki (Fimbristylis cymosa), Pohuehue (Ipomea pes-caprae), Ilima (Sida fallax), Pohinahina (Vitex Rotundifolia).*

Particular challenges: *This construction of this project was slowed as a result in conflicts between land use ordinances and the proposed retrofit. The retrofit was a new concept to the City and County of Honolulu, Department of Permitting and Planning and the Park's department. As such, more detail and information was needed than a traditional storm water work. As a result of the proximity to Ka'elepulu Stream, added review was needed from the U.S. Army Corps of Engineers, State of Hawai'i Department of Health and Department of Land and Natural Resources. The reviews were not insurmountable but this added considerable time before the project could be constructed.*



Green Streets

In addition to assessing urban areas, streets are a major contributor to impervious surfaces in Koʻolaupoko. Green Streets are essentially LIRs intended to be placed in the road ROW to improve water quality and environmental health while also providing traffic calming measures, improve pedestrian safety (protecting lines of sight for both pedestrian and vehicles at crosswalks), and increase aesthetic value. Roadways essentially act as stream networks for storm water runoff. The impermeable surfaces combined with curb and gutter systems direct runoff towards the shoulders of the roadways and into storm drains distributed along the length of the road. As such, roadways provide an opportunity to implement LIRs. For this reason the USBAP includes regional analysis of street networks in conjunction with the analysis of individual parcels within Koʻolaupoko . Dependant on site specific characteristics, LIRs for roadways may require the removal of specific street parking stalls situated directly adjacent to a storm drain. Often storm drains are located at or near intersections, so the removal of a single parking stall closest to the intersection could improve both pedestrian and vehicular safety (lines of sight) along with address non-point source pollution. However, green streets can also be built into the ROW not disturbing parking spaces.

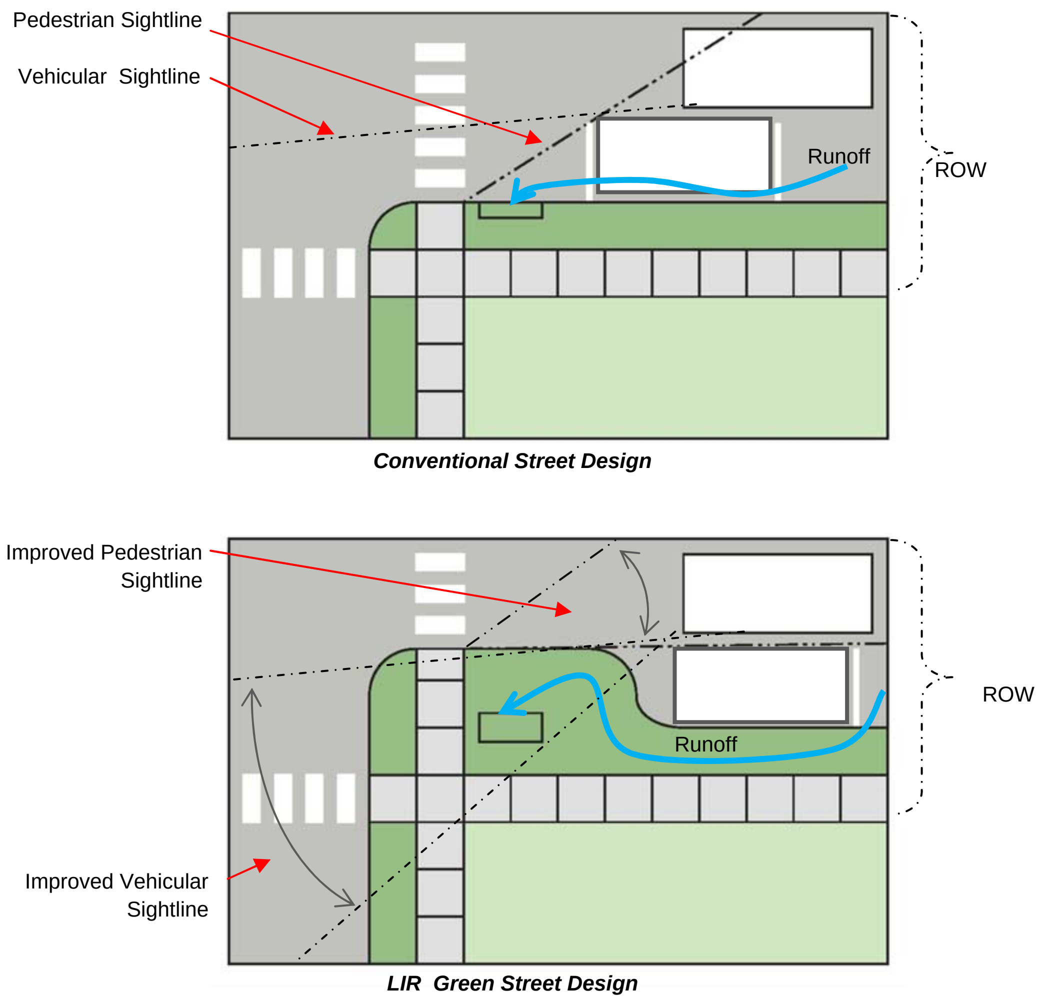


Figure 10 Conventional Street Design vs. LIR Green Street Design

Green Streets Typology:

The following section provides examples of green street typology[5] and how this type of project can fit within the existing ROW.

Stormwater Curb Extension: Extending into the street, stormwater curb extensions transform the curb lane into a landscape area. Curb extensions can conveniently integrate a ramp for safe pedestrian crossing.

Portland: SE 12th and Clay

Portland: SE 42nd and Belmont

Stormwater Street Planter: Stormwater Street Planters between the sidewalk and the curb work well in areas with limited space, and they allow for adjacent street parking or travel.

Portland: SW 12th and Montgomery

Portland: Unknown Location

[5] Environmental Services City of Portland. Stormwater Management for Clean Rivers: Green Streets. WS 0895 August 2008.

Rain Gardens: Where there is space available, rain gardens are ideal. Rain gardens can also transform street intersections into safe pedestrian and bicycle crossings.

Simple Green Street: Excavating an existing planting area behind a reinforced curb, making curb cuts for inflow and outflow, and landscaping with climate appropriate native vegetation is a simple approach to capture and treat street runoff.

(Source: Environmental Services City of Portland. Stormwater Management for Clean Rivers: Green Streets WS 0895 August 2008).

Local Green Street Application Opportunities:

Installing Green Streets could prove very valuable in highly dense, ultra urban areas where commercial lots are developed at near 100% of capacity leaving very little room for retrofits. As storm water exits a private commercial site and flows along a municipal curb adjacent to a road on its way to the storm drain, a green street could be installed to intercept and infiltrate the flow. Determining the exact location for green streets was outside the scope of this document, however, there are general recommendations that can be followed to prioritize these areas fairly easily.

Green streets can be built in areas with a typical right of way (see page 17 Green Streets Portland, Oregon) and as bump-outs in areas with street parking. With a wide enough ROW, the treatment can be constructed with 3:1 sloped sides, have a pre-treatment cell with a check dam and planted with native vegetation. A narrower ROW might require vertical concrete sides with and underdrain to provide the same function with a smaller footprint while dealing with storm water. In Koʻolaupoko, green street location recommendations follow similar recommendation as urban LIR. Watersheds with higher road density or areas with higher impervious surfaces coverage such as Kea'ahala watershed in Kāneʻohe or Kawainui in Kailua priority areas recommended.

Green streets could serve both a water quality function and traffic calming function if built near crosswalks, schools or oversized streets. Constructing green streets in these areas with bump-outs, a practice already used in Koʻolaupoko to calm traffic, could be redesigned and integrated with a rain garden for storm water infiltration.

Figure 11 Green Street Retrofit Opportunity: Intersection of Ulupuni St. & Uluhala St., Kailua

Benefits of green streets are many; the following were adapted from the City of Portland, Oregon "Green Street Policy."

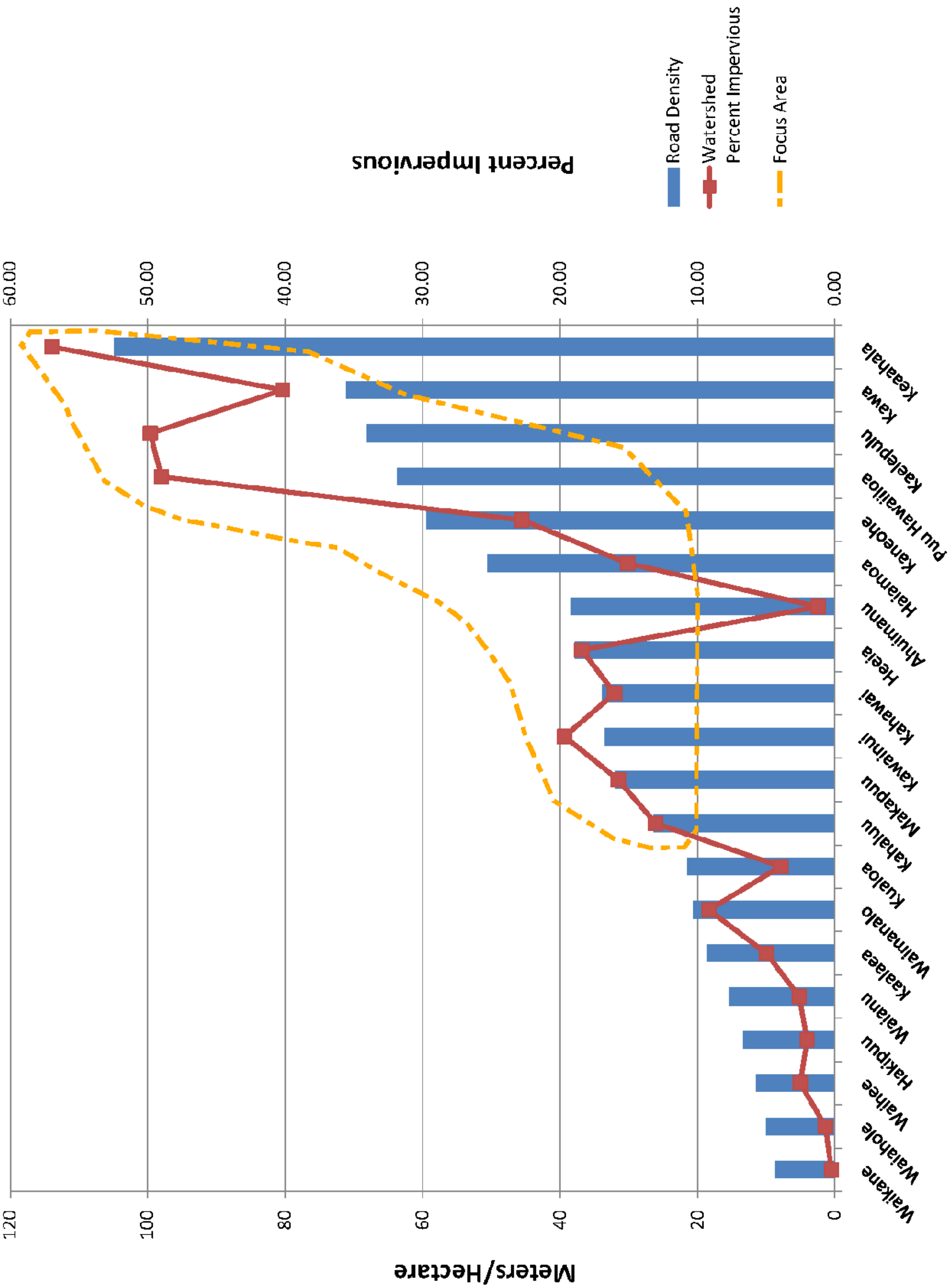
- Handles stormwater on site through use of vegetated facilities;
- Provides water quality benefits and replenishes groundwater (if an infiltration facility);
- Creates attractive streetscapes that enhance neighborhood livability by enhancing the pedestrian environment and introducing park-like elements into neighborhoods;
- Serves as an urban greenway segment that connects neighborhoods, parks, recreation facilities, schools, mainstreets, and wildlife habitats; and
- Meets broader community goals by providing pedestrian, and where appropriate, bicycle access.

Other cities in America are implementing green streets at a community level. For example, Tucson, Arizona has a very successful Green Infrastructure program run by a community group called Watershed Management Group. As a component of their Green Infrastructure, a Green Streets program is designed around many of the same goals: improved storm water management, cooling and beatifying streets, pedestrian access and empowering the community to be involved with the building and maintaining of these structures.

Chart 1 represents the relationship between imperviousness and street densities. Generally, as total watershed imperviousness increases, so too does the watersheds road density. Implementing green streets could prove most effective in areas that have a total imperviousness of ten-percent or greater in a watershed. This guideline is based on various relationships showing streams become impacted at ten-percent imperviousness and higher. For example, a priority project would be working to implement a green street pilot project in the Keaʻahala Watershed where street density and imperviousness are greatest and several commercial sites are not suitable for on-site retrofits. Likewise, working in the Kaʻelepulu Watershed has good potential for green streets pilot projects and educational opportunities.

Many, if not all of these benefits, could be realized in Koʻolaupoko with the adaption of these practices and ultimate implementation of green streets.

Chart 1 Ko'olaupoko Moku: Road Density/Percent Impervious per Watershed



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USBAP Process Methodology

The following sections have been created to describe the planning process used to identify, prioritize, and select potential LIR project sites within the developed lands of Koʻolaupoko moku.

LIR Project Process

Assuming a majority of runoff from urban areas within Koʻolaupoko is directed via municipal separate storm sewer system (MS4) conveyance systems towards receiving waters, it would be logical to assume all runoff producing sites within Koʻolaupoko should be retrofitted. While this may be true, it becomes logistically and financially unobtainable. Therefore, a method for identifying and prioritizing projects becomes crucial to ensure efficient use of HOK resources (time and money). A project prioritizing hierarchy has been developed by HOK to clearly define and target specific urban retrofit opportunities within the Koʻolaupoko moku using GIS based tools and on site observations. The images exhibited in Figure 13 on page 29 show the process of investigation and conceptualization for a proposed LIR site. For more detail see Appendix IV: Detailed USBAP LIR Process Methodology.

1. Physical Data

Determine total TMK parcels per region

A total of 27,323 TMK parcels exist in Koʻolaupoko moku.

2. Digital Analysis

Establish a min/max % Imperviousness

The target percent imperviousness per TMK parcel was identified as consisting of between 50 and 100 percent coverage. Using the target percent imperviousness between 50 and 100 percent reduced the total TMK parcels to ***19,886*** out of the total 27,323 TMK parcels in Koʻolaupoko.

Determine min/max TMK Parcel Size

The target TMK parcel size between 0.03 and 10 acres was established based on City & County of Honolulu (CCH) minimum parcel size according to the zoning district classifications (ZDC). Using the target TMK parcel size reduced the total TMK parcels to ***1,432*** out of the 19,886 TMK parcels.

Define a ZDC Focus Group

The target ZDC focus group is used to limit the search to TMK parcels having distinctly “urban” characteristics. Using the ZDC focus group further reduced the remaining 1,432 TMK parcels down to ***197*** TMK parcels.

3. Physical Analysis

Groundtruthing

The ***220*** TMK parcels identified through digital analysis are groundtruthed using Retrofit Site Investigation (RSI) and Hotspot/Pollution Prevention data sheets.

4. Project Prioritization

Space availability

Potential project sites either have space hydrologically available for LIR or not. Is the site able to be retrofitted with minimal conflicts to pre-existing site requirements.

Hotspot Score

Hotspot scores are based on the results of the *Hotspot/Pollution Prevention* Data Sheets.

NPS Pollution Loading Score

Once the LIR load reduction per each potential project site, the effectiveness of each project can be analyzed.

5. *Master LIR Project List*

A master LIR project list is created which summarizes the characteristics of each potential LIR project site. The user is able to sort projects through a wide number of variables such as; TMK No., sub-watershed, site name, ZDC, TMK size, percent imperviousness per TMK, visual access, annual rainfall, target rainfall (90th%), hydrologic soil group (HSG) classification, total contributing drainage area (CDA), LIR size, volume provided, volume needed, percent of volume provided, annual runoff reduction, total phosphorus (TP) reduced, total nitrogen (TN) reduced, total suspended solids (TSS) reduced, hotspot score, and LIR ranking score.

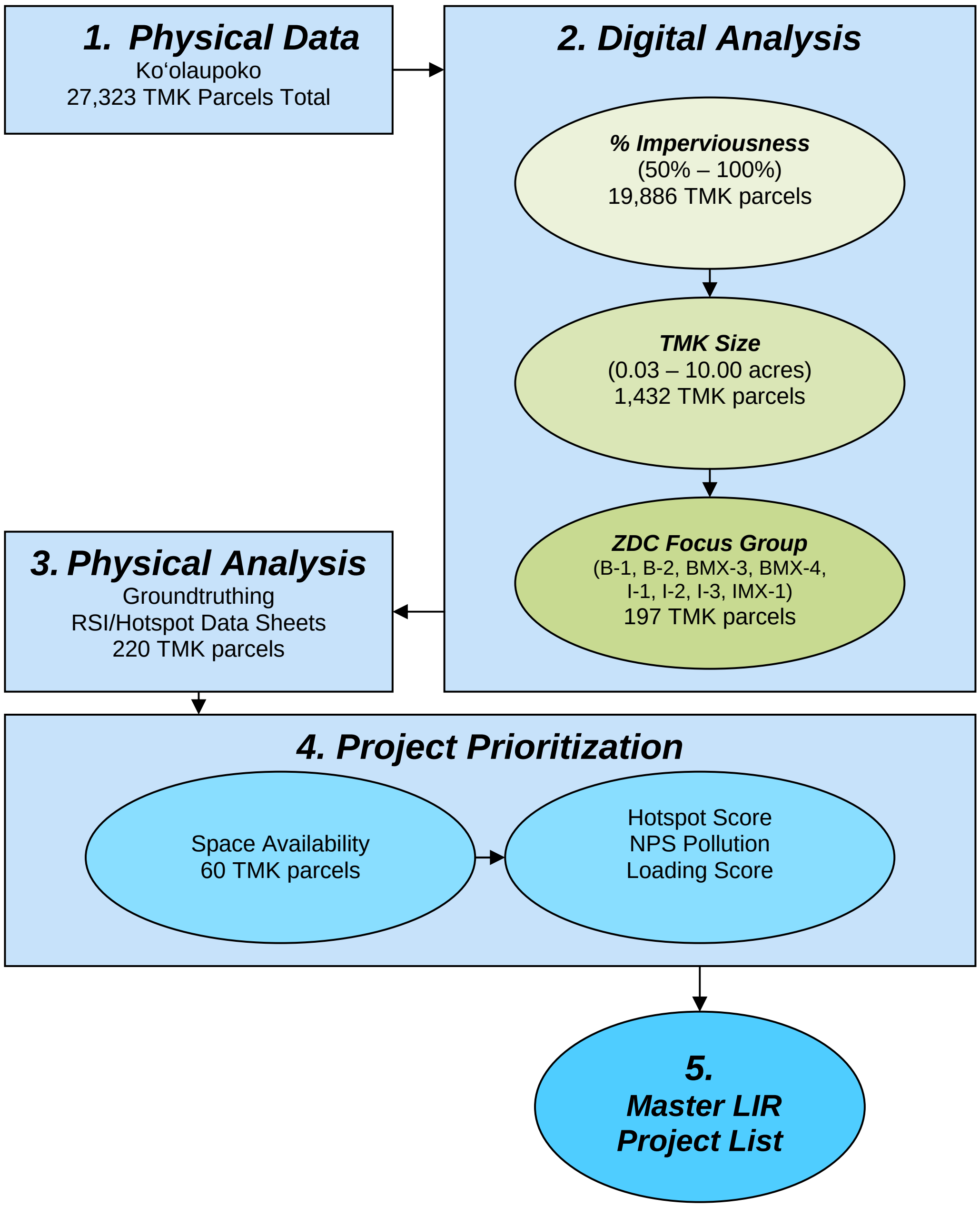

Figure 12 USBAP Process Methodology Diagram

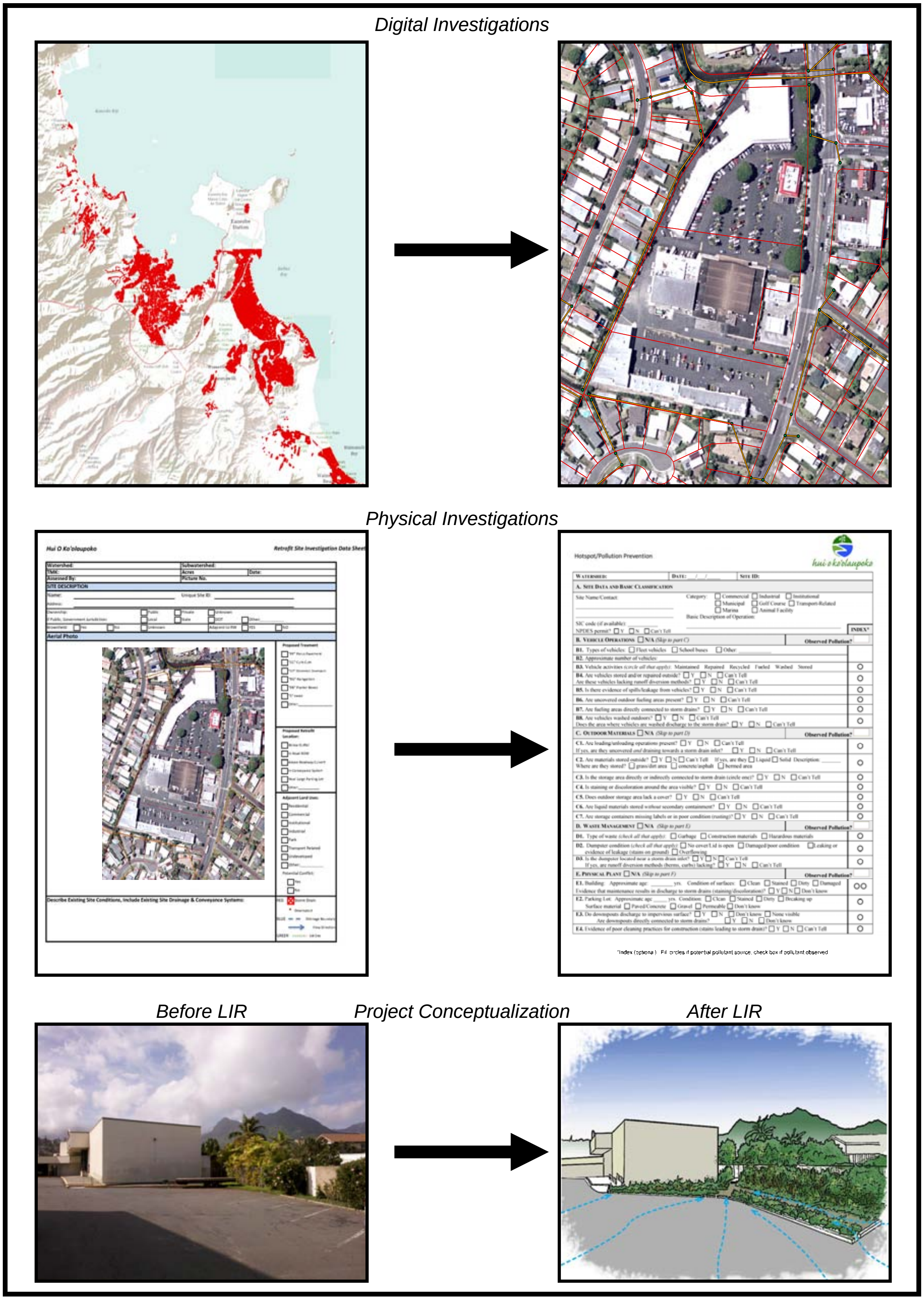

Figure 13 Digital to Physical

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Selected Projects

As a result of the project identification and prioritization process, a number of project sites have been selected for conceptual design for LIR within Koʻolaupoko. For the purpose of this document, conceptual design is defined as; *site sketches used to illustrate conceptual intent. The conceptual illustrations shall include the use of preliminary site plans, sections, and or vignettes.* The conceptual site designs will provide a foundation for future schematic design development of selected LIR projects. The selection of a particular LIR is dependent on specific site characteristics. Each LIR can be categorized according to the specific function the BMP has been created to provide. Appendix II: LIR Definitions provides industry standard definitions of commonly used LIRs.

Figure 14 shows the relationship of the total potential project sites to impervious cover and stream quality, 31 are located in "Non-Supporting" watersheds, 23 are located in "Impacted" watersheds, and 4 are located in "Sensitive" watersheds. The results of the GIS analysis used to identify potential project sites logically corresponds with existing stream quality. Figure 15 located on the following page shows the LIR Project Sites for the total Koʻolaupoko Moku. Table 2 Selected LIR Project Sites located on pages 33 provides a detailed list of potential LIR project sites found with Koʻolaupoko Moku. The following sections will outline the selected projects per sub region. See Figure 15 on the following page for further detail.

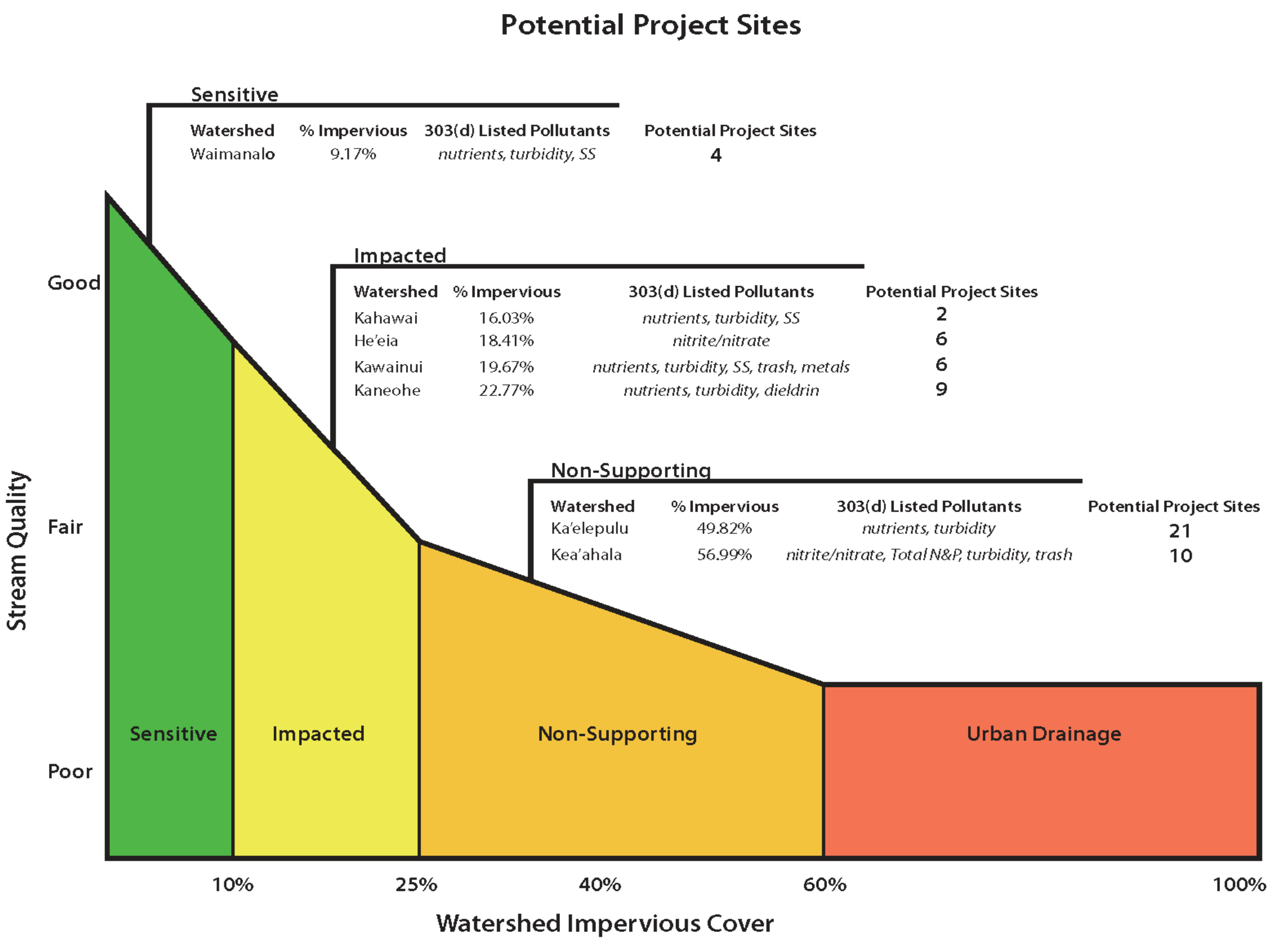


Figure 14 Locations of Potential Projects vs. Impervious Cover & Stream Quality

Adapted from Center for Watershed Protection, Urban Stream Repair Practices.

Figure 15 Ko‘olaupoko Moku: LIR Project Sites

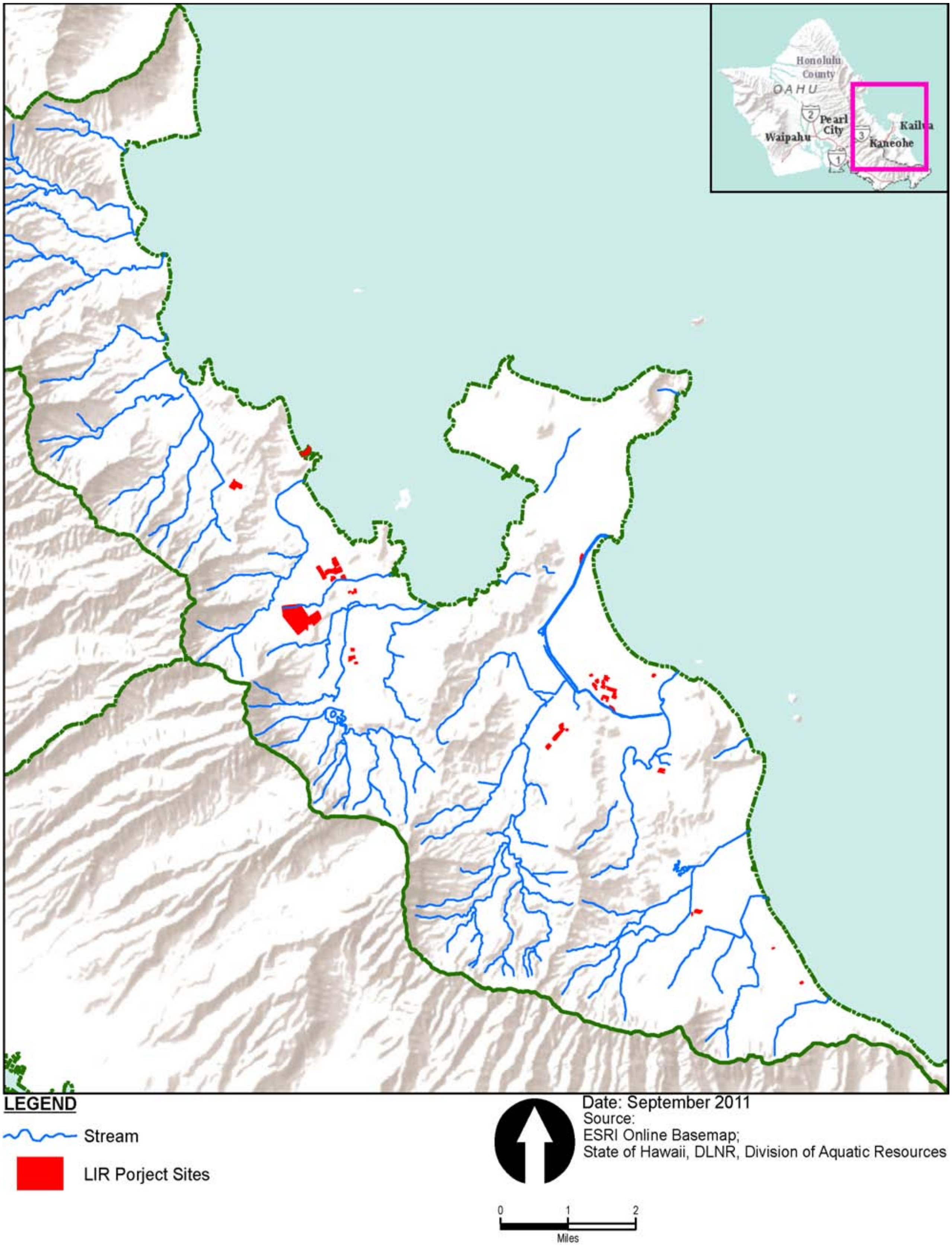


Table 2 Selected LIR Project Sites

Region			Site Data				CDA				LIR Site		NPS Pollution Reduction						
TMK	Sub-Watershed	Site Name	Zoning Type	Total Acres	% Imperviousness	Visibility	Annual Rainfall (inches)	Target Rainfall (90th)	Soil Group (HSG)	Total CDA (acres)	LIR site (sq ft)	Volume Provided (cu. ft.)	Volume Needed (cu. ft.)	% Provided/Needed	Annual Runoff Reduction (inches)	TP lb/yr	TN lb/yr	TSS lb/yr	**Ranking Score**
Waimanalo																			
41009278	Waimanalo	Coral Factory	B-1	0.58	97.04	H	44.19"	1.40"	D	0.570	1960	2752	2752	100%	1101	0.72	6.25	202	**90**
41007037	Kahawai	McDonalds'	B-1	0.33	99.97	H	44.19"	1.40"	C	0.160	696	698	698	100%	279	0.18	1.58	51	**90**
41022007	Waimanalo	Shimas	B-1	0.33	99.97	H	44.19"	1.40"	B	0.150	479	718	724	99%	287	0.19	1.63	53	**80**
41004006	Kahawai	Kenekes	B-1	0.46	99.97	L	44.19"	1.40"	C	0.110	261	392	531	74%	157	0.1	0.89	29	**75**
41009279	Waimanalo	Health Center	R-5	1.00	84.00	M	44.19"	1.40"	A	0.070	479	338	338	100%	135	0.09	0.77	25	**70**
41009275	Waimanalo	Jack N Box	B-1	1.56	99.97	M	44.19"	1.40"	B	0.040	1045	193	193	100%	77	0.05	0.44	14	**70**
Kailua																			
42001043	Ka'elepulu	Post Office	B-2	1.24	99.54	H	41.65"	1.43"	C	0.127	871	626	626	100%	250	0.15	1.31	42	**90**
42038034	Ka'elepulu	Macy's PRKNG	B-2	0.41	99.96	H	41.65"	1.43"	C	0.275	434	652	1356	48%	250	0.15	1.31	42	**90**
43056001	Ka'elepulu	McDonalds'	BMX-3	0.50	87.41	H	41.65"	1.43"	C	0.103	522	508	508	100%	203	0.12	1.06	34	**90**
42001005	Ka'elepulu	Down To Earth	B-2	2.12	80.55	M	41.65"	1.43"	B	0.290	392	588	1430	41%	235	0.14	1.23	40	**85**
42024016	Ka'elepulu	DT SFWY	B-2	3.16	98.95	H	41.65"	1.43"	C	0.39	4573	1923	1923	100%	769	0.47	4.03	130	**85**
42038008	Ka'elepulu	NAPA	B-2	0.35	99.97	H	41.65"	1.43"	C	0.430	479	212	212	100%	85	0.05	0.44	14	**85**
42038053	Ka'elepulu	Pali Lanes	B-2	1.68	67.22	H	41.65"	1.43"	C	0.179	696	883	883	100%	353	0.21	1.85	60	**85**
43054006	Ka'elepulu	Checker Auto Parts	B-2	0.60	99.64	H	41.65"	1.43"	C	0.159	1437	784	784	100%	314	0.19	1.64	53	**85**
43056002	Ka'elepulu	Pali Bottle Shop	B-2	0.43	99.95	H	41.65"	1.43"	C	0.136	653	671	671	100%	268	0.16	1.41	45	**85**
43057002	Ka'elepulu	Kailua Square Shpng Cntr	B-2	3.06	82.76	H	41.65"	1.43"	C	0.500	1176	1764	2367	75%	706	0.43	3.7	119	**85**
43057016	Ka'elepulu	K Town Pub	B-2	0.49	99.95	M	41.65"	1.43"	C	0.151	392	588	745	79%	235	0.14	1.23	40	**85**
42001026	Ka'elepulu	Fat Boys	B-2	0.71	99.97	M	41.65"	1.43"	C	0.073	304	360	360	100%	144	0.09	0.75	24	**80**
42038004	Ka'elepulu	Koolau Farms	R-7.5	0.48	96.71	M	41.65"	1.43"	B	0.184	261	392	907	43%	157	0.1	0.82	26	**80**
42038020	Ka'elepulu	Garden Accents	B-2	0.34	99.97	H	41.65"	1.43"	C	0.048	130	196	237	83%	78	0.05	0.41	13	**80**
42051003	Kawainui	Faith Baptist Church	R-5	2.10	74.43	M	41.65"	1.43"	B	0.630	1089	1633	2523	65%	653	0.4	3.42	110	**80**
42103032	Kawainui	Christ Church	R-5	2.00	35.64	M	41.65"	1.43"	B	0.245	696	1045	1208	87%	418	0.25	2.19	71	**80**
43053029	Ka'elepulu	Island Snow	B-1	0.92	81.61	M	41.65"	1.43"	B	0.222	217	326	1095	30%	130	0.08	0.68	22	**80**
43055001	Ka'elepulu	Cinnamon's Parking lot	BMX-3	1.76	80.91	M	41.65"	1.43"	C	0.710	1655	2482	3501	71%	993	0.6	5.2	168	**80**
43057019	Ka'elepulu	Block Buster	B-2	0.42	99.96	M	41.65"	1.43"	C	0.156	217	326	769	42%	130	0.08	0.68	22	**80**
43057073	Ka'elepulu	Agnesse's Bakery	B-2	0.39	99.96	H	41.65"	1.43"	C	0.177	1350	873	873	100%	349	0.21	1.83	59	**80**
43057073	Kawainui	Arbys	B-2	0.33	99.41	H	41.65"	1.43"	C	0.072	1045	355	355	100%	142	0.09	0.74	24	**80**
44023001	Kawainui	Pinkies	B-1	3.18	68.08	L	41.65"	1.43"	B	0.206	871	1016	1016	100%	406	0.25	2.13	69	**80**
42033050	Kawainui	Enchanted Lakes Safeway	B-1	2.74	96.57	L	41.65"	1.43"	D	0.450	914	1372	2219	62%	549	0.33	2.87	93	**75**
43014002	Ka'elepulu	YMCA	R-5	5.3	28	L	41.65"	1.43"	B	0.249	479	527	527	100%	211	0.13	1.1	36	**75**
43056005	Ka'elepulu	Bank of Hawaii	B-2	0.67	85.00	M	41.65"	1.43"	C	0.089	348	439	439	100%	176	0.92	0.92	30	**75**
42051001	Kawainui	CreekSide	I-2	0.35	75.50	L	41.65"	1.43"	B	0.069	435	340	340	100%	136	0.08	0.71	23	**70**
43057038	Ka'elepulu	Manuhea Alii	B-2	0.34	99.96	M	41.65"	1.43"	C	0.340	1916	1677	1677	100%	671	0.41	3.51	113	**70**

Table 2 Selected LIR Project Sites

Region			Site Data				CDA				LIR Site		NPS Pollution Reduction						
TMK	Sub-Watershed	Site Name	Zoning Type	Total Acres	% Imperviousness	Visibility	Annual Rainfall (inches)	Target Rainfall (90th)	Soil Group (HSG)	Total CDA (acres)	LIR site (sq ft)	Volume Provided (cu. ft.)	Volume Needed (cu. ft.)	% Provided/Needed	Annual Runoff Reduction (inches)	TP lb/yr	TN lb/yr	TSS lb/yr	**Ranking Score**
Kaneohe																			
46030061	Keeahala	Post Office	B-2	1.17	96.66	H	54.06"	1.15"	B	0.280	435	653	1110	59%	261	0.26	2.21	71	**95**
45023010	Kaneohe	Kaneohe District Park	P-2	12.6	N/A	H	74.30"	1.23"	B	0.386	696	1045	1570	67%	418	0.53	4.54	147	**90**
46006069	He'eia	He'eia Boat Launch	P-2	3.4	N/A	H	54.06"	1.15"	B	0.502	6534	1991	1991	100%	796	0.78	6.73	217	**90**
46011043	He'eia	WMP3	B-2	3.40	80.52	H	54.06"	1.15"	B	0.439	740	1110	1741	64%	444	0.44	3.75	121	**90**
46011047	He'eia	WMP2	B-2	3.80	N/A	H	54.06"	1.15"	B	0.429	2657	1701	1701	100%	680	0.67	5.75	186	**90**
46030053	Keeahala	Kaneohe Washerette	B-2	0.61	99.96	H	54.06"	1.15"	B	0.241	1045	956	956	100%	382	0.38	3.23	104	**90**
45019019	Keeahala	American Savings Bank	B-2	0.51	89.97	H	54.06"	1.15"	B	0.629	784	1176	2416	49%	470	0.46	3.98	128	**85**
45023002	Kaneohe	Kaneohe Court House	AG-2	2	N/A	M	74.30"	1.23"	B	0.775	3267	2785	2785	100%	1114	1.4	12.1	390	**85**
45039029	Kaneohe	Burger King	B-2	0.94	N/A	H	54.06"	1.15"	B	0.526	522	784	2086	38%	314	31	2.65	86	**85**
46011042	He'eia	WMP1	B-2	5.70	94.30	H	54.06"	1.15"	B	1.155	653	980	4580	21%	392	0.38	3.31	107	**85**
46011046	He'eia	Mall Overflow Parking	B-2	4.80	73.40	M	54.06"	1.15"	B	0.757	958	1437	2946	49%	575	0.56	4.86	157	**85**
47004037	Ahuimanu	Koolau Theaters	B-1	3.60	74.13	M	74.30"	1.23"	C	0.684	1698	2548	2749	93%	1019	1.28	11.07	357	**85**
45017007	Keeahala	Zippys Allstate	B-2	1.01	77.48	L	54.06"	1.15"	B	0.898	1219	1829	3389	54%	732	0.72	6.18	200	**80**
45019020	Keeahala	Pizza Hut	B-2	0.30	73.28	L	54.06"	1.15"	B	0.418	740	1110	1658	67%	444	0.44	3.75	121	**80**
45020023	Kaneohe	MAY MAY BBQ	B-2	0.32	99.96	L	54.06"	1.15"	B	0.167	740	662	662	100%	265	0.26	2.24	72	**80**
45023014	Kaneohe	WWCC A3	B-2	64	N/A	H	74.30"	1.23"	B	0.049	2874	208	208	100%	83	0.1	0.9	29	**80**
45023014	Kaneohe	WWCC A4	B-2	N/A	N/A	L	74.30"	1.23"	B	0.474	1698	1800	1800	100%	720	0.91	7.82	252	**80**
45023014	Kaneohe	WWCC A5	B-2	N/A	N/A	H	74.30"	1.23"	B	0.035	2221	148	148	100%	59	0.07	0.64	21	**80**
45039005	Kaneohe	Kaiser Clinic	B-2	2.74	53.93	H	54.06"	1.15"	B	2.549	3049	4573	6884	66%	1829	1.79	15.46	499	**80**
45076042	Kaneohe	Koolau Farms	I-2	0.51	99.96	M	54.06"	1.15"	B	0.143	566	567	567	100%	227	0.22	1.92	62	**80**
46030031	Keeahala	Windward Auto Spa	I-2	1.25	99.96	H	54.06"	1.15"	B	0.197	1655	781	781	100%	312	0.31	2.64	85	**80**
45019021	Keeahala	Fresh Catch	B-2	0.48	89.73	L	54.06"	1.15"	B	0.497	566	849	1846	100%	340	0.33	2.87	93	**75**
45023014	Kaneohe	WWCC PKNG 3	B-2	N/A	N/A	L	74.30"	1.23"	B	0.709	1001	1502	3007	50%	601	0.76	6.53	211	**75**
46030022	Keeahala	Hawaiian Designs	I-2	0.80	99.58	M	54.06"	1.15"	B	0.194	174	261	769	34%	104	0.1	0.88	28	**75**
46030035	Keeahala	Lex Brodies	I-2	0.45	99.96	M	54.06"	1.15"	B	0.136	174	261	539	48%	104	0.1	0.88	28	**75**
46030057	He'eia	Windward Center	B-2	0.67	97.10	M	54.06"	1.15"	B	0.063	392	250	250	100%	100	0.1	0.85	27	**75**
45017003	Keeahala	Kaneohe Medical BLDG	B-2	0.37	95.21	L	54.06"	1.15"	B	0.266	174	261	1055	25%	105	0.1	0.88	29	**70**
45023015	Kaneohe	WW Fam Guidance Center	AG-2	4.1	N/A	L	74.30"	1.23"	B	0.904	3702	3299	3299	100%	1320	1.66	14.34	463	**70**

Regional Summaries

High priority projects vs. lower priority projects:

The following sections highlight projects Waimānalo, Kailua and Kāneʻohe and provide conceptual examples of retrofits for priority ranked projects in each area. Each project in its own right has value to overall watershed health. High priority projects which have been identified and ordered according to the criteria established above are intended to have the greatest impact with respect to water quality and education/outreach. Lower priority projects do not necessarily denote a lower possible positive impact on watershed health. A lower priority ranking could result from site conflicts as listed above, which may slow or impede implementation. Each project which was identified in the identification process, as stated, has its own value to overall watershed health in its own right and as such, will qualify for education and outreach programs facilitated by HOK in the future.

Waimānalo LIR Project Sites

Table 3 shows the potential LIR projects selected and ranked in Waimānalo. The relatively low number of LIR project sites for this region could reflect the generally low intensity of urban development. The Waimānalo urban core, although small, can be viewed as having two distinct "urban" centers. Figure 16 shows the locations of the six potential project sites; four are located in the same shopping center in the "western" urban core. The remaining two potential project sites are located along Kalanianaʻole Highway in the "eastern" urban core area.

Space Availability:

6 potential projects were identified based on Space Availability.

Hotspot Score:

3 were confirmed Hotspots.

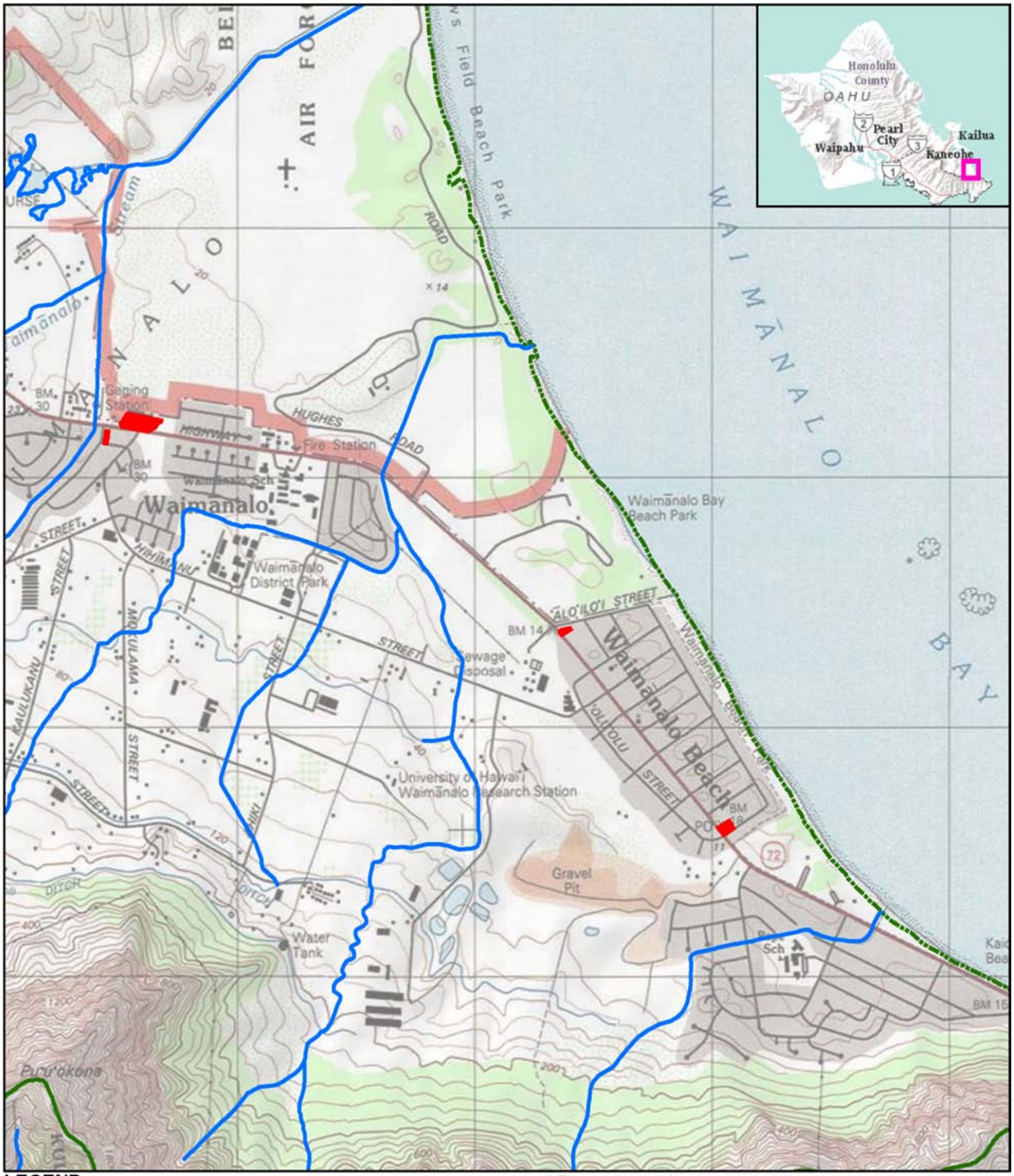
Ranking Score:

The average ranking score for Waimānalo LIR project sites is 79.2.

Table 3 Waimānalo LIR Project Sites

Waimanalo		Site Data				CDA				LIR Site		NPS Pollution Reduction							
Sub-Watershed	Site Name	Zoning Type	Total Acres	% Imperviousness	Visibility	Annual Rainfall (inches)	Target Rainfall (90th)	Soil Group (HSG)	Total CDA (acres)	LIR site (sq ft)	Volume Provided (cu. ft.)	Volume Needed (cu. ft.)	% Provided/Needed	Annual Runoff Reduction (inches)	TP lb/yr	TN lb/yr	TSS lb/yr	**Hotspot Score**	**Ranking Score**
Waimanalo	Coral Factory	B-1	0.58	97.04	H	44.19"	1.40"	D	0.570	1960	2752	2752	100%	1101	0.72	6.25	202	**10**	**90**
Kahawai	McDonalds'	B-1	0.33	99.97	H	44.19"	1.40"	C	0.160	696	698	698	100%	279	0.18	1.58	51	**10**	**90**
Waimanalo	Shimas	B-1	0.33	99.97	H	44.19"	1.40"	B	0.150	479	718	724	99%	287	0.19	1.63	53	**0**	**80**
Kahawai	Kenekes	B-1	0.46	99.97	L	44.19"	1.40"	C	0.110	261	392	531	74%	157	0.1	0.89	29	**10**	**75**
Waimanalo	Jack N Box	B-1	1.56	99.97	M	44.19"	1.40"	B	0.040	1045	193	193	100%	77	0.05	0.44	14	**0**	**70**
Waimanalo	Health Center	R-5	1.00	84.00	M	44.19"	1.40"	A	0.070	479	338	338	100%	135	0.09	0.77	25	**0**	**70**

Figure 16 Waimānalo: LIR Project Sites



LEGEND

Stream

LIR Project Sites

Date: September 2011

Source:
ESRI Online Basemap;
State of Hawaii, DLNR, Division of Aquatic Resrources

0 0.2 0.4
Miles

McDonald's; Kahawai Watershed, Waimānalo

Project Summary

Annual Rainfall	44.19"
Target Rainfall Event	1.40"
Hydrologic Soil Group (HSG)	C
Impervious Area Treated (acres)	0.16
Type of LIR Practice	RG
Annual Runoff Reduction (cu. ft)	279
TN Removed (lb/yr)	0.18
TP Removed (lb/yr)	1.58
TSS Removed (lb/yr)	51
Ranking Score	90

Site Description

The proposed LIR project site is located at the Waimānalo McDonald's, on the corner of Kalanianaʻole hwy and Aloiloi St. A popular drive thru and fast food establishment, this location receives significant vehicular traffic.

Existing Conditions

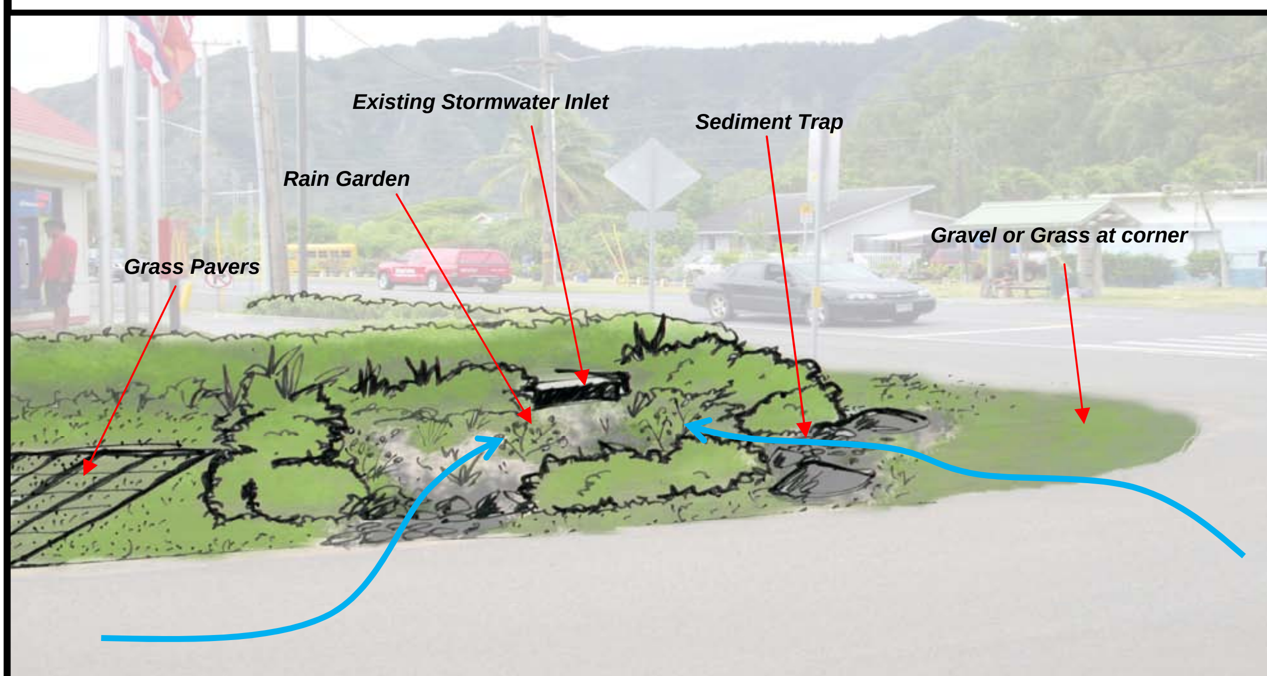
The existing site conditions are average. The parking lot shows signs of age. Four large storm drains are located at or near the four corners of the property. Landscaped areas are well maintained with little signs of litter. Waste management BMPs are in place and in use. Particular concern can be found along the north property line bordering Aloiloi St. Overflow parking has reduced groundcover and exposed soils to erosion.

Proposed LIR

North property line bordering Aloiloi St. Install rain garden and sediment trap to pre-treat stormwater runoff before entering the storm drains. Pervious pavers or grass pavers could be used to maintain supplemental parking along Aloiloi St.

McDonald’s; Kahawai Watershed, Waimānalo

Notes:
Install rain garden and sediment trap to pre-treat stormwater runoff before entering the storm drains. Existing stormwater infrastructure should be utilized and improved. Pervious pavers or grass pavers could be used to maintain supplemental parking along Aloiloi St.



Kailua LIR Project Sites

Table 4 shows the potential LIR projects selected and ranked located in Kailua. The number of potential LIR project sites in Kailua reflects the urban development intensity. Figure 17 shows the locations of potential project sites. With the exception of the Aikahi and Enchanted Lakes areas, a majority of the project sites are located in what is commonly known as Downtown Kailua. The remaining project sites are located along Kailua Rd.

Space Availability:

27 potential projects were identified based on Space Availability.

Hotspot Score:

Of the 27 potential projects; 16 are confirmed Hotspots, 10 are potential Hotspots, and 1 did not score high enough to be classified as a Hotspot.

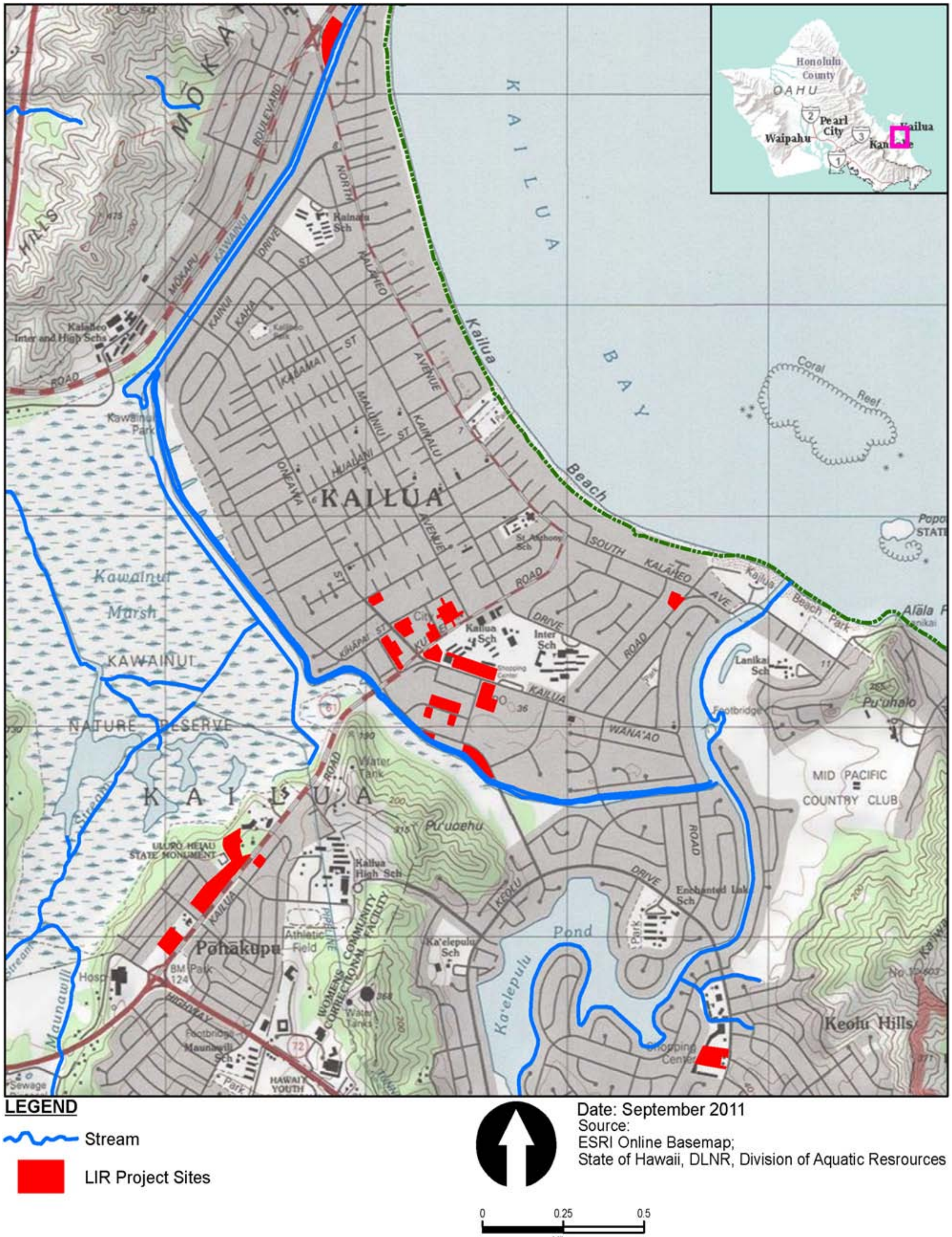
Ranking Score:

The average ranking score for Kailua LIR project sites is 81.3.

Table 4 Kailua LIR Project Sites

Kailua		Site Data				CDA				LIR Site		NPS Pollution Reduction							
Sub-Watershed	Site Name	Zoning Type	Total Acres	% Imperviousness	Visibility	Annual Rainfall (inches)	Target Rainfall (90th)	Soil Group (HSG)	Total CDA (acres)	LIR site (sq ft)	Volume Provided (cu. ft.)	Volume Needed (cu. ft.)	% Provided/Needed	Annual Runoff Reduction (inches)	TP lb/yr	TN lb/yr	TSS lb/yr	**Hotspot Score**	**Ranking Score**
Ka'elepulu	Post Office	B-2	1.24	99.54	H	41.65"	1.43"	C	0.127	871	626	626	100%	250	0.15	1.31	42	**10**	**90**
Ka'elepulu	Macy's PRKNG	B-2	0.41	99.96	H	41.65"	1.43"	C	0.275	434	652	1356	48%	250	0.15	1.31	42	**10**	**90**
Ka'elepulu	McDonalds'	BMX-3	0.50	87.41	H	41.65"	1.43"	C	0.103	522	508	508	100%	203	0.12	1.06	34	**10**	**90**
Ka'elepulu	Down To Earth	B-2	2.12	80.55	M	41.65"	1.43"	B	0.290	392	588	1430	41%	235	0.14	1.23	40	**10**	**85**
Ka'elepulu	DT SFWY	B-2	3.16	98.95	H	41.65"	1.43"	C	0.39	4573	1923	1923	100%	769	0.47	4.03	130	**5**	**85**
Ka'elepulu	NAPA	B-2	0.35	99.97	H	41.65"	1.43"	C	0.430	479	212	212	100%	85	0.05	0.44	14	**10**	**85**
Ka'elepulu	Pali Lanes	B-2	1.68	67.22	H	41.65"	1.43"	C	0.179	696	883	883	100%	353	0.21	1.85	60	**10**	**85**
Ka'elepulu	Checker Auto Parts	B-2	0.60	99.64	H	41.65"	1.43"	C	0.159	1437	784	784	100%	314	0.19	1.64	53	**10**	**85**
Ka'elepulu	Pali Bottle Shop	B-2	0.43	99.95	H	41.65"	1.43"	C	0.136	653	671	671	100%	268	0.16	1.41	45	**5**	**85**
Ka'elepulu	Kailua Square Shpng Cntr	B-2	3.06	82.76	H	41.65"	1.43"	C	0.500	1176	1764	2367	75%	706	0.43	3.7	119	**10**	**85**
Ka'elepulu	K Town Pub	B-2	0.49	99.95	M	41.65"	1.43"	C	0.151	392	588	745	79%	235	0.14	1.23	40	**10**	**85**
Ka'elepulu	Fat Boys	B-2	0.71	99.97	M	41.65"	1.43"	C	0.073	304	360	360	100%	144	0.09	0.75	24	**10**	**80**
Ka'elepulu	Koolau Farms	R-7.5	0.48	96.71	M	41.65"	1.43"	B	0.184	261	392	907	43%	157	0.1	0.82	26	**10**	**80**
Ka'elepulu	Garden Accents	B-2	0.34	99.97	H	41.65"	1.43"	C	0.048	130	196	237	83%	78	0.05	0.41	13	**5**	**80**
Kawainui	Faith Baptist Church	R-5	2.10	74.43	M	41.65"	1.43"	B	0.630	1089	1633	2523	65%	653	0.4	3.42	110	**10**	**80**
Kawainui	Christ Church	R-5	2.00	35.64	M	41.65"	1.43"	B	0.245	696	1045	1208	87%	418	0.25	2.19	71	**5**	**80**
Ka'elepulu	Island Snow	B-1	0.92	81.61	M	41.65"	1.43"	B	0.222	217	326	1095	30%	130	0.08	0.68	22	**10**	**80**
Ka'elepulu	Cinnamon's Parking lot	BMX-3	1.76	80.91	M	41.65"	1.43"	C	0.710	1655	2482	3501	71%	993	0.6	5.2	168	**5**	**80**
Ka'elepulu	Block Buster	B-2	0.42	99.96	M	41.65"	1.43"	C	0.156	217	326	769	42%	130	0.08	0.68	22	**10**	**80**
Ka'elepulu	Agnesse's Bakery	B-2	0.39	99.96	H	41.65"	1.43"	C	0.177	1350	873	873	100%	349	0.21	1.83	59	**5**	**80**
Kawainui	Arbys	B-2	0.33	99.41	H	41.65"	1.43"	C	0.072	1045	355	355	100%	142	0.09	0.74	24	**5**	**80**
Kawainui	Pinkies	B-1	3.18	68.08	L	41.65"	1.43"	B	0.206	871	1016	1016	100%	406	0.25	2.13	69	**10**	**80**
Kawainui	Enchanted Lakes Safeway	B-1	2.74	96.57	L	41.65"	1.43"	D	0.450	914	1372	2219	62%	549	0.33	2.87	93	**10**	**75**
Ka'elepulu	YMCA	R-5	5.3	28	L	41.65"	1.43"	B	0.249	479	527	527	100%	211	0.13	1.1	36	**5**	**75**
Ka'elepulu	Bank of Hawaii	B-2	0.67	85.00	M	41.65"	1.43"	C	0.089	348	439	439	100%	176	0.92	0.92	30	**5**	**75**
Kawainui	CreekSide	I-2	0.35	75.50	L	41.65"	1.43"	B	0.069	435	340	340	100%	136	0.08	0.71	23	**5**	**70**
Ka'elepulu	Manuhea Alii	B-2	0.34	99.96	M	41.65"	1.43"	C	0.340	1916	1677	1677	100%	671	0.41	3.51	113	**0**	**70**

Figure 17 Kailua: LIR Project Sites



Post Office; Ka‘elepulu Watershed, Kailua

Project Summary

Annual Rainfall	41.65"
Target Rainfall Event	1.43”
Hydrologic Soil Group (HSG)	C
Impervious Area Treated (acres)	0.275
Type of LIR Practice	RG
Annual Runoff Reduction (cu. ft)	250
TN Removed (lb/yr)	1.31
TP Removed (lb/yr)	0.15
TSS Removed (lb/yr)	42
Ranking Score	90

Site Description

The proposed LIR project site is located along Hahani St. This location receives significant vehicular traffic.

Existing Conditions

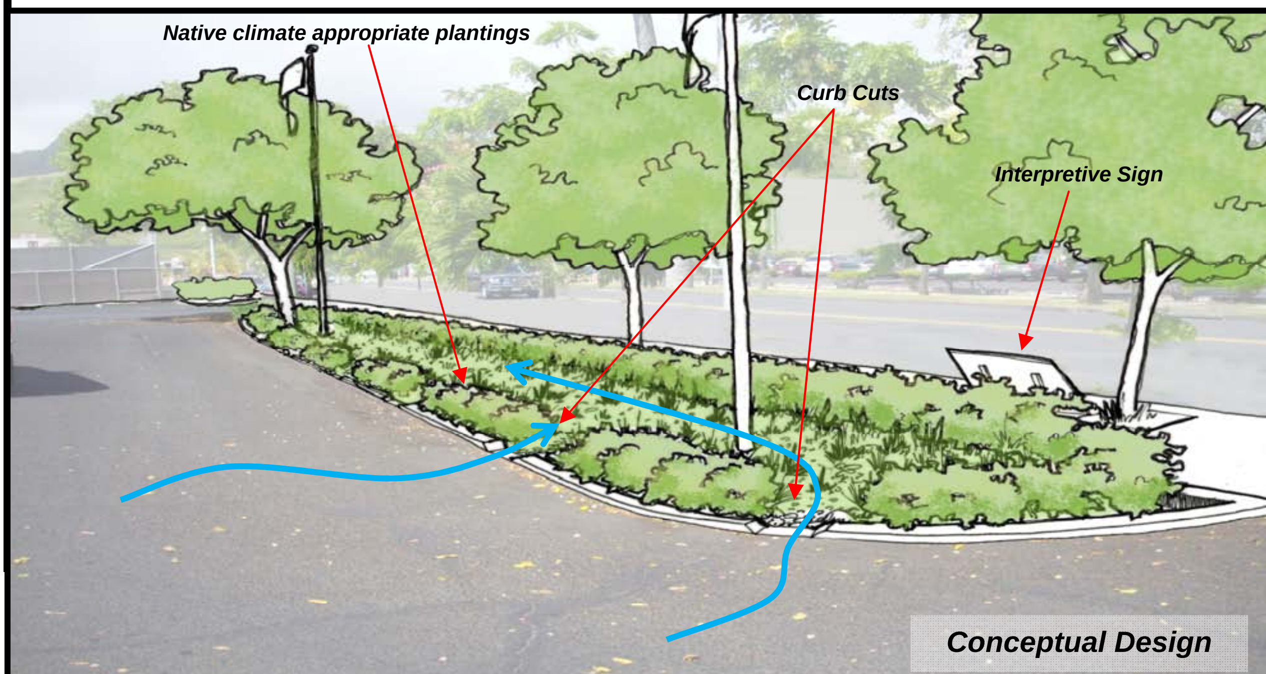
The parking lot shows signs of age. Parking stalls have evidence of oil and grease stains. Landscaped areas are maintained, yet noticeably large amounts of organic waste can be seen. A majority of the runoff from the front of the parcel is directed towards the street.

Proposed LIR

The existing landscape planter has low curbing, which could be easily retrofitted to accept stormwater runoff. Particular challenges would be the removal of medium sized palms located within the landscape planter.

Post Office; Ka‘elepulu Watershed, Kailua

Notes:
Extend curbing higher and insert curb cuts to allow stormwater runoff to enter the rain garden. Access to flag poles will need to be maintained.



"Fat Boy's"; Ka'elepulu Watershed, Kailua

Project Summary

Annual Rainfall	41.65"
Target Rainfall Event	1.43"
Hydrologic Soil Group (HSG)	C
Impervious Area Treated (acres)	0.073
Type of LIR Practice	RG
Annual Runoff Reduction (cu. ft)	144
TN Removed (lb/yr)	0.75
TP Removed (lb/yr)	0.09
TSS Removed (lb/yr)	24
Ranking Score	80

Site Description

The proposed LIR project site is located at the intersection of Hahani St. and Kailua Rd. This location houses a number of small retail shops and boutique restaurants, receiving a significant amount of vehicular traffic.

Existing Conditions

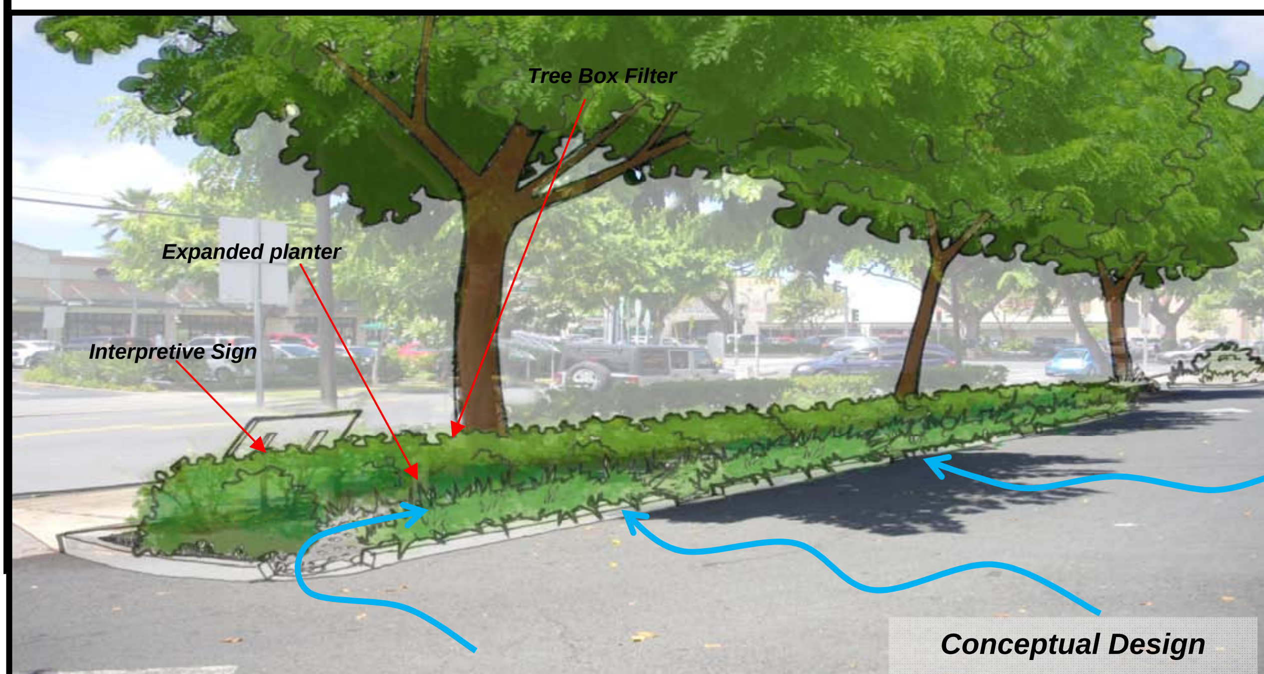
The existing site conditions are average. The parking lot shows slight signs of ageing. Stormwater runoff from the structure and parking lot is directed into the street. Landscaped areas are well maintained with little signs of litter. One landscaped planter is already receiving runoff from the roof.

Proposed LIR

The landscape planter along the Hahani St. frontage is best suited to receive stormwater runoff. The existing planter could be widened, and place curb cuts along the perimeter. The existing trees could be converted into "tree box" filters, placed along the sidewalk.

“Fat Boy’s”; Ka‘elepulu Watershed, Kailua

Notes:
With minimal conflicts, the landscape planter could be expanded to facilitate the proposed LIR. Existing trees should be moved into the sidewalk, placed in “tree box” filters designed to accept street generated stormwater runoff.



Kāneʻohe LIR Project Sites

Table 5 shows the potential LIR projects selected and ranked located in Kāneʻohe. As shown in figure 20, the potential LIR project sites in Kāneʻohe are mainly located around the core urban areas, with the exception of Heʻeia small boat harbor, District Court office, and the Windward Community College. From the highest number of potential LIR project sites, Kāneʻohe appears to have the highest urban intensity within the Koʻolaupoko moku.

Space Availability:

28 potential projects were identified based on *Space Availability*.

Hotspot Score:

Of the 28 potential projects; 11 are confirmed as Hotspots, 16 are potential Hotspots, and 1 did not score high enough to be classified as a Hotspot.

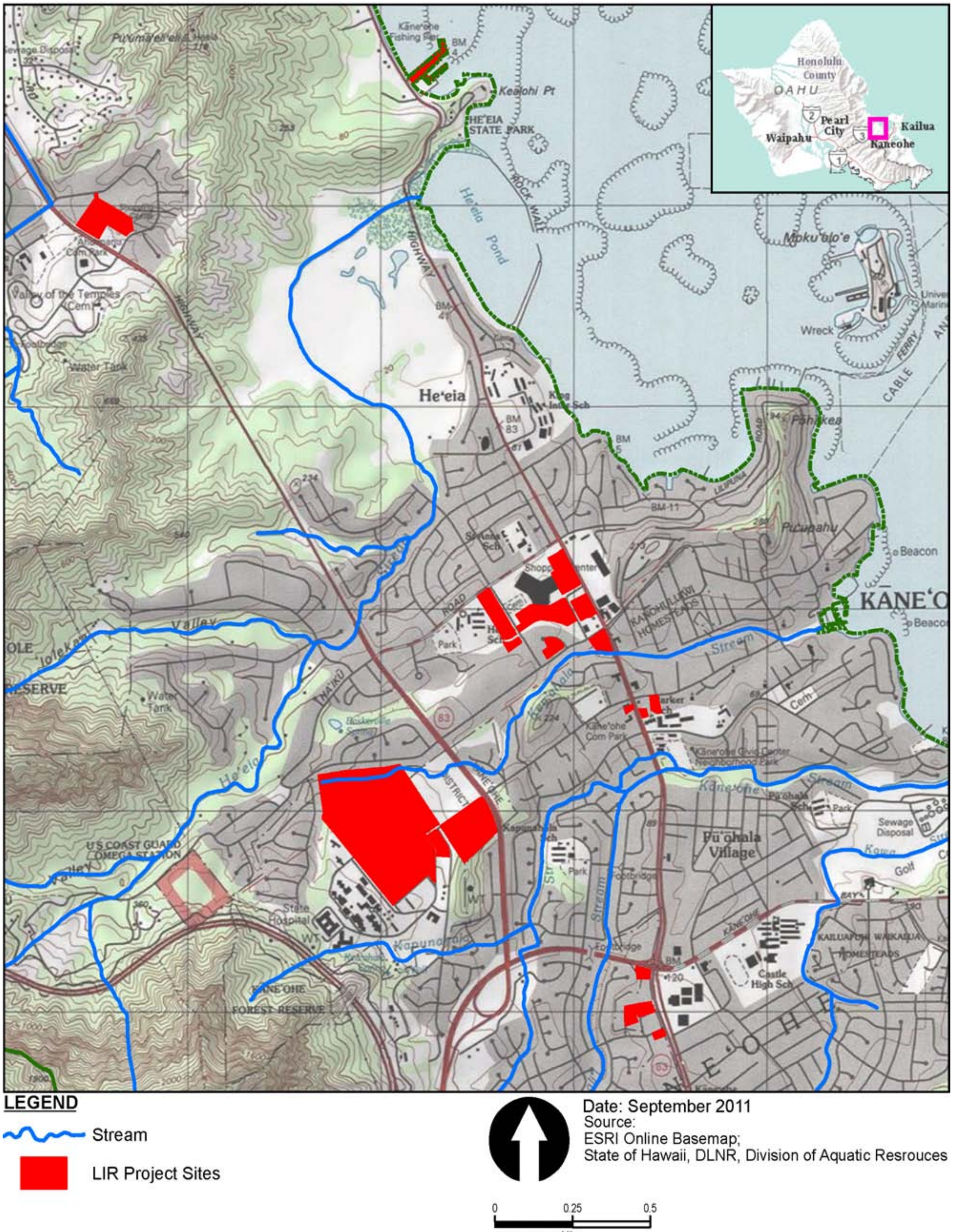
Ranking Score:

The average ranking score for Kāneʻohe LIR project sites is 81.8.

Table 5 Kāneʻohe LIR Project Sites

Kaneohe		Site Data				CDA				LIR Site		NPS Pollution Reduction							
Sub-Watershed	Site Name	Zoning Type	Total Acres	% Imperviousness	Visibility	Annual Rainfall (inches)	Target Rainfall (90th)	Soil Group (HSG)	Total CDA (acres)	LIR site (sq ft)	Volume Provided (cu. ft.)	Volume Needed (cu. ft.)	% Provided/Needed	Annual Runoff Reduction (inches)	TP lb/yr	TN lb/yr	TSS lb/yr	**Hotspot Score**	**Ranking Score**
Keeahala	Post Office	B-2	1.17	96.66	H	54.06"	1.15"	B	0.280	435	653	1110	59%	261	0.26	2.21	71	**10**	**95**
Kaneohe	Kaneohe District Park	P-2	12.6	N/A	H	74.30"	1.23"	B	0.386	696	1045	1570	67%	418	0.53	4.54	147	**5**	**90**
He'eia	He'eia Boat Launch	P-2	3.4	N/A	H	54.06"	1.15"	B	0.502	6534	1991	1991	100%	796	0.78	6.73	217	**10**	**90**
He'eia	WMP3	B-2	3.40	80.52	H	54.06"	1.15"	B	0.439	740	1110	1741	64%	444	0.44	3.75	121	**10**	**90**
He'eia	WMP2	B-2	3.80	N/A	H	54.06"	1.15"	B	0.429	2657	1701	1701	100%	680	0.67	5.75	186	**10**	**90**
Keeahala	Kaneohe Washerette	B-2	0.61	99.96	H	54.06"	1.15"	B	0.241	1045	956	956	100%	382	0.38	3.23	104	**10**	**90**
Keeahala	American Savings Bank	B-2	0.51	89.97	H	54.06"	1.15"	B	0.629	784	1176	2416	49%	470	0.46	3.98	128	**5**	**85**
Kaneohe	Kaneohe Court House	AG-2	2	N/A	M	74.30"	1.23"	B	0.775	3267	2785	2785	100%	1114	1.4	12.1	390	**10**	**85**
Kaneohe	Burger King	B-2	0.94	N/A	H	54.06"	1.15"	B	0.526	522	784	2086	38%	314	31	2.65	86	**5**	**85**
He'eia	WMP1	B-2	5.70	94.30	H	54.06"	1.15"	B	1.155	653	980	4580	21%	392	0.38	3.31	107	**5**	**85**
He'eia	Mall Overflow Parking	B-2	4.80	73.40	M	54.06"	1.15"	B	0.757	958	1437	2946	49%	575	0.56	4.86	157	**10**	**85**
Ahuimanu	Koolau Theaters	B-1	3.60	74.13	M	74.30"	1.23"	C	0.684	1698	2548	2749	93%	1019	1.28	11.07	357	**10**	**85**
Keeahala	Zippys Allstate	B-2	1.01	77.48	L	54.06"	1.15"	B	0.898	1219	1829	3389	54%	732	0.72	6.18	200	**10**	**80**
Keeahala	Pizza Hut	B-2	0.30	73.28	L	54.06"	1.15"	B	0.418	740	1110	1658	67%	444	0.44	3.75	121	**10**	**80**
Kaneohe	MAY MAY BBQ	B-2	0.32	99.96	L	54.06"	1.15"	B	0.167	740	662	662	100%	265	0.26	2.24	72	**5**	**80**
Kaneohe	WWCC A3	B-2	64	N/A	H	74.30"	1.23"	B	0.049	2874	208	208	100%	83	0.1	0.9	29	**5**	**80**
Kaneohe	WWCC A4	B-2	N/A	N/A	L	74.30"	1.23"	B	0.474	1698	1800	1800	100%	720	0.91	7.82	252	**10**	**80**
Kaneohe	WWCC A5	B-2	N/A	N/A	H	74.30"	1.23"	B	0.035	2221	148	148	100%	59	0.07	0.64	21	**5**	**80**
Kaneohe	Kaiser Clinic	B-2	2.74	53.93	H	54.06"	1.15"	B	2.549	3049	4573	6884	66%	1829	1.79	15.46	499	**5**	**80**
Kaneohe	Koolau Farms	I-2	0.51	99.96	M	54.06"	1.15"	B	0.143	566	567	567	100%	227	0.22	1.92	62	**5**	**80**
Keeahala	Windward Auto Spa	I-2	1.25	99.96	H	54.06"	1.15"	B	0.197	1655	781	781	100%	312	0.31	2.64	85	**0**	**80**
Keeahala	Fresh Catch	B-2	0.48	89.73	L	54.06"	1.15"	B	0.497	566	849	1846	100%	340	0.33	2.87	93	**5**	**75**
Kaneohe	WWCC PKNG 3	B-2	N/A	N/A	L	74.30"	1.23"	B	0.709	1001	1502	3007	50%	601	0.76	6.53	211	**5**	**75**
Keeahala	Hawaiian Designs	I-2	0.80	99.58	M	54.06"	1.15"	B	0.194	174	261	769	34%	104	0.1	0.88	28	**5**	**75**
Keeahala	Lex Brodies	I-2	0.45	99.96	M	54.06"	1.15"	B	0.136	174	261	539	48%	104	0.1	0.88	28	**5**	**75**
He'eia	Windward Center	B-2	0.67	97.10	M	54.06"	1.15"	B	0.063	392	250	250	100%	100	0.1	0.85	27	**5**	**75**
Keeahala	Kaneohe Medical BLDG	B-2	0.37	95.21	L	54.06"	1.15"	B	0.266	174	261	1055	25%	105	0.1	0.88	29	**5**	**70**
Kaneohe	WW Fam Guidance Center	AG-2	4.1	N/A	L	74.30"	1.23"	B	0.904	3702	3299	3299	100%	1320	1.66	14.34	463	**5**	**70**

Figure 18 Kāneʻohe: LIR Project Sites



Windward Community College “A3”; Kāne‘ohe Watershed, Kāne‘ohe

Project Summary

Annual Rainfall	74.30"
Target Rainfall Event	1.23”
Hydrologic Soil Group (HSG)	B
Impervious Area Treated (acres)	0.049
Type of LIR Practice	RG
Annual Runoff Reduction (cu. ft)	83
TN Removed (lb/yr)	0.9
TP Removed (lb/yr)	0.1
TSS Removed (lb/yr)	29
Ranking Score	80

Site Description

The proposed LIR project site is located at the Windward Community College.

Existing Conditions

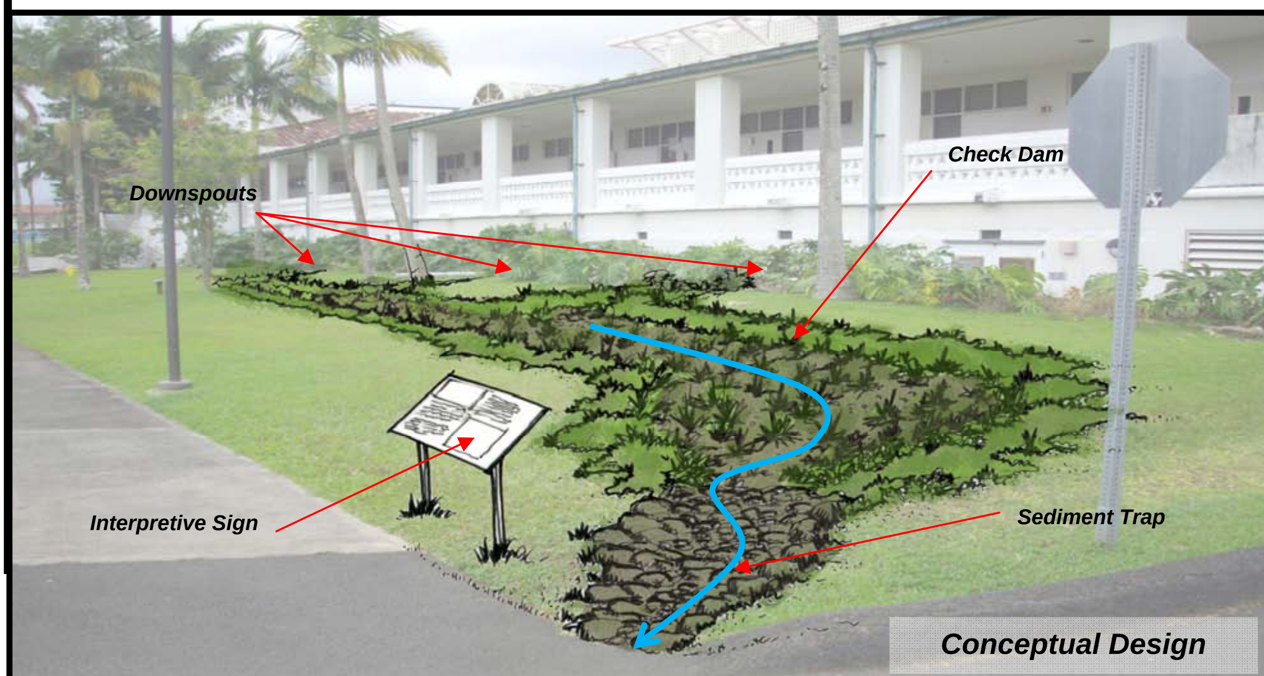
The surrounding area is well landscaped and maintained. Multiple drainage areas are located within this site. Rooftop generated runoff is directed onto the grassed area to the northeast, while runoff from adjacent impervious surfaces is directed into storm drains located in a grassed depression to the northwest of the structure. This area could also be retrofitted although it is not shown here.

Proposed LIR

Along the eastern frontage, a rain garden could be installed to accept rooftop generated runoff. With a single retrofit installation, multiple downspouts could be directed into the rain garden.

Windward Community College “A3”; Kāneʻohe Watershed, Kāneʻohe

Notes:
Multiple downspouts could be services by a single rain garden. Planting selections should match surrounding landscape motifs as much as possible.



Windward Community College "A4"; Kāneʻohe Watershed, Kāneʻohe

Project Summary

Annual Rainfall	74.30"
Target Rainfall Event	1.23"
Hydrologic Soil Group (HSG)	B
Impervious Area Treated (acres)	0.474
Type of LIR Practice	RG
Annual Runoff Reduction (cu. ft)	720
TN Removed (lb/yr)	7.82
TP Removed (lb/yr)	0.91
TSS Removed (lb/yr)	252
Ranking Score	80

Site Description

The adjacent area appears to be Windward Community College maintenance facilities.

Existing Conditions

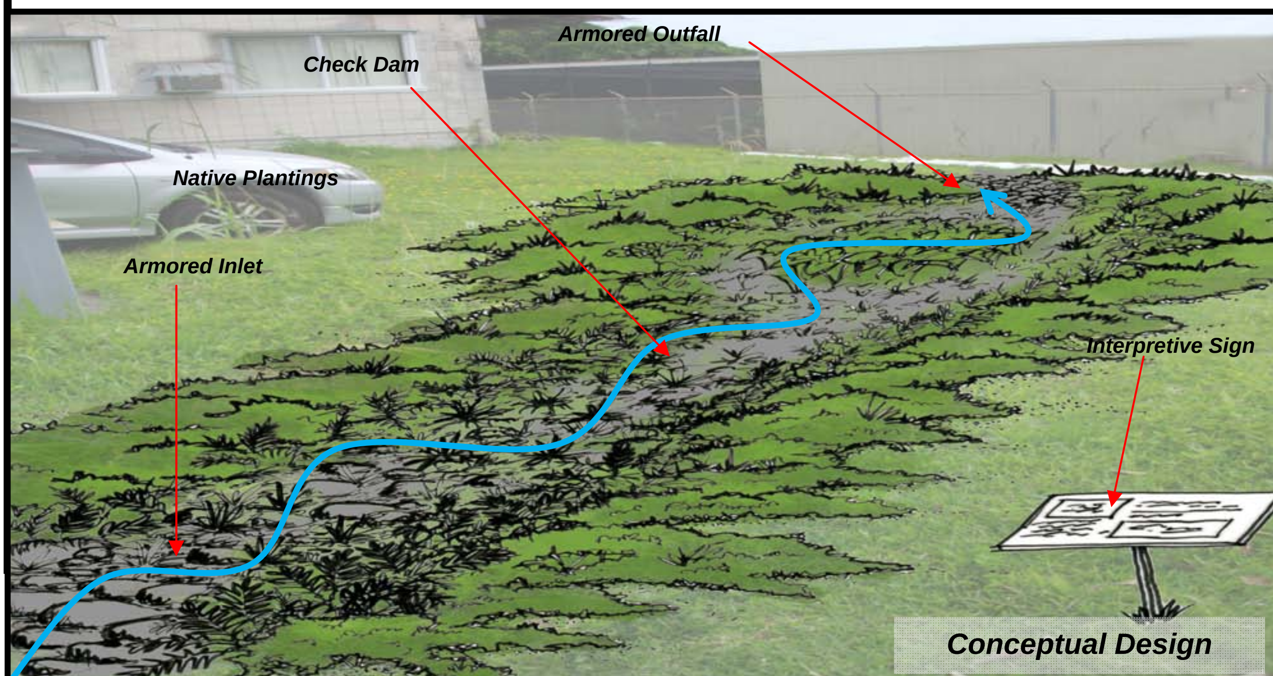
Current non-permanent modifications (sandbags) along the down slope of a grassed swale show existing problems with runoff.

Proposed LIR

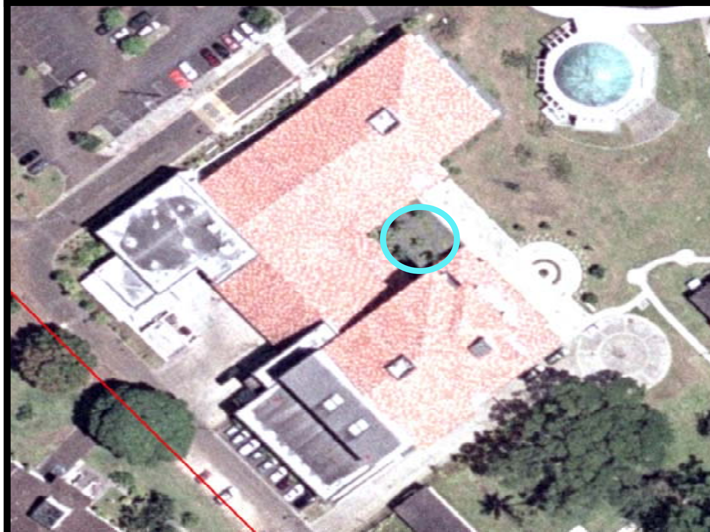
At or near the current stormwater modifications, a rain garden could be used to slow runoff velocities and volumes. The location of the retrofit will not cause known conflicts with existing use.

Windward Community College "A4"; Kāneʻohe Watershed, Kāneʻohe

Notes:
Replace the current grassed swale and install a single or series of smaller rain gardens.



Windward Community College “A5”; Kāneʻohe Watershed, Kāneʻohe



Project Summary

Annual Rainfall	74.30"
Target Rainfall Event	1.23”
Hydrologic Soil Group (HSG)	B
Impervious Area Treated (acres)	0.035
Type of LIR Practice	RG
Annual Runoff Reduction (cu. ft)	148
TN Removed (lb/yr)	0.64
TP Removed (lb/yr)	0.07
TSS Removed (lb/yr)	21
Ranking Score	80

Site Description

Located at the Paliku Theater and adjacent classrooms, this sight receives daily pedestrian traffic.

Existing Conditions

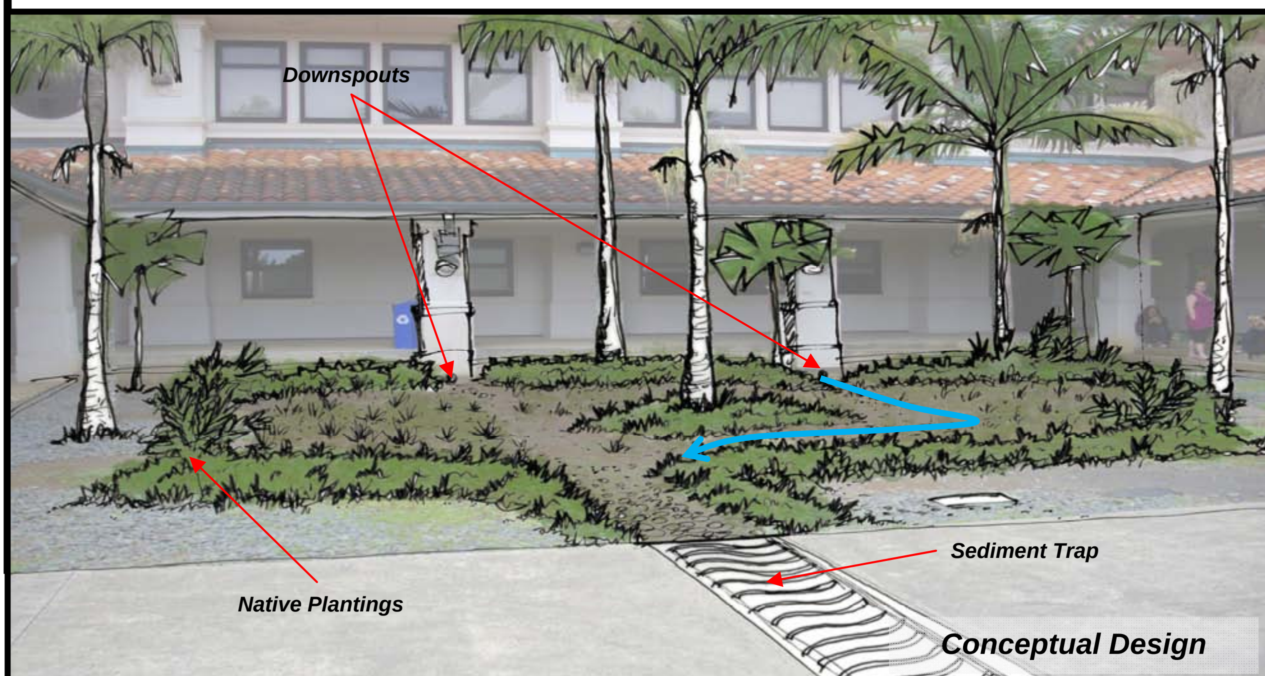
The existing “court yard” is relatively devoid of plantings with the exception of a few palms and grasses. Currently it appears rooftop downspouts are connected to storm drains. A larger stormwater system is located down slope to the east. This area could also receive some slight improvements, although the proximity of the slope should be noted and the structural integrity should be protected.

Proposed LIR

The existing “court yard” could be retrofitted with a rain garden which will effectively disconnect downspouts from the storm drain system. The rain garden could potentially incorporate existing landscape plantings.

Windward Community College "A5"; Kāneʻohe Watershed, Kāneʻohe

Notes:
The existing sight shows signs of pedestrian "trail blazing". It could be possible to improve these pathways with the use of strategically located stepping stones integrated into the LIR BMP.



Windward Community College “PRKNG 3”; Kāneʻohe Watershed, Kāneʻohe

Project Summary

Annual Rainfall	74.30"
Target Rainfall Event	1.23”
Hydrologic Soil Group (HSG)	B
Impervious Area Treated (acres)	0.709
Type of LIR Practice	RG
Annual Runoff Reduction (cu. ft)	601
TN Removed (lb/yr)	6.53
TP Removed (lb/yr)	0.76
TSS Removed (lb/yr)	211
Ranking Score	75

Site Description

The proposed LIR project site is located at the northwest corner of the campus. This location receives significant vehicular traffic during regular school hours.

Existing Conditions

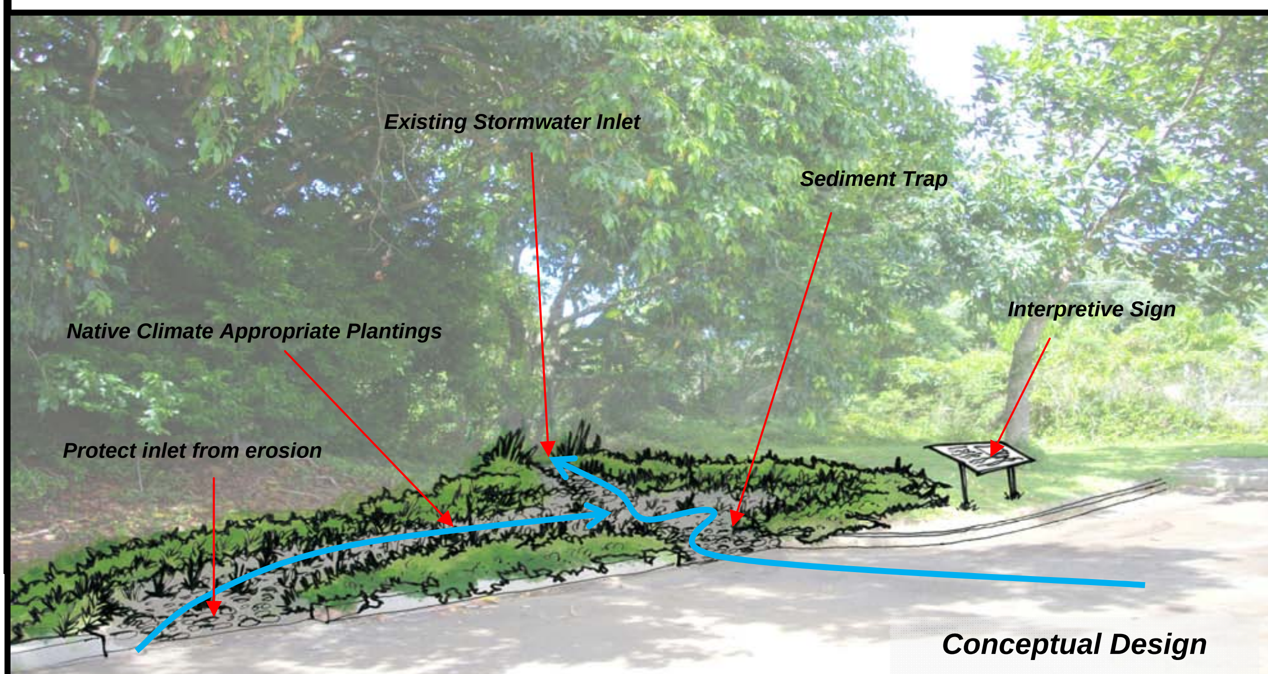
The existing site conditions are average. The parking lot shows signs of daily use. Visible sediment trails can be seen in the aerial photo as well during multiple site visits. One existing stormwater inlet is centrally located along the northern perimeter of the site.

Proposed LIR

The proposed LIR site is located in the northeast corner of the parking lot. Upon physical investigation, it appears a majority of stormwater runoff is conveyed towards this location. A small swale has been cut out of the ground to facilitate the runoff. The location does not appear to be an established stormwater inlet, although it appears the be receiving a majority of the runoff.

Windward Community College "PRKNG 3"; Kāneʻohe Watershed, Kāneʻohe

Notes:
The existing earth swale can easily be retrofitted with a minimal to no site conflicts.



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Implementation Strategy

Low Impact Retrofits

Table 2 on pages 33/34 list all of the prioritized LIR projects with a score based on potential pollution reduction, hotspot score and cost. Implementing projects with the highest priority ranking in numerical order starting at one and working down the list is one logical approach. For example, according to analyses, in Kāneʻohe, the highest ranked project is located at the Post Office following by projects at the Kāneʻohe District Park and Heʻeia Pier with tied rankings. The total pollution reduction if all projects were implemented is show in charts 2 – 5 on page 61-64. However, grouping projects together on a spatial scale or by landowners will allow HOK to be most effective with limited resources and reduce pollutants on a larger scale.

The strategy is represented in Figure 22 which maps projects with various numerical ranking together spatially across the same landowners and highlights pollution removal. For example, ranked project at Windward Mall owned by Kamehameha Schools have a prioritized ranking near the top, middle and bottom of the priority. However, these projects should be grouped together and implemented concurrently. Similarly, working to implement projects at Windward Community College in Kāne'ohe could result in partnerships with professors and students. In Kailua, working with larger landowners or grouping projects together spatially could provide a level of efficacy to the organizations' work not realized working on discrete, isolated projects. When implemented as part of a comprehensive approach, the overall pollutant reduction is maximized compared to implementing ranked projects discreetly which are spatially isolated. This approach allows HOK and its partners to work together on a larger spatial scale, reduce cost for implementation if projects happen concurrently and have a greater impact on pollution reduction compared to implementing only top-tier projects in Waimānalo, Kailua and Kāneʻohe.

Additionally, this strategy could help for long-term buy-in from landowners when earmarking Capital Improvement Projects or planning redevelopment of properties.

Pollution Prevention and Education/Outreach

As part of the comprehensive approach to address non-point source pollution, education and outreach focused on pollution prevention is an important component. Restoration projects can take several years to complete; however, with current NPDES permits and the City and County of Honolulu's responsibilities under this federal permit, education and outreach is currently being conducted and could be strengthened with HOK input and support. All ranked sites, as well as others, could benefit from a pollution prevention initiative.

HOK will work with CCH to identify areas, landowners and businesses in the urban environment to target for the outreach as a method of conducing pollution prevention. HOK will partner, whenever possible, with CCH to deliver a consistent message to land/business owners, use previously developed materials for presentations and celebrate successes.

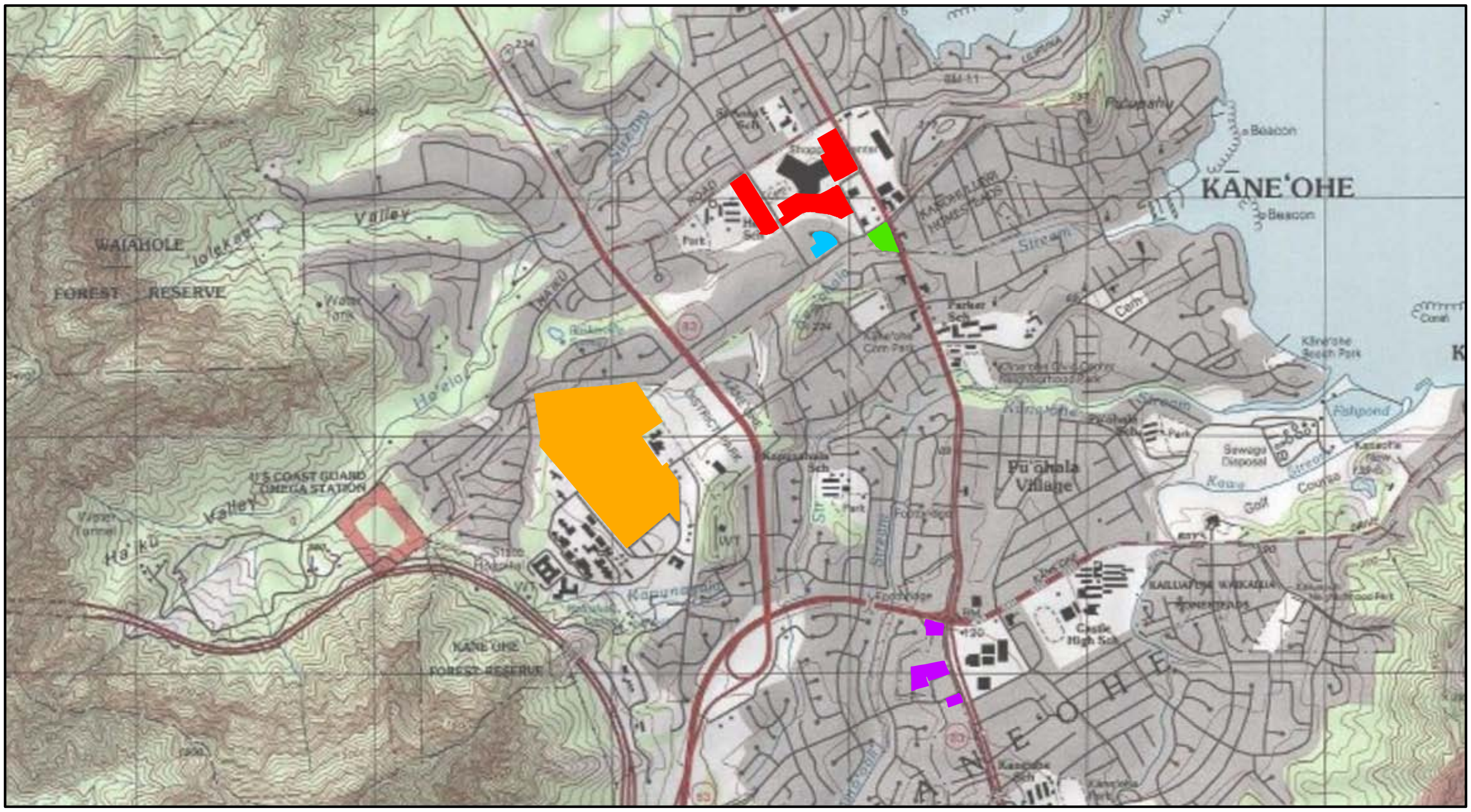
Long-term, HOK hopes to develop a program that recognizes businesses that are implementing best management practices to protect watershed health.

Green Streets

HOK views Green Streets as a way to improve the aesthetics of the existing streetscape, reduce storm water runoff, create improved pedestrian experiences and address the urban heat island effect. As noted previously in the Green Street sections of this report, there are several areas that are appropriate for these types of structures. In several instances through HOK urban assessment for this document, commercial/business lots were either too built out for retrofitting, or storm water flowed from the site to a municipal roadway or both. As such, constructing Green Streets is an optimal choice to capture and infiltrate storm water where space is limited for retrofitting, storm water is exiting private property and flows to a MS4 system, road ROW and widths allow for this work.

HOK will proceed with Green Street implementation in conjunction with the City and County of Honolulu to further prioritizes areas for a pilot/demonstration project. Green Street could very easily be adopted by community groups via CCH's established adopt a park/street/stream program.

Figure 19 Kāneʻohe Prioritized Spatial Grouping

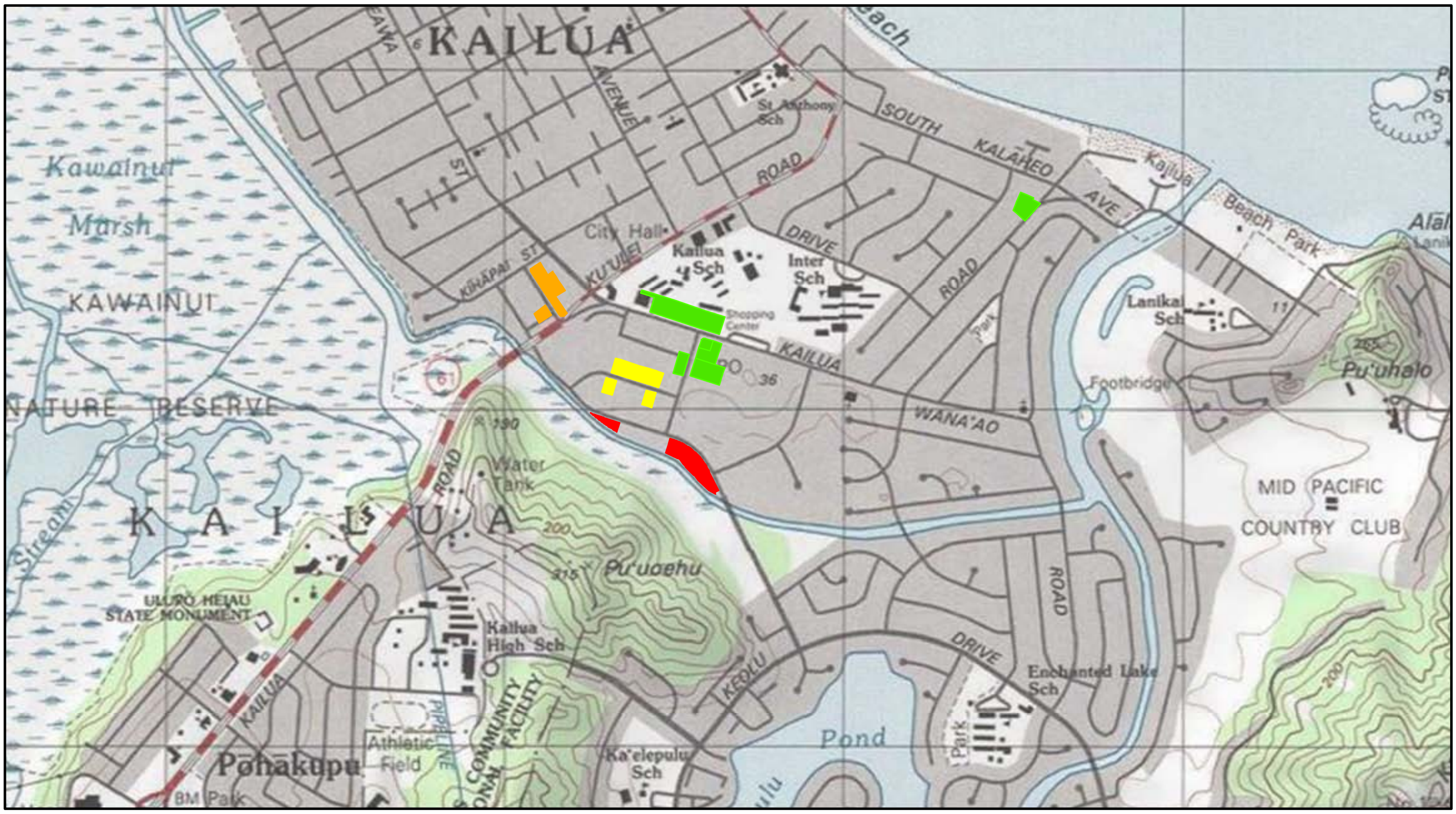


TMK	Watershed	Name	Score	Runoff	TP	TN	TSS
46011043	Heeia	WMP3	90	444	0.44	3.75	121
46011047	Heeia	WMP2	90	680	0.67	5.75	186
46011042	Heeia	WMP1	85	392	0.38	3.31	107
46011046	Heeia	Mall Overflow Parking	85	575	0.56	4.86	157
46030057	Heeia	Windward Center	75	100	0.1	0.85	27
		Subtotal	85	2191	2.15	18.52	598
45023014	Kaneohe	WWCC A3	80	83	0.1	0.9	29
45023014	Kaneohe	WWCC A4	80	720	0.91	7.82	252
45023014	Kaneohe	WWCC A5	80	59	0.07	0.64	21
45023014	Kaneohe	WWCC PKNG 3	75	601	0.76	6.53	211
		Subtotal	80	1463	1.84	15.89	513
45039029	Kaneohe	Burger King	85	314	31	2.65	390
45039005	Kaneohe	Kaiser Clinic	80	1829	1.79	15.46	499
45076042	Kaneohe	Koolau Farms	80	227	0.22	1.92	62
		Subtotal	81.67	2370	33.01	20.03	951
45019019	Keeahala	American Savings Bank	85	470	0.46	3.98	128
45019020	Keeahala	Pizza Hut	80	444	0.44	3.75	121
45019021	Keeahala	Fresh Catch	75	340	0.33	2.87	93
		Subtotal	80	1254	1.23	10.6	342
46030031	Keeahala	Windward Auto Spa	80	312	0.31	2.64	85
46030035	Keeahala	Lex Brodies	75	104	0.1	0.88	28
		Subtotal	77.5	416	0.41	3.52	113
		TOTAL	**326.67**	**7278**	**38.23**	**65.04**	**2404**

Date: September 2011

Source:
ESRI Online Basemap

Figure 20 Kailua Prioritized Spatial Grouping



TMK	Watershed	Name	Score	Runoff	TP	TN	TSS
42001043	Kaelepulu	Post Office	90	250	0.15	1.31	42
42038034	Kaelepulu	Macy's PRKNG	90	250	0.15	1.31	42
42001056	Kaelepulu	DT SFWY	85	769	0.47	1.31	42
43056005	Kaelepulu	Kailua Square Shopping Center	85	706	0.43	3.7	119
42001026	Kaelepulu	Fat Boys	80	144	0.09	0.75	24
43014002	Kaelepulu	Island Snow	80	130	0.08	0.68	22
		Subtotal	85	2249	1.37	9.06	291
42038004	Kaelepulu	NAPA	85	85	0.05	0.44	14
42038020	Kaelepulu	Pali Lanes	85	35	0.21	1.85	60
42038008	Kaelepulu	Garden Accents	80	78	0.05	0.41	13
		Subtotal	83.33	198	0.31	2.7	87
43057002	Kaelepul	Kailua Town Pub	85	235	0.14	1.23	20
43057016	Kaelepulu	Block Buster	80	130	0.08	0.68	22
43057019	Kaelepulu	Agnesse's Bakery	80	349	0.21	1.83	59
43057073	Kaelepulu	Arbys	80	142	0.09	0.24	24
43057038	Kaelepulu	Manuhealii	70	671	0.41	3.51	113
		Subtotal	79	1527	0.93	7.49	238
42001005	Kaelepulu	Down To Earth	85	235	0.14	1.23	40
42038053	Kaelepulu	CreekSide	70	136	0.08	0.71	23
		Subtotal	77.5	371	0.22	1.94	63
		TOTAL	**247.33**	**3974**	**2.61**	**19.25**	**616**

Date: September 2011

Source:
ESRI Online Basemap

Chart 2 Annual Total TP Removal for all Prioritized Project Sites

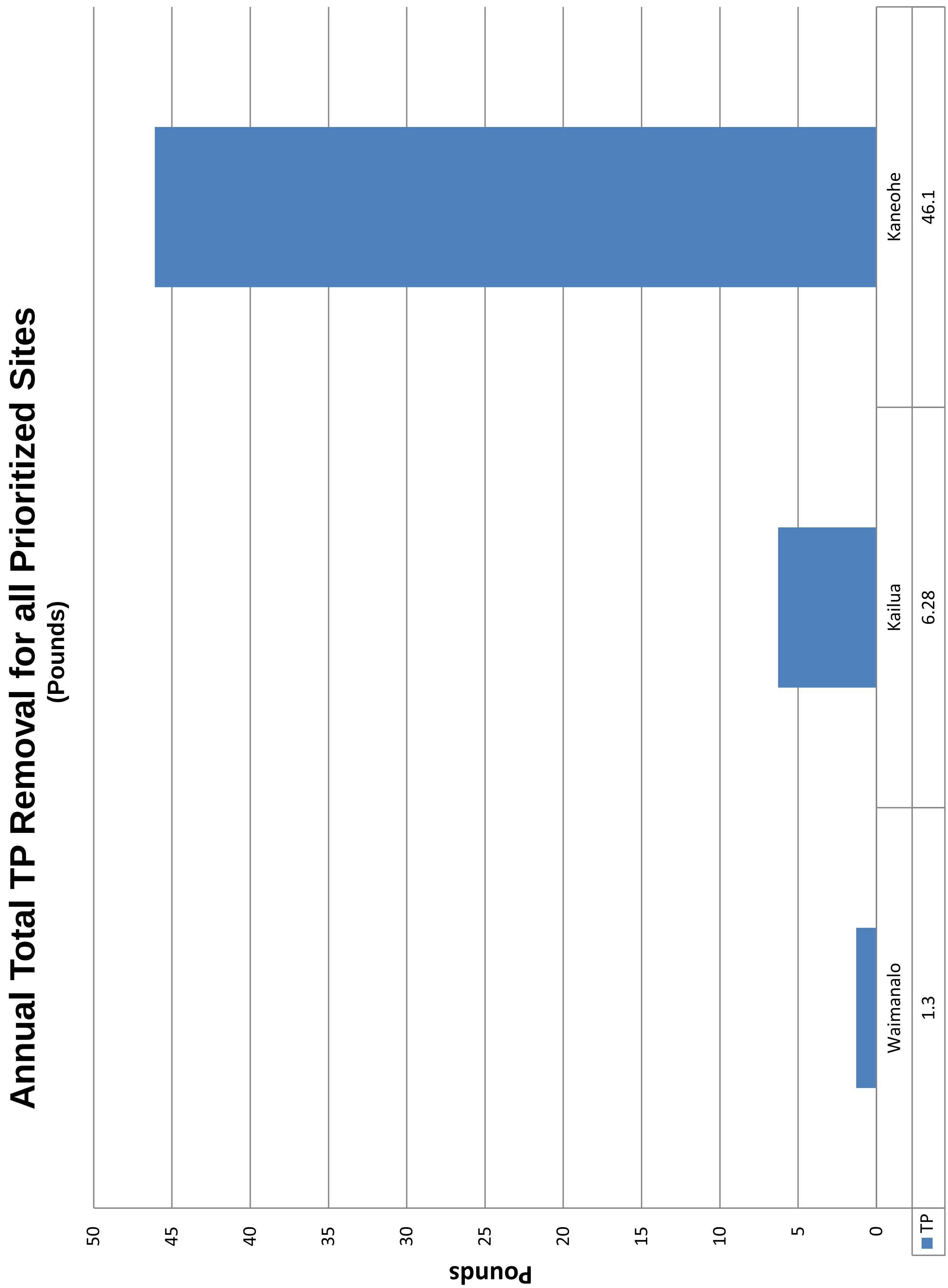


Chart 3 Annual Total TN Removal for all Prioritized Sites

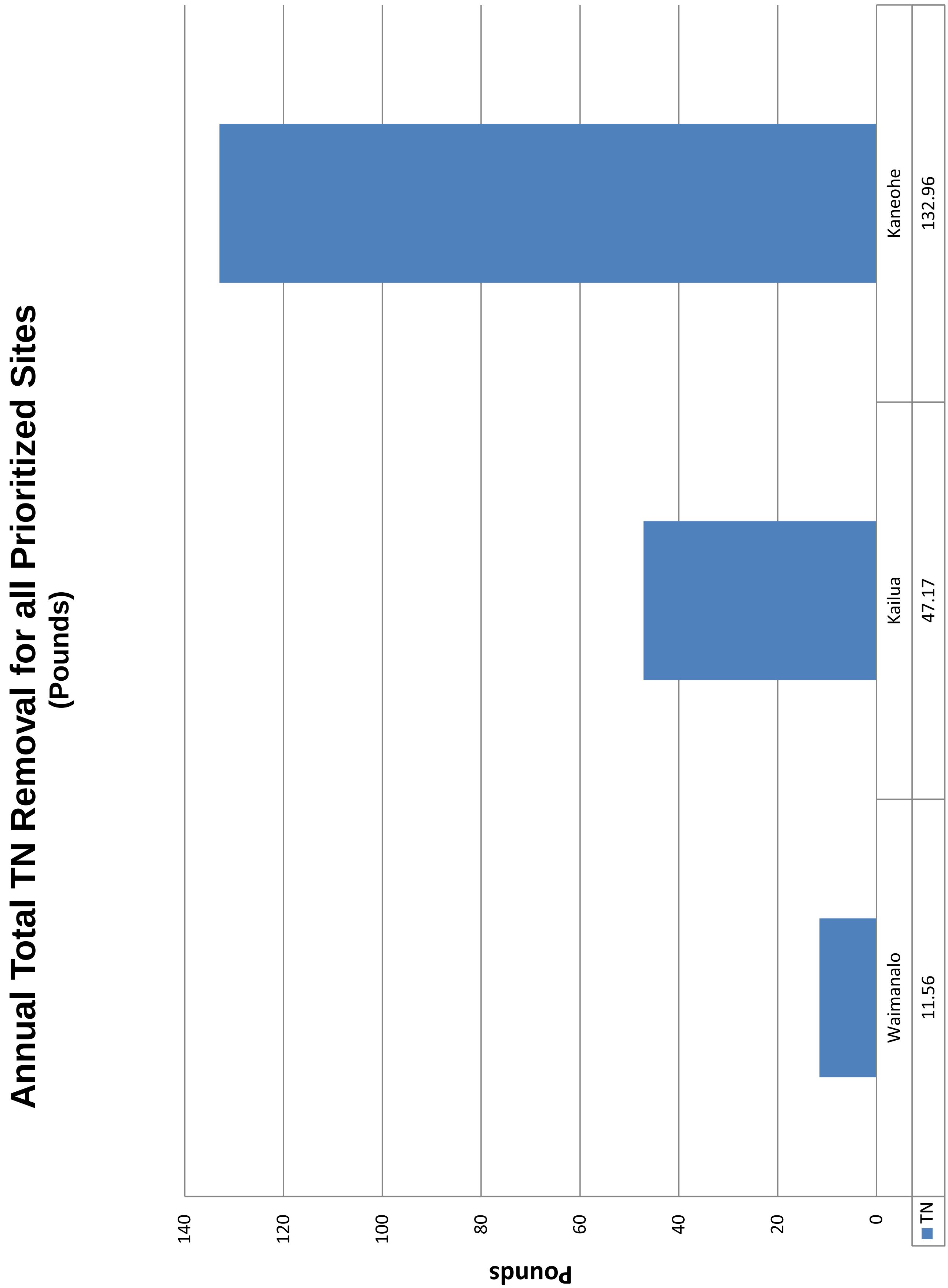


Chart 4 Annual Total TSS Removal for all Prioritized Sites

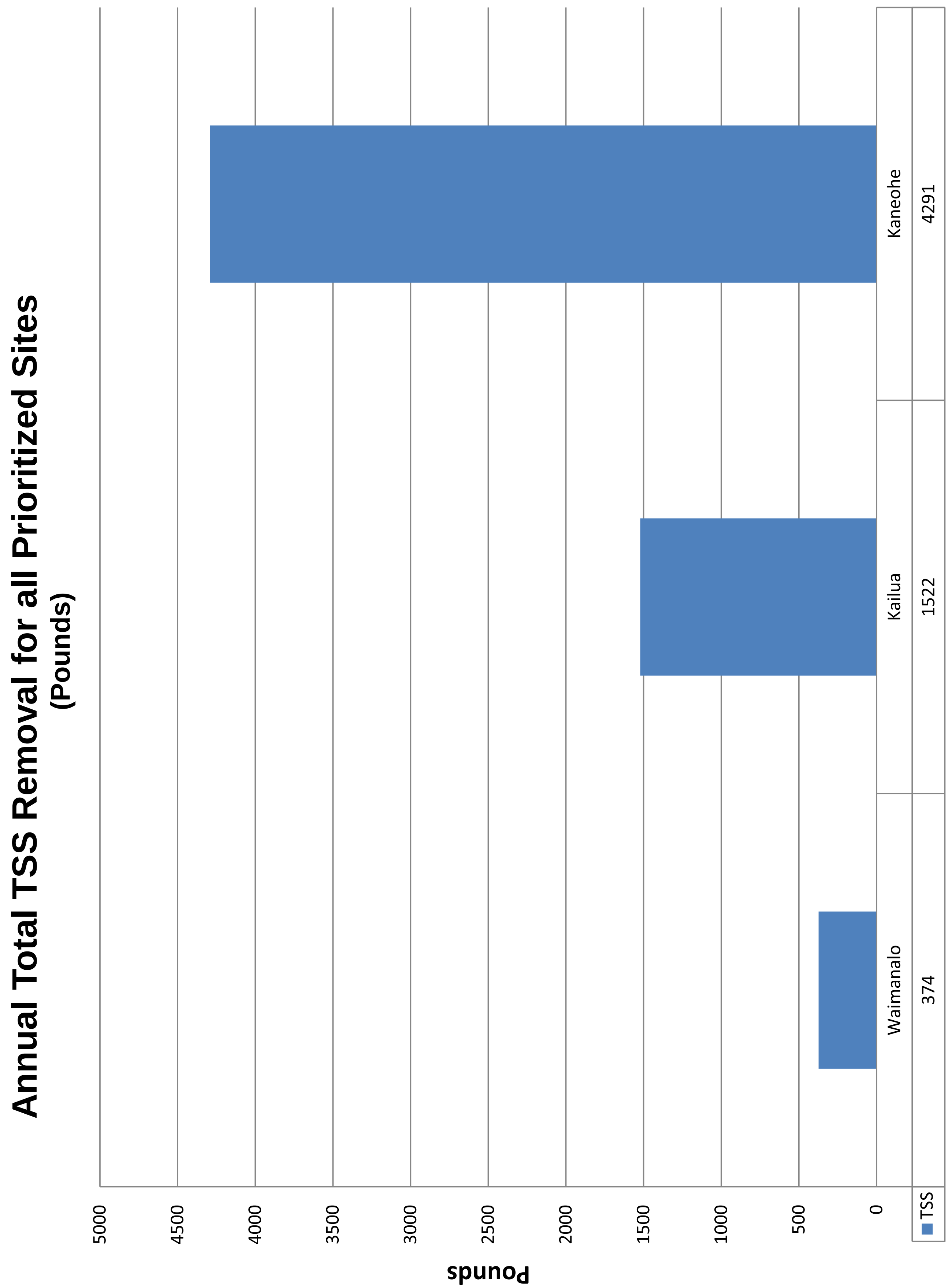
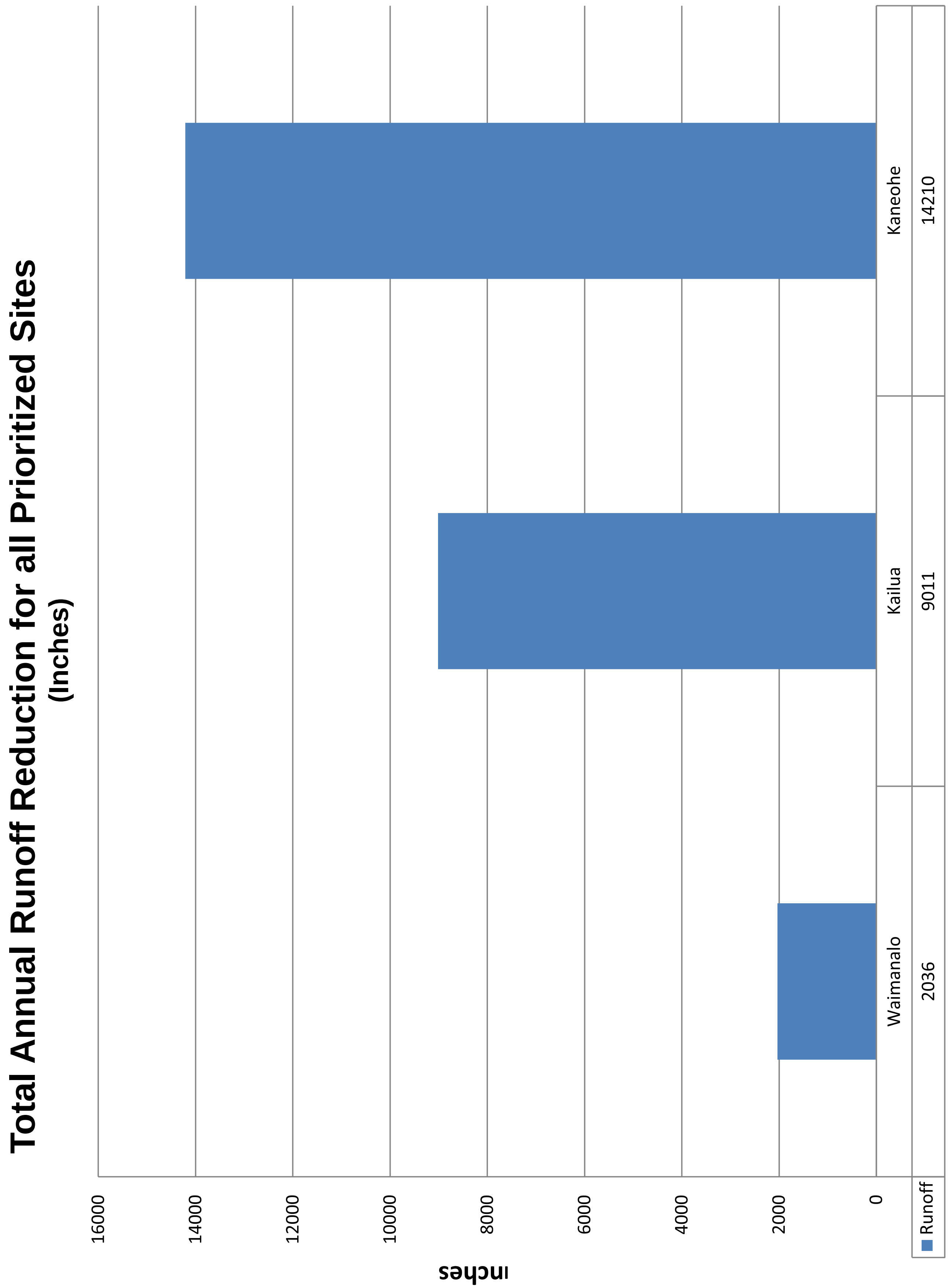


Chart 5 Total Annual Runoff Reduction for all Prioritized Sites



Conclusion

Working in the urban environment and seeking opportunities presents a very challenging set of obstacles to implementation. As discovered in our field work, many of the individual TMKs are built-out nearly one-hundred percent with limited options for retrofitting the site for noticeable pollution reduction. Other factors such as overhead/underground utilities, existing infrastructure such as trees, parking stalls or inconsistencies between proposed retrofit state-of-the art and current land use ordinances all limit opportunities for work. The importance of implementing well thought-out, priority-based work in the urban setting is no different than other watershed restoration. The projects presented in this document are not all of the possible retrofit opportunities across all land uses; however, the methods developed allows HOK to continue to assess urban opportunities for such land use as schools, parks, apartment/condominiums and other land uses not addresses in this document.

In concert with on-the-ground urban restoration, creating a program and building on current efforts for pollution prevention is very important for future watershed protection. In areas that have limited opportunities for on-site infiltration, educating the land/business owner about good housekeeping practices could prove invaluable and make noticeable improve in stream health.

Additionally, this work highlights the need to have more ordinances on the books for future development with regards to on-site storm water management. It is nearly universally agreed in watershed science that it more effective and cost efficient to protect the best compared to restoring the rest. If we think of new development as, “protecting the best” of our watersheds, new requirements and incentives are needed for developer to implement effective post-construction BMP that deal with storm water on-site compared to, “restoring the rest,” as retrofits in the future.

HOK sees itself as an entity that can encourage this type of work in the future on both private development as well as municipal properties. Implementing pilot projects that demonstrate the effectiveness of the practices, educational opportunities, cost-effectiveness and aesthetics is a priority for the organization. However, HOK also realizes that to see watershed-wide improvements, restoration work is needed in streams, in residential areas, on agricultural land as well as continued education and outreach. Additionally, it will be very important to have participation by the City and County of Honolulu to be supportive of pilot projects, adopt new design standards, follow their federal NPDES permit, provide incentives for developers and create a storm water utility fee that can off-set the cost for inspection and implementation of such practices as green streets.

All these programs packaged together will provide the comprehensive approach needed for watershed restoration and protection.

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Appendix I: Sub-basin Summaries

Waimānalo

The Waimānalo Watershed drains approximately 7,147 acres consisting of predominantly agriculture/residential lands. Unlike the watersheds of Kāneʻohe and Kailua, the Waimānalo watershed has retained much of its rural character and remains the least populated.

Waimānalo Sub-basin

Waimānalo Stream[1] originates in the Koʻolau Mountains, draining approximately 3,789 acres (1,533 hectares) flowing through a variety of land uses including: forested lands, agriculture and low intensity development before entering Waimānalo Bay at Bellows Beach.

Waimānalo Stream is a highly altered waterway with just over 1% remaining natural; in many ways no longer functions as a natural stream. The channelized mouth of this stream is estuarine. Waimānalo Stream runs through a predominately agricultural area and is designated as a Water Quality Limited Segment (WQLS) for failing to meet the State's water quality standards. The highly degraded stream listed for nutrients, turbidity and suspended solids on the 2004 303 (d) list, is 3.4 miles (5.5 meters) in length at 13% average gradient and has an average discharge of 5 cubic feet per second (Waimānalo Health Center's Waimānalo Watershed Restoration Plan, September 2002). The Waimānalo watershed contains approximately 10.7 miles (17,181 meter) of mainstem and tributary streams. The watershed has a maximum elevation of 2,611 feet (796 meters) rising above its lowest elevation at sea level.

Environmental impacts: Waimānalo Stream has been straightened with concrete lined channel and riparian areas eliminated and replaced with urbanized activities. Waimānalo Stream no longer has the ability to filter the high concentrations of pollutants. Pollutants enter directly to the receiving waters, Class A Waimānalo Bay.

TMDLs: The TMDL for Waimānalo Stream notes eroding roads, driveways and bare road sides contribute excess sediments to the stream.

303 (d): Waimānalo Stream is on the 2004 303 (d) list for nutrients, turbidity and suspended solids. The TMDL completed in 2001 concluded both animal waste and inorganic chemical fertilizers are contributors to the excess nutrient loads measured in surface waters, and are discharged into stream channels via both the surface runoff and shallow groundwater flows (Hawaiʻi State Department of Health, 2001). A Non-point source Pollution and Erosion Comparison (N-SPECT) modeling project conducted by KBAC suggests approximately 83,126 kg of nitrogen and over one-million kg of TSS are contributed from the watershed annually.

Land Use: A majority of land use within Waimānalo is agricultural or residential lands.

[1] Waimanalo Stream refers to Waimanalo Stream and Kahawai tributaries as Waimanalo Stream.

Kailua

The two sub-basins within the Kailua watershed encompasses just over 20 square miles and drains into Kailua Bay. Kawai Nui, the larger of these two water systems draining the rain forests of the Pali and Maunawili highlands into Kawai Nui Marsh, enters Kailua Bay through the channelized Oneawa Canal. Kailua's shallow groundwater table is partially responsible for major flooding that tends to occur during large storm events. The Kawai Nui Flood Control Project, completed in 1966, was created to move water from Kawai Nui Marsh to Kailua Bay; and the Kaʻelepulu Canal. Urbanization and the increase of impervious surfaces have created localized flooding problems.

Kaʻelepulu Sub-Basin Watershed

Kaʻelepulu Stream flows into Kaʻelepulu Pond (Enchanted Lake). The watershed is approximately 3,486 acres (1411 hectares) flowing through a predominately residential landscape before entering Kailua Bay at Kailua Beach Park. The highly channelized stream is 9.6 miles (15.52 meters) in length with a nine-percent average gradient; primarily above Kaʻelepulu Pond. Ka'elepulu Pond (Enchanted Lake), is central to the highly urbanized watershed and drains to the ocean across Kailua Beach through the Honolulu City owned Ka'elepulu Stream. Ka'elepulu and Kawai Nui canals each add about 10 acres to the water surface area of the estuary system. Kawai Nui Stream receives only urban runoff and is essentially stagnant for much of the year. The City of Honolulu has 37 NPDES permitted storm drains entering Ka'elepulu Pond and another 36 entering the Kawai Nui Stream and lower Ka'elepulu Stream. Some of the City permitted drains also receive runoff from drains under the Kalaniana'ole Highway and a separate NPDES permit to the State Department of Transportation (Bourke, April 2006). Based on data collected from the Enchanted Lakes Residents Association during storm events between January 2002 and March 2006, storm drains appear to be the largest contributor to sediment load in Enchanted Lake. The 2007 KBAC report recommended creating an outreach project to capture stormwater at individual residents and commercial lots is feasible and could prove effective to limit the amount of storm water and the subsequent polluted runoff entering Kaʻelepulu Stream. Activities such as disconnecting downspouts, creating rain gardens and using rain barrels can be used to capture and recycle stormwater. Installing storm-drain filters or other BMP such as bio-retention ponds could prove feasible and effective in the Enchanted Lake sub-basin to control stormwater from entering the lake.

TMDL: Pollutants are likely settle into Kaʻelepulu Pond or migrate downstream and settle with low stream gradient and flow. High concentrations of pollutants are likely found at the river mouth as flow is stopped due to the sand bar. When the sandbar is naturally or mechanically breached at Kailua Bay, increased level of pollutants spill directly into the bay, exceeding the State standard 80 percent of the time and the Federal standard 60 percent of the time (Babcock 2005). Based on these studies, Babcock summarizes recreational water standards for Kaʻelepulu were exceeded at almost all sampling locations and recreational water standards for Kailua Bay were exceeded when the Kaʻelepulu Stream mouth was open.

303 (d): Kaʻelepulu Stream is a high priority stream on the 2004 303 (d) list for nutrients and turbidity. The possible non-point source s of nutrients derives from the residential use of fertilizers and pesticides, wastewater treatment plants and animal droppings in addition to urban runoff (Babcock, 2005). NSPECT modeling estimates nearly 1.5 million kg of TSS could be contributed to the Kaʻelepulu watershed annually. TSS is likely derived from eroding bare soil (construction sites), forested lands and urban runoff.

Land Use: Kaʻelepulu watershed is a mix of land use with development (both high and low intensity) dominating 50% of the watershed. Within 100 m (328 feet) of Kaʻelepulu Stream, 88% of the land is dominated by development with approximately 1% remaining as wetlands. As a result, the stream is not able to filter pollutants before runoff enters the stream.

Kawainui Sub-Basin Watershed

Kawainui watershed is comprised of several tributary streams draining to Kawai Nui Marsh including, Maunawili, Kahanaiki and Kapaʻa. The watershed is approximately 9,422 acres (3,813 hectares) with a mix of land use including residential, industrial and forested land. Drainage from Kawai Nui Marsh is highly manipulated for flood control. Historically, draining through Kawai Nui Stream, it now drains through Oneawa Canal at about 10 million gallons per day before entering into northern Kailua Bay (KBAC, 2002). According to the document, *Kapaʻa Stream Hydrology, Biology, and Water Quality Survey* (Oceanit, 2002), pollutants are likely derived from several sources. Oceanit summarizes turbidity being attributed to four main sources: Ameron Hawaiʻi, H3 Highway, Kapaʻa landfill and steep, non-vegetated slopes in the surrounding watershed (these are not listed in order of magnitude). Nutrients, such as nitrogen and phosphorus, in Kapaʻa Stream appear to originate from two sources. Nitrogen is likely derived from groundwater inputs as a result of leaching from Kapaʻa Landfill, while phosphorus is manifested in surface runoff from eroding hillsides in the upper watershed (Oceanit, 2002).

TMDL: The 2007 TMDL for Kapaʻa Stream notes primary sources of discharged runoff volumes (60%) and pollutant loads (96% TSS, 75% TN, 71% TP) are the Kapaʻa and Kalaheo landfill areas.

303 (d): Maunawili Stream is the largest and is a medium priority for nutrients, turbidity and trash on the 2004 303 (d) list while Kapaʻa Stream is listed for nutrients, turbidity, suspended solids and metals.

Land Use: Kawai Nui watershed has a mix of land use with the majority of the watershed comprised of forested and other land use category (shrub/scrub vegetation).

Kāneʻohe

The largest sub region within Koʻolaupoko moku accounts for nearly half of the moku's shoreline. The watershed can be divided into two regions, north and south. The scope of the USBAP has intentionally limited a majority of the focus towards higher density urbanized environments primarily located within the southern district of Kāneʻohe.

Kawa Stream

Kawa flows through residential and light industrial areas, passes through remnants of Waikalua-Loka fishponds (Kawa TMDL. 2002). Kawa stream is on the 2004 303 (d) list for nutrients, turbidity and suspended solids. A TMDL completed in 2002 identified sources of pollutants based on existing and newly collected monitoring data. For nutrients, A Total Maximum Daily Load Implementation Plan for watershed health notes, the largest source areas for these loads [nitrogen] seem to be cemetery lands and residential areas (combined, about 68% of total loads), where as the largest source areas for phosphorous loads seem to be forest land and residential area (combined, about 67% of the total loads). Additionally, the largest source areas for sediment loads seem to be residential areas and cemetery lands (combined, about 65% of the total load).

Kāneʻohe

Kāne'ohe Stream flows through a variety of land uses, and drains into Southern Kāne'ohe Bay. Two streams in the watershed are on the 2004 303 (d) list for pollutants: Kāne'ohe Stream for nutrients, turbidity and dieldrin and Kamoʻoaliʻi Stream for nutrients and turbidity. Currently, a TMDL is being conducted for both streams. Based on the five major land use types and other scientific literature review, the likely contributors for pollutants come from a variety of sources including;

> <u>turbidity</u>: eroding slopes and surface runoff from roads;
>
> <u>nutrients</u>: sewage systems; and
>
> <u>dieldrin</u>: residuals from past agricultural practices and pest control.

Keaʻahala

Keaʻahala stream originates in the foothills of the Koʻolau Mountains flowing to its receiving waters in southern Kāne'ohe Bay. Keaʻahala Stream is a high priority stream on the 2004 303 (d) list for nitrite/nitrates, total nitrogen and phosphorus, turbidity and trash. Limited monitoring has been conducted to determine likely sources of pollutants. However, based on land use in the watershed and sources of pollutants in the surrounding watersheds, inferences can be made. Nitrites, nitrates, total nitrogen and phosphorus are likely from personal use of yard fertilizers and sewage sources such as cesspools, or antiquated sewer infrastructure and polluted run-off. Because the watershed has fewer steep slopes compared to other watersheds, turbidity is likely derived from construction runoff and sediment collected on impervious surfaces such as roads and parking lots, while trash is from anthropogenic sources.

Heʻeia

Heʻeia Stream is as medium priority on the 2004 303(d) list for nitrites and nitrates. Heʻeia Stream flows though conservation, ag and residential landscapes before entering Kāneʻohe Bay.

<u>Environmental impacts</u>

Heʻeia Stream drains through Heʻeia Wetland before entering Kāneʻohe Bay, which is designated as Class AA waters, providing the highest priority water quality protection. A portion of the stream enters He'eia fishpond which is used for fish harvesting and limu (ogo) aquaculture—for commercial and personal consumption. Heʻeia's receiving waters of Central Kāneʻohe Bay are listed as low priority on the

2004 303(d) list for nutrients, nitrites/nitrates, NH4, turbidity, and *chlorophyll A*. The receiving waters within Kane‘ohe Bay provide important habitat for freshwater and marine species of importance to subsistence, commercial and cultural uses.

Appendix II: LIR Definitions

Remediation:

Includes designs intended for filtration, infiltration. These types of retrofits generally utilize bio/phytoremediation to remove non-point source pollutants from the stormwater.

- ***Bioretention Systems:*** Bioretention areas have the added benefit of biological filtration for stormwater runoff. Compared to an infiltration trench where the primary function is stormwater conveyance and infiltration, bioretention systems include depressional storage, flow through planters, infiltration trenches, micro-site-basins, rain gardens, tree box filters, and vegetated swales.

- ***Depressional Storage:*** Depressional storage or detention basins are a commonly used to reduce peak flow rates at a point of discharge and temporarily store water. The depressional storage basins hold small amounts of stormwater runoff during and directly after small storm events. This design can be effective for the retention of “first flush” associated with larger storm events. It should be noted that this particular design isn’t always the most aesthetically pleasing due to code requirements which will require fences to keep people safe while water is present.

- ***Eco-Roofs:*** Eco-Roofs otherwise known as “green” roofs are gaining in application and popularity. Eco-Roofs essentially replace the pre-development hydrologic site functions lost to a specific building footprint. Vegetated roof covers act as permeable surface atop an otherwise non-permeable roof. As an additional benefit worthy of noting is the ability to reduce urban heat island effects often associated with large roof tops and hardscapes. Eco-roofs require specific design considerations and maintenance regimes. Eco-roofs are highly effective at runoff reduction (40% – 60%) (Virginia URBAN BMP) It has been noted that in particular site specific cases such as high island flashy stream watersheds found in the Pacific region, Eco-roofs may not necessarily achieve their intended design goal, because of a high rate of rainfall in short periods of time. The success or shortcoming of an Eco-roof design is directly related to amount of rain intended to accumulate in a given area in a given amount of time. “Design should be developed for the storm events that most significantly contribute to hydrologic overloads and runoff problems for a given area.” (United States Environmental Protection Agency, p. 8)

- ***Flow through Planters:*** Also known as stormwater planters are an appropriate retrofit choice when used to disconnect downspouts from buildings. Stormwater planters provide areas for vegetative uptake of stormwater pollutants, pretreatment of suspended solids, provide added aesthetic value and potential reduce peak discharge rates.

- ***Infiltration Trench:*** Stormwater infiltration trenches direct surface water runoff into the underlying soil within a specific allowable space. The trench collects surface water that has been directed towards the application, stores the water in a subsurface space while the water infiltrated into the ground. The soil ecosystem removes non-point source pollutants from infiltrating into groundwater tables. Surface water runoff volumes effectively reduced. An infiltration trench is appropriate for treating and infiltrating stormwater runoff from impervious parking lots, high and low density housing types and recreational areas. Although not well suited for high density urban areas due to space constraints and potential problems associated to infiltration and building foundation security, infiltration trenches are an appropriate choice for commercial sites where large parking lots are required.

- ***Micro-Site Basins:*** A term for small retrofits such as swales that are used in sequence to allow overflow to pass from one LIR site into another as opposed to larger centralized detention basin often associated with conventional stormwater management practices.

- **_Parking Lot Islands:_** Used primarily in association with large impermeable parking surfaces. Parking lot islands are bioretention systems which may include multiple LIR designs such as vegetated swales, tree box filters, and curb cuts. An added benefit to the implementation of parking lot islands is the potential to provide shade for parked vehicles, reducing urban heat island effects.

- **_Porous Pavements:_** Permeable Pavements "significantly reduce runoff volume and peak flows, decreases its temperature, and improves water quality" (UHN Stormwater Center, p. 14). Stormwater is allowed to infiltrate underlying soils where pollutants are biologically degraded. Over the past 8 years the price for permeable asphalts has dropped considerably. In 2000, permeable pavements are four times more expensive than conventional asphalt paving methods (United States Environmental Protection Agency, 2000). The University of New Hampshire Stormwater Center installed a half-acre porous asphalt test site for $2.80 per square foot compared to $2.30 per square foot for conventional asphalt (UHN Stormwater Center, p. 15). According to the New Hampshire Stormwater Center 2009 Biannual Report, porous asphalt exceeds EPA's recommended level for the removal of suspended solid, and water quality criteria for petroleum hydrocarbons and zinc.

    - **_Asphalt:_** Pervious Asphalt filters contaminants from runoff prior to its discharge to the storm sewer system, reduces peak velocity and volume of stormwater runoff delivered to storm sewer system, can potentially alleviate flooding downstream, applicable to all types of sites (residential/commercial/industrial), recharges groundwater supply, reduces total amount of impervious cover, allows for land use in areas that otherwise would not meet stormwater retention guidelines, requires less need for curbing and storm sewers. The design for application of porous asphalt consists of at least four layers: a two to four-inch layer of asphalt, a one to two-inch filter layer of half-inch crushed aggregate, a 12-inch minimum reservoir layer of one to three-inch aggregate, and a layer of geotextile material. Porous asphalt consists of standard bituminous asphalt in which the fines have been screened and reduced, creating void space to make it highly permeable to water. The void space of porous asphalt is approximately 16%, as opposed to two to three percent for conventional asphalt. Porous asphalt itself provides for some pretreatment of runoff. The crushed aggregate filter layer aids with pollutant removal and provides stability for the stone reservoir layer during application of pavement. Treated runoff is stored in the reservoir bed, a highly permeable layer of open-graded clean-washed aggregate with at least 40% void space. Nonwoven geotextile material placed between the reservoir bed and uncompacted subsoil prevents the migration of fines into the stone reservoir, which could clog the system. The treated water then percolates through the uncompacted soil base to recharge the groundwater supply.

    - **_Concrete:_** Pervious concrete is an effective means to address site specific decrease of infiltration rates and increased surface runoff coefficients created by impervious surfaces by capturing stormwater and allowing it to infiltrate on site. Porous concrete meets EPA stormwater regulations. Pervious concrete is among the BMPs recommended by the EPA for the management of stormwater runoff. Pervious concrete may eliminate the need for retention ponds, swales, and other stormwater management devices. In previous concrete, carefully controlled amounts of water and cementitious materials are used to create a paste that forms a thick coating around aggregate particles. A pervious concrete mixture contains little or no sand, creating a substantial void content. Using sufficient paste to coat and bind the aggregate particles together creates a system of highly permeable, interconnected voids that drains quickly. Typically, between 15% and 25% voids are achieved in the hardened concrete, and flow rates for water through pervious concrete are typically around 480 in./hr (0.34 cm/s, which is 5 gal/ft²/ min or 200 L/m²/min), although they can be much higher. Both the low mortar content and high porosity also reduce strength compared to conventional concrete mixtures, but sufficient strength for many applications is readily achieved.

- ***Rain Gardens:*** Rain Gardens are a popular and effective measure for retaining pre-development hydrologic site functions. Rain Gardens are on site bioretention systems where in aggregate sheet flow from rooftop surfaces are directed via gutters and downspouts towards a specific location to treat and infiltrate stormwater runoff. Rain Gardens offer an attractive alternative to conventional stormwater solutions. Each Rain Garden design must respond to specific limiting factors such as soil infiltration rates and volume of water that is to be treated as well as considerations for the plantings selected for the application, such as available direct sun light or shade.

- ***Tree Box Filters*:** function as mini bioretention systems. Relatively small in comparison to other LIR practices, the tree box filters can be easily installed along sidewalks and streets or where minimal space is available. A concrete form is used to collect water while the tree filters the pollutants. Perhaps one of the least invasive and highly functional aspects LIR design strategies, the tree box filter is compact in size, versatile, coupled with its high water quality performance level makes this design well suited for both urban and suburban development.

- ***Vegetated Swales:*** Can be applied in a variety of drainage site conditions and are very cost effective. Swales are most appropriate in areas where the topography is gently sloping and located in a smaller drainage area. The function of the Grass swales is to reduce runoff velocity, increase water infiltration and filtration. Sedimentation is the main pollutant removed with this type of application. Bioretention systems should be located in soils with high to moderate infiltration rates. These systems are most effective as local source control devices (UHN Stormwater Center, p. 20).

Supporting LIR Designs:

Supporting LIR designs are generally used in conjunction with remediation designs. When used alone these types of LIR designs may not directly achieve the specific function of removing non-point source pollution.

- ***Amending Soils:*** Soils should be matched to the proper planning type desired at each location. Soils with higher infiltration rates are best suited for plants which require less frequent watering, because the time of concentration associated with higher infiltration rates will result in less water that can be filtered and used by the selected plantings. For this reason engineered soils and planting must be carefully matched and design for to reduce maintenance intervals and plant loss due to too much or too little water.

- ***Check Dams:*** Check Dams are useful for increasing time of contact surface water runoff has with an individual LIR site. The dams create small ponding areas during runoff events. In vegetated swales, check dams cause water to spend more time in contact with soils and vegetation; infiltration is increased and runoff volume is reduced. The ponding action created by check dams causes suspended sediments to settle out of the runoff. For swales with steep longitudinal slopes, the ponding action created by the use of check dams may decrease flow rates to reduce the effects of erosion.

- ***Curb Cuts:*** Conventional concrete or asphalt curbs are often necessary to confine street traffic and stormwater runoff. Traditionally the “curb and gutter” method carries surface water runoff from streets into conventional stormwater conveyance systems be it MS4 or combined conveyance and treatment systems depending on the location. The use of curb cuts allows for a designed amount of stormwater runoff to be directed towards a LIR site, allowing stormwater to be treated on site and effectively retains pre-development hydrologic site functions. Inlets or small openings allow surface water runoff flowing along the curb to enter designated swales or other LIR sites.

- ***Disconnect Downspouts:*** Downspouts from roof top surfaces (impervious) can be designed to enter into an array or individual LIR sites such as a Rain Garden or Vegetated Swale to effectively control and filter roof top runoff, preventing roof top runoff from reaching larger and necessarily stormwater conveyance systems. Often seen in the form of post construction retrofits, this type of LIR practice should be integrated into the architectural design process for each structure. Roof top sheet flow can either be filtered and stored for future use or be allowed to infiltrate into the surrounding soils during a rainfall event.

- ***Elongated Flow Paths:*** An important aspect for most any LIR site is to increase the time of concentration surface water runoff was with permeable surfaces. Multifunctional landscape features such as recreational pathways can be designed to serve a variety of functions one being infiltration and lengthening surface runoff flow paths.

- ***Increased Vegetation:*** Pre-development site analysis will have been used to identify areas to be conserved and or protected allowing to the fullest extent possible pre-existing vegetation to be preserved. In areas where natural vegetation has been lost, increasing vegetation within a swale can be use in areas where they may be impractical or impossible to lengthen flow paths over permeable surface due to site constraints. Overall increasing on-site vegetation provides added aesthetic value and hydrologic as well as ecologic functions. Proper planting selections enhance filtration and infiltration of surface water during storm events or other sources of surface water runoff directed towards storm drains. Plants absorb pollutants while microbes associated with the plant roots and soil break down the particulates. Soil composition also known as engineered soil media plays a roll entrapping and filtering suspended particles and will determine the rate at which water is able to infiltrate. Vegetation should be carefully selected to ensure the plantings are able to survive hydrologic fluctuations such as periods of drought or flooding. Vegetation enhances water quality filtration and infiltration of surface water during storm events. Vegetation absorbs pollutants while microbes associated with plant roots and soil brakes down pollution particulates.

- ***Longer Grass Lengths:*** In areas where turf is desired by the occupants it is recommended that grass lengths should be kept at about 3”. Cutting grass short deprives the grass of photosynthetic surface area of each blade. This in turn forces the grass to grow faster, requiring higher amounts of irrigation and maintenance. Increased grass lengths will slow the growth of the grass and require less irrigation and effectively lower maintenance intervals.

- ***Native Climate Appropriate Plantings:*** Selecting appropriate plantings based on climate and intended use is a crucial step in establishing successful LIR projects. Especially important to sensitive ecosystems is the selection on non-invasive species. The advantages to selecting endemic, indigenous, and Polynesian introduced plantings are many. Native climate appropriate plantings will require less intensive irrigation, increase genetic diversity, and perpetuate a more honest sense of place.

- ***Post Construction Re-naturalization:*** Assuming all steps have been taken to minimize impact, such as site fingerprinting, in areas where construction is unavoidable, post construction re-naturalizations should be employed shortly after construction has been completed. Re-naturalized landscapes play an important role for sediment control and stabilizing sloped conditions. This action also restores potentially sensitive habitat that may have been lost during construction.

- ***Reduce Turf Areas:*** Turf areas require large amounts of water when compared to naturalized landscapes. Turf areas can also be associated with a decrease in infiltration, due to increased rates of surface runoff. Minimizing turf areas can potentially reduce maintenance as well.

- ***Roughening of Surfaces:*** An appropriate method of increasing time of contact time of contact surface water has with individual LIR sites is to use materials of topography to roughen the surface. This slows flow rates and sediment erosion, encourages infiltration and allows more surface water runoff to be treated. Materials gathered during the construction phase of the project can be saved for latter use such as rocks of various sizes or selecting particularly good ground cover plant.

Appendix III: LIR Maintenance

LIR Maintenace:

Low Impact Retrofits are dynamic features which will change over time. As such they may require future alterations to maintain proper functioning. All of the proposed conceptual LIR will require varied intensities of maintenance to remain functional over the life cycle of the design.

Routine maintenance includes: irrigation (*can be reduced or removed with the use of native climate appropriate plantings*), invasive plant removal, clearing inlets and outlets of debris, pruning of plants to maintain safe visibility (lines of site for pedestrian and vehicular traffic), removal of sediment build up, replace plant mortalities, repair effects of erosion and human-caused damage.

Proper plant selection is an important aspect of reducing maintenance intensities. Climate-appropriate native plantings are inherently adapted to the specific climate regime and require less overall care compared to a non-native plant species which have evolved according to different climate regimes. Constant irrigation can cause accelerated plant growth which is less resistant to natural climate variations. In contrast, deep infrequent irrigation conditions plantings for their natural climate variations. In turn these plants require less irrigation and develop deeper root systems. These features in turn increase the plants ability for uptake of pollutants and lower the need for soil media replacement.

Perhaps most crucial to the maintenance intensity is the LIR design itself. A well designed LIR incorporates the potential effects of erosion, sedimentation, properly selected plantings, as well as provides accessibility to areas prone to natural sedimentation or erosion. In order to reduce maintenance intensity, sediment traps can be used to confine the majority of sediment accumulation within a specific location, prior to the runoff entering a bioremediation zone within the LIR. Without the use of sediment traps, sediment will settle within the LIR itself (dispersed around plantings or clogging outfalls which may result in overtopping and LIR design failure). The dispersal of sediment within the LIR site may hamper access and necessitate removal of plantings or other features within the LIR site.

Closed cell LIR designs such as flow-through planters, may require higher levels of routine maintenance. These maintenance aspects include monitoring of soil contaminant levels, removal and replacement of soil media, and previously specified plant care. In general the higher number of plantings within a given LIR (either closed cell or not) will reduce the overall maintenance required for soil media. This is primarily due to the bioremediation processes which naturally occur in healthy soils and plant root systems. These aspects are fundamental to the concept of LIR design, which incorporates natural systems to reduce the demand on man-made systems. To summarize, the most important step in reducing the overall maintenance of system is the proper planning and design of the LIR itself.

Appendix IV: Detailed USBAP LIR Process Methodology

Project Identification

Working in an ultra-urban environment, the opportunities are potentially endless with regard to retrofits simply based on the era in which most of Koʻolaupoko was built out. The most common limiting factor is space availability. The majority of the landscape was designed for moving stormwater from point A to point B via street networks which connect to the MS4 system These networks lack the systems to address NPS pollution and water quality. As a result, it becomes necessary to determine a way in which HOK could identify areas for assessment and ultimately LIR implementation. The first step in identifying potential project sites is to determine which developed parcels are contributing the highest NPS pollution loads and or runoff volumes. Figure 1 illustrates the challenges in identifying per parcel the highest NPS pollution loads and or runoff volumes.

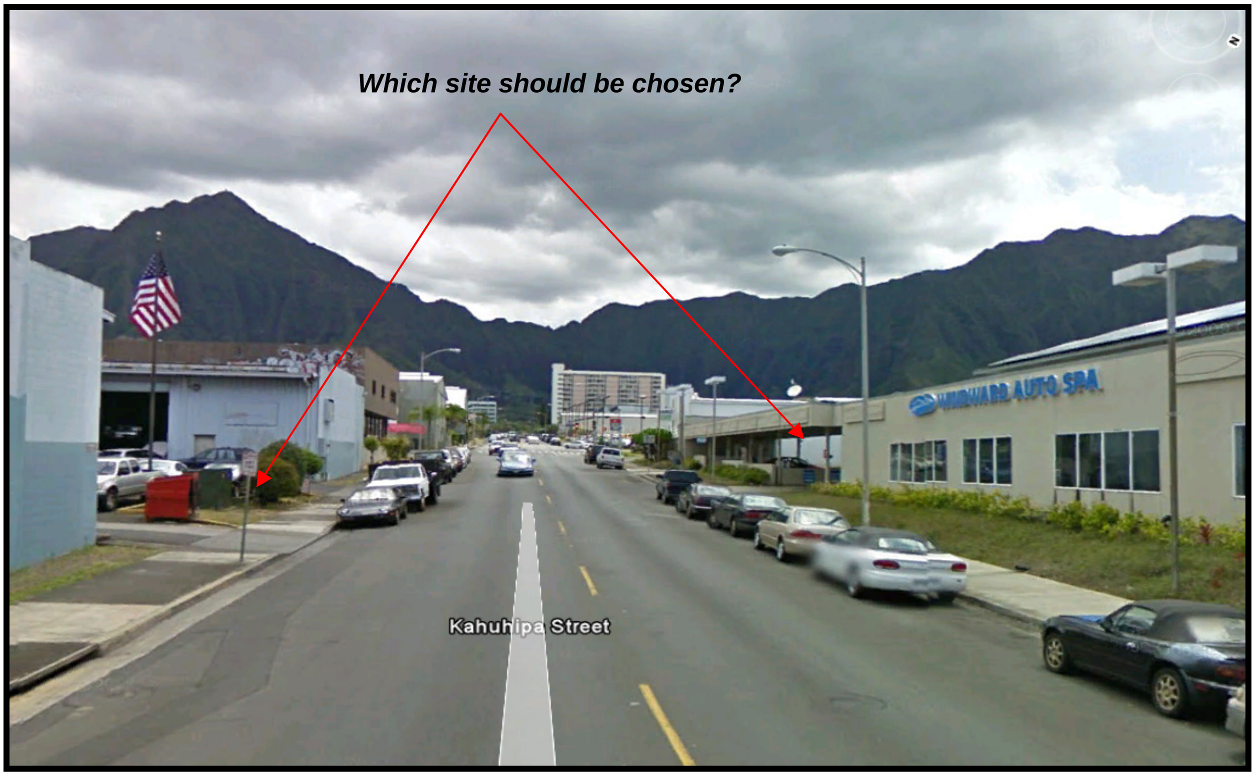

Figure 1 Challenges to Project Identification

For example, it can be generalized that a large shopping mall parking lot of sixteen acres is contributing more NPS pollution and runoff volume than a smaller office parking lot. However, hotspots such as gas stations which are generally under a half an acre are important to assess because of the types of pollution they contribute. Zoning districts within the urban scope of the USBAP generally consist of City and County of Honolulu (CCH) zoning district classifications (ZDCs). Each ZDC can be associated to different degrees of NPS pollution. Table 1 has been adapted from the Center for Watershed Protection *Urban Subwatershed Restoration Manual 3* and provides a summary of pollutant event mean concentrations (EMC's) commonly found in stormwater runoff per land-use type.

Table 1 Summary of Pollutant EMCs in Stormwater Runoff per Land Use

(mg/L or ppm)

	Residential	Commercial	Industrial
TDS	72	72	86
TSS	49	43	81
BOD	9.0	11.0	9.0
COD	54.5	58	58.6
Fecal Coliform	7,000	4,600	2,400
NO2 + NO3	0.6	0.6	0.69
TKN	1.5	1.5	1.4
TOTAL N	2.1	2.1	2.09
DISSOLVED P	0.18	0.11	0.10
TOTAL P	0.31	0.22	0.25
DISSOLVED Cu	7.0	7.57	8.0
TOTAL Cu	12	17	20.8
DISSOLVED Zn	31.5	59	112
TOTAL Zn	73	150	199

The specific land-use within each ZDC must be accounted for on an individual parcel by parcel basis as part of the project identification process. The systematic parcel by parcel GIS investigations identifies projects according to the CCH ZDCs, which then leads to field investigations wherein specific land-uses can be identified. In addition to land-use verification, the field investigations noted a suite of site conditions. These factors, as well as others led HOK to develop three leading factors which could be attributed to higher NPS pollution loads and or runoff volumes. The following sections outline in further detail, the project site identification process.

Note: Professional judgment and regional knowledge was also used for the identification process.

Digital Analysis:

Geographic Information System (GIS) digital investigations of Ko'olaupoko was conducted using various GIS data and precision conservation tools (2009 Light Detection and Ranging (LiDAR) data, Nonpoint Source Pollution and Erosion Comparison Tool (N-SPECT) analysis, Habitat Priority Planner (HPP)) to identify potential project sites according to a number of indicators which have been identified as directly or indirectly affecting water quality within Ko'olaupoko. A cooperative effort between HOK and the NOAA Pacific Service Center resulted in a detailed analysis of the Ko'olaupoko using various tools. Figure 2 illustrates the initial digital investigation process using number of digital tools, while also calling out the need for field observations (*includes groundtruthing digital information and HOK's previous knowledge of the problematic areas within the region*) to provide further details not apparent from the desktop analysis.

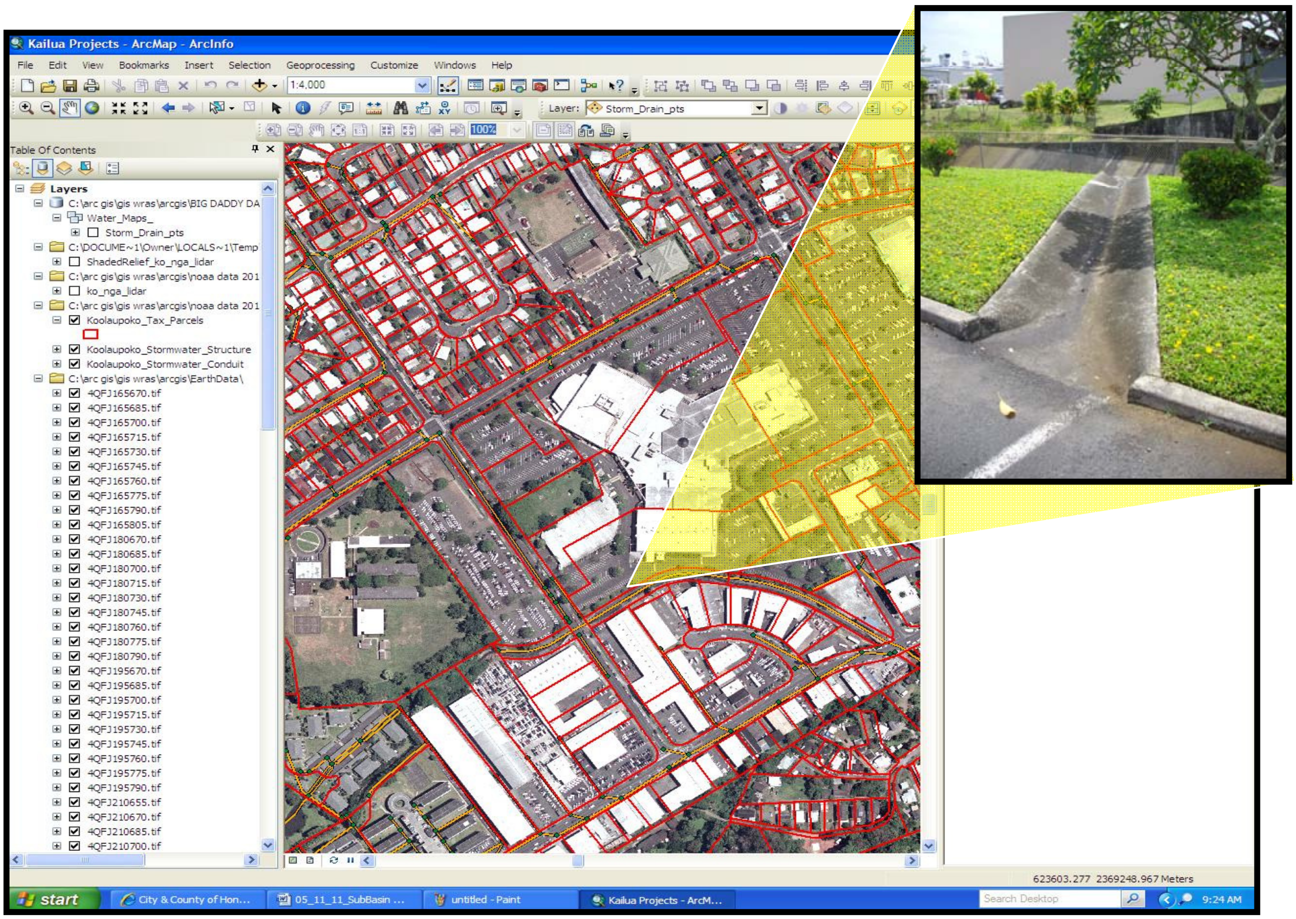

Figure 2 Digital Investigations: GIS ArcMap 10

In order to conduct the digital analysis, a number of search parameters had to be established. HOK initially examined a number of search parameters, such as distance to receiving waters, receiving water classifications, soil compositions, TMDL/303d listed, etc. Upon further research, these parameters were found to be either insufficient in locating appropriate project sites or not directly applicable to the direct causality of lowered water quality. For example, distance to receiving waters is negated by the fact that a majority of stormwater is conveyed via MS4 to receiving waters, so the distance traveled via storm drain cannot be directly associated with NPS pollution concentrations or runoff volumes. Soil compositions, while important in their own right, soil analysis at the Tax Map Key (TMK) parcel scale were found to be insufficient. Taking these factors into consideration, HOK based its digital analysis on qualities which could be directly or indirectly associated to the origins and amounts of NPS pollution and runoff volume. The search parameter criteria was established through research of industry standards (Center of Watershed Protection, Horsley Witten Group) and regional characteristics (State of Hawaiʻi regulations, CCH zoning district classifications and local knowledge) which were found to pertain to the scope of the USBAP. These were found to be *percent impervious surface per TMK parcel, TMK parcel size, and CCH zoning district classification (ZDC)*.

Digital Analysis Search Parameters:

Percent Imperviousness per TMK Parcel: A defined total imperviousness surface coverage per TMK parcel can be directly related to the amount of runoff generated by a site. Higher imperviousness results in higher runoff amounts and the transportation of NPS pollution. The target percent imperviousness per TMK parcel was identified as consisting of 50 – 100 percent coverage.

TMK Parcel Size: Parcel size is determined from GIS digital analysis according to the CCH established TMKs. Generally larger parcels with a high percent imperviousness can be assumed to have higher amounts of runoff laden with NPS pollution; this is of course dependant on the land-use and use intensity. The target parcel size scope was defined as TMK parcels consisting of 0.3 – 10 acres. The minimum parcel area (0.3 acres) has been established based on GIS analysis which found a majority of parcels within the urban environment are generally greater than 0.3 acres. The maximum lot area (10 acres) has been established based on GIS analysis which found TMK parcels within the urban environment are generally not larger than 10 acres. However, exceptions were observed, noted, and defined as follows;

- *Exception 1: The regulated minimum lot area (acres) for the majority of ZDCs within the urban environment (Business and Industrial) was found to be 0.11 acres. Generally parcels within the Koʻolaupoko were found to be larger than the regulated CCH ZDC minimum allowable lot area (0.11 acres).*

- *Exception 2: Sites greater than 10 acres, consisting of multiple parcels, are identified by individual parcel size. (Example: Windward Mall equals a total of 19.3 acres, while individual parcels range from 3.2 – 5.7 acres)*

- *Exception 3: Sites greater than 10 acres* ***not*** *within the urban environment ZDCs, consisting of a single parcel, are identified using professional judgment by their applicability to the scope and intent of "developed lands". (Example: Windward Community College consists of a single 64 acre parcel zoned as AG-2.)*

- *Exception 4: In specific cases, a single business may occupy a number of smaller adjacent parcels. (Example: Shell Gas Station at the intersection of Oneawa St. and Kuʻulei Rd in Kailua consists of two parcels at 0.19 and 0.29 acres) These specific instances may be excluded by application of parcel size range, but are observed and noted through digital GIS investigations.*

Zoning District Classifications: The ZDC focus group is defined based on GIS observations and criteria established by the CCH. Specific information related to minimum allowable parcel size and maximum allowable building areas (impervious coverage) are supplied by the CCH ZDC definitions[2]. Zoning District Classifications are helpful in determining the general land-use permitted per TMK parcel which can be used to identify EMCs based on the general land-use designation. The ZDC focus group has been established to consist of zoning types generally but not limited to; Business (B-1, B-2, BMX-3, BMX-4) and Industrial (I-1, I-2, I-3, IMX-1). Within a given ZDC, a number of various land-uses are permitted. For example: the Windward Business Center in Kāneʻohe (ZDC = I-2). This area drains directly into to the adjacent Keaʻahala Stream. Land-uses range from vehicular (retail, rental and service types) to retail and restaurants (Kailua Bay Advisory Council, 2006). Other ZDCs are either not identified as contributing to stream degradation according to the Impervious Coverage Model (Center for Watershed Protection Manual 1) or addressed through other HOK programs. Specific exceptions to the ZDC focus group are identified, examined and accounted for on a case by case basis.

- *Exception 1:* *Multiple Land-uses are permitted on a parcel by parcel basis within a singular ZDC. Example: Permitted land-uses per B-2 according to Chapter 21 Table 21-3: Land Use Ordinance provided by the CCH range from Commercial & Business Services, Dwelling & Lodgings, Industrial Services, Social & Civic Services, Transportation & Parking Services, and Utilities & Communication Services.* (City and Couty of Honolulu)

- *Exception 2:* *The CCH ZDCs listed as Preservation (P-2) and Agricultural (AG-1, AG-2)(see Chapter 21 Table 21-3.1 P-2, Agricultural & Country Districts Development Standards) were found to have a maximum of 5% - 10% building area (impervious surfaces) respectively, thus applying the Impervious Coverage Model (ICM) to these zoning types could result in the general exclusion of these ZDCs due to the relatively low contribution to stream degradation with respect to stormwater runoff and % impervious surface coverage.*
  - *The scope and intent of the USBAP is designed as such to address "developed lands".*
  - *Impervious surface coverage within Koʻolaupoko is not the sole contributor to decreased water quality.*
  - *Agricultural lands are found to have qualities (allowable land-uses) which contribute to decreased water quality in their own right, which can be attributed to "development" and other land-uses. (Example: Windward Community College is found to be AG-2 and thus could be excluded by the application of the ICM, but in accordance with the scope of the USBAP "developed lands", and professional judgment of HOK, the Windward Community College has been included within the identification phase.)*

- *Exception 3:* *Other CCH ZDCs excluded from the focus group consist of Residential zoning types which are concurrently addressed through the HOK Hawaii Rain Garden Program.*

Table 2 shows the minimum allowable lot area (acres), maximum allowable building area (does not include parking areas) per CCH ZDC Regulations. Business and Industrial ZDCs have the highest allowable percent imperviousness per TMK parcel, not regulated and 80% respectively. These ZDCs would logically have higher runoff amounts associated with the higher percentages of impervious surfaces.

[2] *CCH Chapter 21 Land Use Ordinance Section 21-3.10 to Section 21 – 3.140-1*

Table 2 City & County of Honolulu Zoning District Classification Regulations

ZDC per CCH definitions		Map Designation	Min. Lot Area (ACRES)	Max. Building Area (% Imperviousness)
Preservation				
	General	P-2	5	5%
Agricultural				
	Restricted	AG-1	5	10%
	General	AG-2	2	10%
Residential				
		R-3.5	0.08	50%
		R-5	0.11	
		R-7.5	0.17	
		R-10	0.22	
		R-20	0.45	
Apartment				
	Low-Density	A-1	0.17	40%-60%
	Med. Density	A-2	0.22	
	High-Density	A-3	0.34	
Apartment Mixed Use				
	Low-Density	AMX-1	0.17	
	Med. Density	AMX-2	0.22	
	High-Density	AMX-3	0.34	
Business				
	Neighborhood	B-1	0.11	None
	Community	B-2	0.11	
Business Mixed Use				
	Community	BMX-3	0.11	
	Central	BMX-4	0.11	
Industrial				
	Limited	I-1	0.17	80%
	Intensive	I-2	0.17	
	Waterfront	I-3	0.17	
Industrial-Commercial Mixed Use		IMX-1	0.11	

Koʻolaupoko Moku

Total TMK: 27,232

Total Potential Project Sites: 220

**Not Contributing to stream degradation according to the Impervious Coverage Model*

***Addressed by Hawaii Rain Garden Program*

Not Regulated

ZDC Focus Group

Digital Analysis Results

Habitat Priority Planner (HPP)

The HPP GIS Analysis tool was provided by NOAA, based on an updated impervious cover analysis of Koʻolaupoko in May, 2011. The Habitat Priority Planner tool is commonly used to inform decisions about habitat conservation, restoration and land use planning through the use of user defined scenario modeling. User defined parameters related to specific habitat or land use types are combined with spatial analysis metrics to create scenarios to identify potential project sites as well as model how the LIR sites might impact the watershed. With the help of NOAA, HOK has utilized the HPP to quickly identify and assess potential project sites specific to each sub-basin. The HPP modeling scenarios are based on potential indicators defined by HOK (parcel size and zoning classifications) to focus further investigations. Using the HPP Habitat Analysis Module 1, NOAA created an impervious cover GIS shapefile and conducted five custom analyses based on initial criteria defined by HOK which could be associated to NPS polluted runoff. The analysis results were used to create attribute tables within the GIS shapefile in order to conduct further refinement using the Data Explorer GIS tool.

Data Explorer

Using the Data Explorer GIS tool, HOK was able to filter potential project sites within Koʻolaupoko from *27,232 TMK parcels* down to *197 TMK parcels*.

Groundtruthing

Additional project sites were added to the project sites identified through digital analysis, bringing the total to 220 potential project sites. Each of the 220 TMK parcels identified by HOK were *"groundtruthed"* in order to provide further detail not immediately apparent from the digital analysis. A necessary portion of the project identification process relies upon on-site observations or *"groundtruthing"* of current site conditions such as location of storm drains, location of building downspouts, current post-construction storm water BMPs and potential retrofit feasibility. Additionally, sites were assessed for conflicts such as utilities, right-of-way (ROW) and simply a lack of open space or landscaped areas to implement retrofits. Existing site conditions such as: where does storm water originate on site (e.g. roof, parking lots, or other areas), where is the storm water currently going, are there storm drains and where are they located, are there opportunities to implement LIR, were visually and physically documented using *Retrofit Site Investigation* (*RSI) Data Sheets*. Concurrently each site is examined using a *Hotspot/Pollution Prevention Data Sheet*.

Retrofit Site Investigation (RSI) Data Sheets:

Groundtruthing on a parcel by parcel basis begins with a preliminary survey of the site looking for evidence of runoff and existing stormwater infrastructure. Once the preliminary walking survey is complete, special focus is placed on any evidence of runoff which can be used to indicate areas of interest, or places which may be conducive to LIR objectives. Most runoff is either directed to onsite storm drains or directed off site towards CCH storm drains located in the ROW. An important part of the groundtruthing process is the demarcation of apparent drainages. Often if a site is large enough, it may have multiple drainages, which would need to be treated individually. The demarcation of apparent drainages is used to determine the approximate size of a given LIR. Generally the size of a given LIR is relative to the size of the drainage area to be treated. For larger drainage areas it may be necessary to include multiple LIR in a series, where runoff will flow from one LIR into the next.

In conjunction with the demarcation of apparent drainage areas, open space or landscape areas need to be documented, as these areas could possibly be retrofitted with relatively few conflicts to the existing infrastructure. Notes can be made on each data sheet to describe the physical characteristics to these spaces, such as whether or not they are irrigated and maintained. Each landscape area should be analyzed for their ability to be retrofitted based on the size of the drainage area to be treated, potential conflicts with utilities which may be underground, or if they are located in an area which would allow for sufficient hydrologic head needed for a functioning LIR.

See Appendix VI: Sample Data Sheets *for sample RSI Data Sheets.*

Hotspot/Pollution Prevention Data Sheets:

A *hotspot* is defined as commercial, industrial, institutional, municipal, and transport-related operations that tend to produce higher levels of storm water pollution, or present a higher potential risk for spills, leaks and illegal discharges[3]. Adapted from the Center for Watershed protection data sheets, the *Hotspot/Pollution Prevention Data Sheets* are used to record and identify potential hotspot sites. Items such as vehicle operations, outdoor materials, waste management, physical plant (the building and parking lot), landscaping area, and stormwater infrastructure are documented.

See Appendix VI: Sample Data Sheets *for sample Hotspot/Pollution Prevention Data Sheets.*

Groundtruthing Results:

A master list of all projects is created to clearly summarize all potential project sites within Koʻolaupoko. Of the 220 TMK parcels, 28 were excluded due to limited access (no groundtruthing beyond an external visual survey could be conducted). The remaining 192 sites were documented and recorded. This list is analyzed per the prioritization framework to identify potential projects sites.

Prioritization

The third component of the planning process ranks projects within a prioritizing hierarchical framework for implementation. The prioritization frame work is designed to “filter” projects according to the following technical factors; impervious area treated, pollutant removal capacity, runoff reduction estimates and general maintenance requirements. Concurrently each proposed site is evaluated with respect to non-technical factors such as educational or demonstration potential (visual access). Project sites which were identified and investigated, but not selected for LIR implementation due to a number of site specific constraints may be addressed through education and outreach programs wherein occupants are provided with educational materials pertaining to watershed health, NPS pollution, and pollution prevention to reduce their impact on Koʻolaupoko watersheds.

Project Prioritization Framework:

The project prioritization parameters are established to clearly order projects according to the following characteristics (space availability, hotspot score, NPS pollution retrofit calculations, and visual access) leading to successful LIR implementation. Projects prioritization allows for the projects which are most easily implemented with the greatest possible impact i.e. *“low hanging fruit”* to be given a higher priority. Of the potential *220 TMK parcels* served, *192 TMK parcels* could be considered as possible LIR sites.

Space Availability:

The most basic form of project prioritization is based on space availability per site (potential project sites either have space available for LIR implementation or not). Quite simply the answer is based on whether one is able to retrofit a site with minimal impact/conflicts to the pre-existing requirements of the site (ex. a proposed BMP will not impact parking stalls or require the removal or compromise particular features fundamental to the daily operations of the site). The *192 TMK* parcels were narrowed down to *60 TMK parcels* based on whether or not space was overtly available for a physical retrofit. The number of

[3] Urban Stromwater Restoration Manual Series: An Integrated Framework to Restore Small Urban Watersheds. 2005

potential project sites could be increased with the inclusion of more technical BMPs specifically designed for limited space applications.

Hotspot Score:

The hotspot score is based on the results from the *Hotspot/Pollution Prevention Data Sheets*. If fewer than 5 circles and no boxes are checked, the site is ***not*** a *hotspot*. If 5 to 10 circles but no boxes are checked, the site is a ***potential*** *hotspot*. If 10 to 15 circles and/or 1 box is checked, then the site is a ***confirmed*** *hotspot*. If more than 15 circles and/or 2 boxes are checked then the site is a ***severe*** *hotspot*. See Appendix VI: Sample Data Sheets.

NPS Pollution Retrofit Calculations:

An Excel based spreadsheet has been supplied by the Center for Watershed Protection to aid in the prioritization process. The spreadsheet automates the computations for NPS pollutant removal, runoff reduction, and cost. Runoff Reduction & EMC Pollutant Removal Efficiencies are derived from Runoff Reduction Technical Memo (CWP & CSN, 2008) and Virginia DCR BMP Clearinghouse[4]. The user is able to input site specific data such as parcel size (acres) and percent impervious cover and local climate data to determine the potential runoff/load (TSS, TP, TN) reduction of each project site.

Cost Estimates: Cost estimates are generated by the spreadsheet based on the results of user input data. *NOTE: Cost estimates need to be adjusted to reflect prices for Hawai'i which may or may not reflect those expressed within the cost estimate portion of the CWP Excel spreadsheet.*

Climate Data: Specific climate data was prepared by consulting hydrologist, Neil Berg, Ph.D. The target rainfall event or 90th percentile needed to calculate anticipated runoff volumes uses historical data sets from the National Climatic Data Center. For the purpose of this project, four locations were chosen which more closely matched the general locations of the proposed LIR project sites. As shown in Table 3, the historical climate data was compiled for Waimānalo, Kailua Fire Station, Kāneʻohe Mauka and Kāneʻohe Town.

Table 3 Koʻolaupoko Moku Historical Climate Data

Station Location	Data Set	90th %tile	Annual Rainfall
Waimanalo Exp Stn	1969 - 2010	1.40"	44.19"
Kailua Fire Stn	1959 - 1978	1.43"	41.65"
Kanehoe Mauka	1928 -1998	1.23"	74.30"
Kāneʻohe Town	1906 - 1924, 1985 - 2010	1.15"	54.06"

Please refer to Appendix V: Reduction Methodologies for further detail pertaining to runoff reduction and pollution loading calculations.

High Visual Access (education and outreach):

Visually accessible projects are defined as being located in an area which receives higher traffic, either pedestrian or vehicular. A LIR site with high visual access could potentially aid in raising watershed awareness and is a strong component of LIR education and outreach. As such a highly visual project location would be preferred over a less visibly accessible project.

[4] http://www.vwrrc.vt.edu/swc/NonProprietaryBMPs.html

High priority projects vs. lower priority projects:

Each project in its own right has value to overall watershed health. High priority projects which have been identified and ordered according to the criteria established above are intended to have the greatest impact with respect to water quality and education/outreach. Lower priority projects do not necessarily denote a lower possible positive impact on watershed health. A lower priority ranking could result from site conflicts as listed above, which may slow or impede implementation. Each project which was identified in the identification process, as stated, has its own value to overall watershed health in its own right and as such, will qualify for education and outreach programs facilitated by HOK in the future.

Appendix V: Reduction Methodologies

Simple Pollution Load Reduction Method

Using the *Simple Method* adopted from the Center for Stormwater Protection's *Urban Subwatershed Restoration Manual 3 Appendix B*, the annual estimated NPS pollutant load exported in pounds per year from a contributing drainage area to a retrofit application can be identified by solving the following equation.

$$L = [(P)(Pj)(Rv)/(12)](C)(A)(2.72)$$

Where:

L = Average annual pollutant load (lbs)
P = Average annual rainfall depth (inches)
Pj = Fraction of rainfall events that produce runoff
Rv = Runoff coefficient expressed as the fraction of rainfall that is converted into runoff
C = Event Mean Concentration (EMC) of the pollutant in urban runoff (mg/l)
A = Contributing drainage area (acres)

(C) Summary of Pollutant EMC's in Stormwater Runoff per Land Use
Select the targeted pollution type…

	Residential	Commercial	Industrial
TDS	72	72	86
TSS	49	43	81
BOD	9.0	11.0	9.0
COD	54.5	58	58.6
Fecal Coliform	7,000	4,600	2,400
NO2 + NO3	0.6	0.6	0.69
TKN	1.5	1.5	1.4
TOTAL N	2.1	2.1	2.09
DISSOLVED P	0.18	0.11	0.10
TOTAL P	0.31	0.22	0.25
DISSOLVED Cu	7.0	7.57	8.0
TOTAL Cu	12	17	20.8
DISSOLVED Zn	31.5	59	112
TOTAL Zn	73	150	199

(Rv) Site Cover Runoff Coefficients

Soil Conditions	Runoff Coefficient
Forest Cover	0.02 to 0.05*
Disturbed Soils/Managed Turf	0.15 to 0.25*
Impervious Cover	0.95

**Range dependent on original Hydrologic Soil Group (HSG)*

Forest:	*A: 0.02*	*B: 0.03*	*C: 0.04*	*D: 0.05*
Disturbed Soils:	*A: 015*	*B: 0.20*	*C: 0.22*	*D: 0.25*

Runoff Reduction Method

The Runoff Reduction Method is centered on Treatment Volume (Tv). The goal is to reduce Tv by reducing the overall volume of runoff leaving a given site. Treatment Volume is a direct function of impervious cover and disturbed soils. Identifying Tv provides guidance for designing BMPs which are adequate in size to treat pollutants for a range of storm events (first flush effect has been found to be modest for many pollutants). Treatment Volume is a variation of the 90% capture rule or 90th percentile event (based on climate specific data which shows a typical rainfall frequency spectrum identifying the percentage of rainfall events that result in runoff equal to or less than an indicated rainfall depth). The rational for using the 90th percentile event is that it represents the majority of runoff volume on an annual basis for a given site. Larger rainfall events generally produce runoff which is beyond the scope of LIR (i.e. LIR are not intended or designed as flood control BMPs). Larger storm events would still receive a level of treatment, but total treatment become impossible due to the volume of water generated by a given storm event.

To calculate Tv: multiply the "water quality" rainfall depth (one-inch) by the three site cover runoff coefficients (forest, disturbed soils, and impervious cover) present at each potential project site.

$$Tv = \frac{P * (RvI * \%I + RvT * \%T + RvF * \%F) * SA}{12}$$

Where:

Tv = Runoff reduction volume in acre feet
P = Depth of rainfall for "water quality" event
RvI = runoff coefficient for impervious cover
RvT= runoff coefficient for turf cover or disturbed soils
RvF = runoff coefficient for forest cover
%I = percent of site in imperious cover
%T = percent of site in turf cover
% F = percent of site in forest cover
SA = total site area in acrers

(C) Values of Runoff Coefficient for Rational Formula			
Land Use	**C**	**Land Use**	**C**
Business:		***Lawns:***	
Downtown areas	0.70 - 0.95	Sandy soil, flat 2%	0.05 – 0.10
Neighborhood areas	0.50 – 0.70	Sandy soil, avg. 2 -7%	0.10 – 0.15
		Sandy soil, steep, >7%	0.15 – 0.20
		Heavy soil, flat, 2%	0.13 – 0.17
		Heavy soil, avg., 2-7%	0.18 – 0.22
		Heavy soil, steep, >7%	0.25 – 0.35
Residential:		***Agricultural Land:***	
Single Family	0.30 – 0.50	Bare packed soil	
Multi units, detached	0.40 – 0.60	Smooth	0.30 – 0.60
Multi units, attached	0.60 – 0.75	Rough	0.20 – 0.50
Suburban	0.25 – 0.40	Cultivated rows	
		Heavy soil, no crop	0.30 – 0.60
		Heavy soil, crop	0.20 – 0.50
		Sandy soil, no crop	0.20 – 0.40
		Sandy soil, crop	0.10 – 0.25
		Pasture	
		Heavy soil	0.15 – 0.45
		Sandy soil	0.05 – 0.25
		Woodlands	0.05 – 0.25
Industrial:		***Streets:***	
Light	0.50 – 0.80	Asphalt	0.70 – 0.95
Heavy	0.60 – 0.90	Concrete	0.80 – 0.95
		Brick/Pavers	0.70 – 0.85
Parks, Cemeteries	0.10 – 0.25	***Undeveloped lands***	0.10 – 0.30
Playgrounds	0.20 – 0.35	***Drives and walks***	0.75 – 0.85
Roofs	0.75 – 0.95		

Appendix VI: Sample Data Sheets

hui o ko'olaupoko

1051 Keolu Dr. # 208
Kailua, HI 96734
808-277-5611 (p)
www.huihawaii.org

April 2011

To whom it may concern,

Hui o Koʻolaupoko is a non-profit organization whose mission is to: *protect ocean health by restoring the ʻāina: mauka to makai*. This is done in partnership with stakeholders including interested citizens, non-governmental organizations, government, educational institutions and businesses while using and focusing on sound ecological principles, community input, and cultural heritage.

Hui o Koʻolaupoko focuses organizational efforts in three main program areas:

- ✓ Watershed/ahupuaʻa restoration and monitoring
- ✓ Natural resource coordination/stakeholder involvement
- ✓ Scientific data and information dissemination

A current project is to develop an Urban Sub-basin Action Plan focusing on developed lands and how storm water from these lands impact water quality. The goal is to assess developed lands, from retail commercial business to church parking lots, and gain a greater understanding of where storm water flows, where it enters the storm drains and eventually our streams and oceans. The final document will provide a course of action for Hui o Koʻolaupoko over the next several years to address storm water and non-point source pollution and prioritize opportunities for Low-Impact Retrofits (LIR), ultimately improving water quality. A fundamental step towards achieving our goal is creating a detailed understanding and inventory of the Koʻolau region with respect to storm water runoff. At each site we have the following questions:

- ✓ Where does the storm water originate (e.g. roof, parking lots, other areas)?
- ✓ Where is the storm water currently going?
- ✓ Are there storm drains, and if so, where are they located?
- ✓ Are there opportunities to implement LIR?

If you have any questions following our visit, please feel free to call Todd at 808-277-5611.

Sincerely,

Todd Cullison
Executive Director

Merrick Patten
Action Plan Coordinator

Watershed:	**Subwatershed:**	
TMK:	**Acres:**	**Date:**
Assessed By:	**Zoning:**	**Land-Use:**

SITE DESCRIPTION

Name: ______________________ Unique Site ID: ______________________

Address: ____

Ownership: ☐ Public ☐ Private ☐ Unknown

If Public, Government Jurisdiction: ☐ Local ☐ State ☐ DOT ☐ Other:___________

Brownfield: ☐ Yes ☐ No ☐ Unknown

Aerial Photo

Proposed Treament

"PP" Porus Pavement

"CC" Curb Cuts

"DD" Disconnect Downsputs

"RG" Raingarden

"PB" Planter Boxes

Other:_________________

Proposed Retrofit Location:

☐ Below Outfall

☐ In Road ROW

☐ Above Roadway Culvert

☐ In Conveyance System

☐ Near Large Parking Lot

☐ Other:___________

Adjacent Land Uses:

☐ Residential

☐ Commercial

☐ Institutional

☐ Industrial

☐ Park

☐ Transport Related

☐ Undeveloped

☐ Other:___________

Potential Conflict:

☐ Yes

☐ No

Describe Existing Site Conditions, Include Existing Site Drainage & Conveyance Systems:

RED ☒ Storm Drain

* Downspout

BLUE — — Drainage Boundary

→ Flow Direction

GREEN ······ LIR Site

Proposed Retrofit

Purpose of Retrofit:

- ☐ Water Quality
- ☐ Demonstration / Education
- ☐ Recharge
- ☐ Other:___________

Retrofit Volume Calculations - Target Storage:

Retrofit Volume Calculations - Available Storage:

Site Constraints

Constrained Due to :

- ☐ Slope
- ☐ LMTD Space
- ☐ Utilities
- ☐ Structure
- ☐ Head
- ☐ Tree Impact
- ☐ Property Ownership
- ☐ No Constraints
- ☐ Other:______________________

Soils:

GIS Soils Data: ____________________

Soil Auger Test: __________

High Water Table ☐

Shallow Bedrock ☐

Poor Infiltration ☐

Conflicts:

	None	Yes	Possible	Unknown
Vehicular	☐	☐	☐	☐
Sewer	☐	☐	☐	☐
Water	☐	☐	☐	☐
Cable	☐	☐	☐	☐
Electric	☐	☐	☐	☐
Overhead	☐	☐	☐	☐
Other	☐	☐	☐	☐

Potential Permitting Factors:

	Probable	Not Probable
Wetlands	☐	☐
Stream	☐	☐
Floodplain	☐	☐
Forest	☐	☐
MS4 NPDES	☐	☐
__________	☐	☐
__________	☐	☐

Drainage Area to Proposed Retrofit

- # of Apparent Drainage Areas: __________
- Drainage Area __________
- % Imperviousness __________
  - Roof Area __________
  - Parking Area __________
  - Compacted Fill __________
- Impervious Area __________

Non-Structural Management Practices

- Occupant Education & Training ☐
- Covering from Rain ☐
- Secondary Containment ☐

Classification of reciving waters

Inland

- ☐ Class 1
- ☐ Class 1a
- ☐ Class 1b
- ☐ Class 2

Marine

- ☐ Class AA
- ☐ Class A
- ☐
- ☐

Code Research

Research Applicable Codes Pertaining to Zoning Designation...

NOTES:

Hotspot/Pollution Prevention

hui o ko'olaupoko

WATERSHED:	DATE: ___/___/_____	SITE ID:	
A. SITE DATA AND BASIC CLASSIFICATION			
Site Name/Contact: ____________ ____________ SIC code (if available): ________ NPDES permit? ☐ Y ☐ N ☐ Can't Tell	Category: ☐ Commercial ☐ Industrial ☐ Institutional ☐ Municipal ☐ Golf Course ☐ Transport-Related ☐ Marina ☐ Animal Facility Basic Description of Operation: ____________		**INDEX***
B. VEHICLE OPERATIONS ☐ **N/A** *(Skip to part C)*			**Observed Pollution?** ☐
B1. Types of vehicles: ☐ Fleet vehicles ☐ School buses ☐ Other: ________			
B2. Approximate number of vehicles: ______			
B3. Vehicle activities *(circle all that apply)*: Maintained Repaired Recycled Fueled Washed Stored			○
B4. Are vehicles stored and/or repaired outside? ☐ Y ☐ N ☐ Can't Tell Are these vehicles lacking runoff diversion methods? ☐ Y ☐ N ☐ Can't Tell			○
B5. Is there evidence of spills/leakage from vehicles? ☐ Y ☐ N ☐ Can't Tell			○
B6. Are uncovered outdoor fueling areas present? ☐ Y ☐ N ☐ Can't Tell			○
B7. Are fueling areas directly connected to storm drains? ☐ Y ☐ N ☐ Can't Tell			○
B8. Are vehicles washed outdoors? ☐ Y ☐ N ☐ Can't Tell Does the area where vehicles are washed discharge to the storm drain? ☐ Y ☐ N ☐ Can't Tell			○
C. OUTDOOR MATERIALS ☐ **N/A** *(Skip to part D)*			**Observed Pollution?** ☐
C1. Are loading/unloading operations present? ☐ Y ☐ N ☐ Can't Tell If yes, are they uncovered *and* draining towards a storm drain inlet? ☐ Y ☐ N ☐ Can't Tell			○
C2. Are materials stored outside? ☐ Y ☐ N ☐ Can't Tell If yes, are they ☐ Liquid ☐ Solid Description: ______ Where are they stored? ☐ grass/dirt area ☐ concrete/asphalt ☐ bermed area			○
C3. Is the storage area directly or indirectly connected to storm drain (circle one)? ☐ Y ☐ N ☐ Can't Tell			○
C4. Is staining or discoloration around the area visible? ☐ Y ☐ N ☐ Can't Tell			○
C5. Does outdoor storage area lack a cover? ☐ Y ☐ N ☐ Can't Tell			○
C6. Are liquid materials stored *without* secondary containment? ☐ Y ☐ N ☐ Can't Tell			○
C7. Are storage containers missing labels or in poor condition (rusting)? ☐ Y ☐ N ☐ Can't Tell			○
D. WASTE MANAGEMENT ☐ **N/A** *(Skip to part E)*			**Observed Pollution?** ☐
D1. Type of waste *(check all that apply)*: ☐ Garbage ☐ Construction materials ☐ Hazardous materials			○
D2. Dumpster condition (*check all that apply)*: ☐ No cover/Lid is open ☐ Damaged/poor condition ☐ Leaking or evidence of leakage (stains on ground) ☐ Overflowing			○
D3. Is the dumpster located near a storm drain inlet? ☐ Y ☐ N ☐ Can't Tell If yes, are runoff diversion methods (berms, curbs) lacking? ☐ Y ☐ N ☐ Can't Tell			○
E. PHYSICAL PLANT ☐ **N/A** *(Skip to part F)*			**Observed Pollution?** ☐
E1. Building: Approximate age: _______ yrs. Condition of surfaces: ☐ Clean ☐ Stained ☐ Dirty ☐ Damaged Evidence that maintenance results in discharge to storm drains (staining/discoloration)? ☐ Y ☐ N ☐ Don't know			○○
E2. Parking Lot: Approximate age _____ yrs. Condition: ☐ Clean ☐ Stained ☐ Dirty ☐ Breaking up Surface material ☐ Paved/Concrete ☐ Gravel ☐ Permeable ☐ Don't know			○
E3. Do downspouts discharge to impervious surface? ☐ Y ☐ N ☐ Don't know ☐ None visible Are downspouts directly connected to storm drains? ☐ Y ☐ N ☐ Don't know			○
E4. Evidence of poor cleaning practices for construction (stains leading to storm drain)? ☐ Y ☐ N ☐ Can't Tell			○

*Index (optional). Fill circles if potential pollutant source, check box if pollutant observed hui o ko'olaupoko

F. TURF/LANDSCAPING AREAS ☐ N/A *(skip to part G)*	Observed Pollution? ☐
F1. % of site with: Forest canopy ____% Turf grass _____ % Landscaping ____% Bare Soil ____%	○
F2. Rate the turf management status: ☐ High ☐ Medium ☐ Low	○
F3. Evidence of permanent irrigation or “non-target” irrigation ☐ Y ☐ N ☐ Can’t Tell	○
F4. Do landscaped areas drain to the storm drain system? ☐ Y ☐ N ☐ Can’t Tell	○
F5. Do landscape plants shed organic matter (leaves, grass clippings) on adjacent impervious surface? ☐ Y ☐ N ☐ Can’t Tell	○
F6. Is there an adequate vegetated buffer between site and adjacent resource areas? ☐ Y ☐ N ☐ NA	○
G. STORM WATER INFRASTRUCTURE ☐ **N/A** *(skip to part H)*	**Observed Pollution?** ☐
G1. Are storm water treatment practices present? ☐ Y ☐ N ☐ Unknown If yes, please describe: ________________	○
If so, are they infiltrating untreated stormwater? ☐ Y ☐ N ☐ Unknown	○
G2. Are private storm drains located at the facility? ☐ Y ☐ N ☐ Unknown Is trash present in gutters leading to storm drains? If so, complete the index below.	○

Index Rating for Accumulation in Curb/Gutters

	Clean				Filthy
Sediment	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Organic material	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Litter	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

G3. Catch basin inspection – Record SSD Unique Site ID here: ________ Condition: ☐ Dirty ☐ Clean

H. INITIAL HOTSPOT STATUS

Index Alternative: Potential pollutants associated with:
- ☐ Vehicular operations (fueling, storage, maintenance)
- ☐ Waste management (dumping)
- ☐ Outdoor material storage (uncovered, leaking, no 2nd containment)
- ☐ Landscaping (over fertilizing, irrigation)
- ☐ Building/parking lot maintenance (washdowns)
- ☐ Other:

Pollutant of concern?
- ☐Limited ☐Likely ☐Observed for **sediment loading**
- ☐Limited ☐Likely ☐Observed for **oil/grease**
- ☐Limited ☐Likely ☐Observed for **trash**
- ☐Limited ☐Likely ☐Observed for **nutrient loading**
- ☐Limited ☐Likely ☐Observed for **bacteria**
- ☐Limited ☐Likely ☐Observed for **other:**

INDEX RESULTS
- ☐ Not a hotspot (fewer than 5 circles and no boxes checked)
- ☐ Potential hotspot (5 to 10 circles but no boxes checked)
- ☐ Confirmed hotspot (10 to 15 circles and/or 1 box checked)
- ☐ Severe hotspot (>15 circles and/or 2 or more boxes checked)

I. RECOMMENDED ACTION

Follow-up Action:
- ☐ Refer for immediate enforcement
- ☐ Suggest follow-up on-site inspection or review of SWPPP
- ☐ Test for illicit discharge
- ☐ Include in future education effort
- ☐ Catchbasin cleaning or street sweeping
- ☐ Relocate dumpsters
- ☐ Provide secondary containment
- ☐ On-site retrofit
- ☐ Install spill response measures
- ☐ Other:

Severity of Problem: ☐Low ☐Medium ☐High

Describe Conditions:

Notes:

*Index (optional). Fill circles if potential pollutant source, check box if pollutant observed

Appendix VII: USBAP LIR Accounting & Project Ranking Worksheet

USBAP LIR Accounting & Project Ranking

This scoring matrix allows multiple restoration projects to be scored, ranked, and prioritized based on a set of objective and subjective criteria.

SAMPLE SCORING MATRIX FOR PROJECT RANKING & PRIORITIZING

SCREENING FACTOR	DESCRIPTION	MAX. POSSIBLE SCORE	SCORING[1]	SCORE
Total Nitrogen (N) Removed (pounds per year)	Measures area treated combined with pollutant removal efficiency of practice.	20	< 1 pound of N = 5 points 1 to 2 pounds of N = 10 points 2 to 4 pounds of N = 15 points > 4 pounds of N = 20 points	
Cost Per Pound of N Removed ($)	Measure of cost-effectiveness.	20	> $27K per pound = 5 points $20K to $26K per pound = 10 points $12K to $19K per pound = 15 points < $12K per pound = 20 points	
Total Construction Cost ($)	Measure of the total cost to compare to program budgets.	20	> $30K = 5 points $13K to $29K = 10 points $7.5K to $12K = 15 points < $7.5K = 20 points	
Public Visibility/Outreach	How well will the practice serve to engage and educate the public?	10	Low Visibility & Education Opportunity; practice on private land, not very accessible = 0 points Medium Visibility & Education Opportunity; may be on public or private land, but not in high traffic or pedestrian area = 5 points High Visibility & Education Opportunity; located on public land (school or park) = 10 points	
Quick Implementation	Is there momentum to implement the practice; are agencies supportive; are there other projects it can be attached to.	10	Low = project must develop agency support & funding = 0 points Medium = supported by agencies, but funding is not secured; project must stand on its own for implementation = 5 points High = supported by agencies, likelihood to be combined with another project, funding likely = 10 points	

Operation & Maintenance (O&M)	How difficult and costly will it be to maintain the practice over time.	10	High = practice will require frequent and intensive maintenance = 0 points Medium = practice will require maintenance of structural elements, such as dams and pipes, as well as vegetation = 5 points Low = practice maintenance depends largely on maintaining vegetation, mulch, and maybe small weirs or underdrains = 10 points	
Use of Innovative Practices	Is this an innovative practice you'd like to see demonstrated on your island?	10	Not Innovative = practice is routine on the island = 0 points Somewhat Innovative = practice is used on island, but it is not widespread and the proposed practice would be a good example = 5 points Innovative = the practice is very rare or not used, and it would be an excellent demonstration project = 10 points	
TOTAL SCORE		100		

Appendix VIII: USBAP LIR Project List

Region			Site Data				CDA				LIR Site		NPS Pollution Reduction						
TMK	Sub-Watershed	Site Name	Zoning Type	Total Acres	% Imperviousness	Visibility	Annual Rainfall (inches)	Target Rainfall (90th)	Soil Group (HSG)	Total CDA (acres)	LIR site (sq ft)	Volume Provided (cu. ft.)	Volume Needed (cu. ft.)	% Provided/Needed	Annual Runoff Reduction (inches)	TP lb/yr	TN lb/yr	TSS lb/yr	**Ranking Score**
Waimanalo																			
41009278	Waimanalo	Coral Factory	B-1	0.58	97.04	H	44.19"	1.40"	D	0.570	1960	2752	2752	100%	1101	0.72	6.25	202	**90**
41007037	Kahawai	McDonalds'	B-1	0.33	99.97	H	44.19"	1.40"	C	0.160	696	698	698	100%	279	0.18	1.58	51	**90**
41022007	Waimanalo	Shimas	B-1	0.33	99.97	H	44.19"	1.40"	B	0.150	479	718	724	99%	287	0.19	1.63	53	**80**
41004006	Kahawai	Kenekes	B-1	0.46	99.97	L	44.19"	1.40"	C	0.110	261	392	531	74%	157	0.1	0.89	29	**75**
41009279	Waimanalo	Health Center	R-5	1.00	84.00	M	44.19"	1.40"	A	0.070	479	338	338	100%	135	0.09	0.77	25	**70**
41009275	Waimanalo	Jack N Box	B-1	1.56	99.97	M	44.19"	1.40"	B	0.040	1045	193	193	100%	77	0.05	0.44	14	**70**
Kailua																			
42001043	Ka'elepulu	Post Office	B-2	1.24	99.54	H	41.65"	1.43"	C	0.127	871	626	626	100%	250	0.15	1.31	42	**90**
42038034	Ka'elepulu	Macy's PRKNG	B-2	0.41	99.96	H	41.65"	1.43"	C	0.275	434	652	1356	48%	250	0.15	1.31	42	**90**
43056001	Ka'elepulu	McDonalds'	BMX-3	0.50	87.41	H	41.65"	1.43"	C	0.103	522	508	508	100%	203	0.12	1.06	34	**90**
42001005	Ka'elepulu	Down To Earth	B-2	2.12	80.55	M	41.65"	1.43"	B	0.290	392	588	1430	41%	235	0.14	1.23	40	**85**
42024016	Ka'elepulu	DT SFWY	B-2	3.16	98.95	H	41.65"	1.43"	C	0.39	4573	1923	1923	100%	769	0.47	4.03	130	**85**
42038008	Ka'elepulu	NAPA	B-2	0.35	99.97	H	41.65"	1.43"	C	0.430	479	212	212	100%	85	0.05	0.44	14	**85**
42038053	Ka'elepulu	Pali Lanes	B-2	1.68	67.22	H	41.65"	1.43"	C	0.179	696	883	883	100%	353	0.21	1.85	60	**85**
43054006	Ka'elepulu	Checker Auto Parts	B-2	0.60	99.64	H	41.65"	1.43"	C	0.159	1437	784	784	100%	314	0.19	1.64	53	**85**
43056002	Ka'elepulu	Pali Bottle Shop	B-2	0.43	99.95	H	41.65"	1.43"	C	0.136	653	671	671	100%	268	0.16	1.41	45	**85**
43057002	Ka'elepulu	Kailua Square Shpng Cntr	B-2	3.06	82.76	H	41.65"	1.43"	C	0.500	1176	1764	2367	75%	706	0.43	3.7	119	**85**
43057016	Ka'elepulu	K Town Pub	B-2	0.49	99.95	M	41.65"	1.43"	C	0.151	392	588	745	79%	235	0.14	1.23	40	**85**
42001026	Ka'elepulu	Fat Boys	B-2	0.71	99.97	M	41.65"	1.43"	C	0.073	304	360	360	100%	144	0.09	0.75	24	**80**
42038004	Ka'elepulu	Koolau Farms	R-7.5	0.48	96.71	M	41.65"	1.43"	B	0.184	261	392	907	43%	157	0.1	0.82	26	**80**
42038020	Ka'elepulu	Garden Accents	B-2	0.34	99.97	H	41.65"	1.43"	C	0.048	130	196	237	83%	78	0.05	0.41	13	**80**
42051003	Kawainui	Faith Baptist Church	R-5	2.10	74.43	M	41.65"	1.43"	B	0.630	1089	1633	2523	65%	653	0.4	3.42	110	**80**
42103032	Kawainui	Christ Church	R-5	2.00	35.64	M	41.65"	1.43"	B	0.245	696	1045	1208	87%	418	0.25	2.19	71	**80**
43053029	Ka'elepulu	Island Snow	B-1	0.92	81.61	M	41.65"	1.43"	B	0.222	217	326	1095	30%	130	0.08	0.68	22	**80**
43055001	Ka'elepulu	Cinnamon's Parking lot	BMX-3	1.76	80.91	M	41.65"	1.43"	C	0.710	1655	2482	3501	71%	993	0.6	5.2	168	**80**
43057019	Ka'elepulu	Block Buster	B-2	0.42	99.96	M	41.65"	1.43"	C	0.156	217	326	769	42%	130	0.08	0.68	22	**80**
43057073	Ka'elepulu	Agnesse's Bakery	B-2	0.39	99.96	H	41.65"	1.43"	C	0.177	1350	873	873	100%	349	0.21	1.83	59	**80**
43057073	Kawainui	Arbys	B-2	0.33	99.41	H	41.65"	1.43"	C	0.072	1045	355	355	100%	142	0.09	0.74	24	**80**
44023001	Kawainui	Pinkies	B-1	3.18	68.08	L	41.65"	1.43"	B	0.206	871	1016	1016	100%	406	0.25	2.13	69	**80**
42033050	Kawainui	Enchanted Lakes Safeway	B-1	2.74	96.57	L	41.65"	1.43"	D	0.450	914	1372	2219	62%	549	0.33	2.87	93	**75**
43014002	Ka'elepulu	YMCA	R-5	5.3	28	L	41.65"	1.43"	B	0.249	479	527	527	100%	211	0.13	1.1	36	**75**
43056005	Ka'elepulu	Bank of Hawaii	B-2	0.67	85.00	M	41.65"	1.43"	C	0.089	348	439	439	100%	176	0.92	0.92	30	**75**
42051001	Kawainui	CreekSide	I-2	0.35	75.50	L	41.65"	1.43"	B	0.069	435	340	340	100%	136	0.08	0.71	23	**70**
43057038	Ka'elepulu	Manuhea Alii	B-2	0.34	99.96	M	41.65"	1.43"	C	0.340	1916	1677	1677	100%	671	0.41	3.51	113	**70**

Region			Site Data				CDA				LIR Site		NPS Pollution Reduction						
TMK	Sub-Watershed	Site Name	Zoning Type	Total Acres	% Imperviousness	Visibility	Annual Rainfall (inches)	Target Rainfall (90th)	Soil Group (HSG)	Total CDA (acres)	LIR site (sq ft)	Volume Provided (cu. ft.)	Volume Needed (cu. ft.)	% Provided/Needed	Annual Runoff Reduction (inches)	TP lb/yr	TN lb/yr	TSS lb/yr	**Ranking Score**
Kaneohe																			
46030061	Keeahala	Post Office	B-2	1.17	96.66	H	54.06"	1.15"	B	0.280	435	653	1110	59%	261	0.26	2.21	71	**95**
45023010	Kaneohe	Kaneohe District Park	P-2	12.6	N/A	H	74.30"	1.23"	B	0.386	696	1045	1570	67%	418	0.53	4.54	147	**90**
46006069	He'eia	He’eia Boat Launch	P-2	3.4	N/A	H	54.06"	1.15"	B	0.502	6534	1991	1991	100%	796	0.78	6.73	217	**90**
46011043	He'eia	WMP3	B-2	3.40	80.52	H	54.06"	1.15"	B	0.439	740	1110	1741	64%	444	0.44	3.75	121	**90**
46011047	He'eia	WMP2	B-2	3.80	N/A	H	54.06"	1.15"	B	0.429	2657	1701	1701	100%	680	0.67	5.75	186	**90**
46030053	Keeahala	Kaneohe Washerette	B-2	0.61	99.96	H	54.06"	1.15"	B	0.241	1045	956	956	100%	382	0.38	3.23	104	**90**
45019019	Keeahala	American Savings Bank	B-2	0.51	89.97	H	54.06"	1.15"	B	0.629	784	1176	2416	49%	470	0.46	3.98	128	**85**
45023002	Kaneohe	Kaneohe Court House	AG-2	2	N/A	M	74.30"	1.23"	B	0.775	3267	2785	2785	100%	1114	1.4	12.1	390	**85**
45039029	Kaneohe	Burger King	B-2	0.94	N/A	H	54.06"	1.15"	B	0.526	522	784	2086	38%	314	31	2.65	86	**85**
46011042	He'eia	WMP1	B-2	5.70	94.30	H	54.06"	1.15"	B	1.155	653	980	4580	21%	392	0.38	3.31	107	**85**
46011046	He'eia	Mall Overflow Parking	B-2	4.80	73.40	M	54.06"	1.15"	B	0.757	958	1437	2946	49%	575	0.56	4.86	157	**85**
47004037	Ahuimanu	Koolau Theaters	B-1	3.60	74.13	M	74.30"	1.23"	C	0.684	1698	2548	2749	93%	1019	1.28	11.07	357	**85**
45017007	Keeahala	Zippys Allstate	B-2	1.01	77.48	L	54.06"	1.15"	B	0.898	1219	1829	3389	54%	732	0.72	6.18	200	**80**
45019020	Keeahala	Pizza Hut	B-2	0.30	73.28	L	54.06"	1.15"	B	0.418	740	1110	1658	67%	444	0.44	3.75	121	**80**
45020023	Kaneohe	MAY MAY BBQ	B-2	0.32	99.96	L	54.06"	1.15"	B	0.167	740	662	662	100%	265	0.26	2.24	72	**80**
45023014	Kaneohe	WWCC A3	B-2	64	N/A	H	74.30"	1.23"	B	0.049	2874	208	208	100%	83	0.1	0.9	29	**80**
45023014	Kaneohe	WWCC A4	B-2	N/A	N/A	L	74.30"	1.23"	B	0.474	1698	1800	1800	100%	720	0.91	7.82	252	**80**
45023014	Kaneohe	WWCC A5	B-2	N/A	N/A	H	74.30"	1.23"	B	0.035	2221	148	148	100%	59	0.07	0.64	21	**80**
45039005	Kaneohe	Kaiser Clinic	B-2	2.74	53.93	H	54.06"	1.15"	B	2.549	3049	4573	6884	66%	1829	1.79	15.46	499	**80**
45076042	Kaneohe	Koolau Farms	I-2	0.51	99.96	M	54.06"	1.15"	B	0.143	566	567	567	100%	227	0.22	1.92	62	**80**
46030031	Keeahala	Windward Auto Spa	I-2	1.25	99.96	H	54.06"	1.15"	B	0.197	1655	781	781	100%	312	0.31	2.64	85	**80**
45019021	Keeahala	Fresh Catch	B-2	0.48	89.73	L	54.06"	1.15"	B	0.497	566	849	1846	100%	340	0.33	2.87	93	**75**
45023014	Kaneohe	WWCC PKNG 3	B-2	N/A	N/A	L	74.30"	1.23"	B	0.709	1001	1502	3007	50%	601	0.76	6.53	211	**75**
46030022	Keeahala	Hawaiian Designs	I-2	0.80	99.58	M	54.06"	1.15"	B	0.194	174	261	769	34%	104	0.1	0.88	28	**75**
46030035	Keeahala	Lex Brodies	I-2	0.45	99.96	M	54.06"	1.15"	B	0.136	174	261	539	48%	104	0.1	0.88	28	**75**
46030057	He'eia	Windward Center	B-2	0.67	97.10	M	54.06"	1.15"	B	0.063	392	250	250	100%	100	0.1	0.85	27	**75**
45017003	Keeahala	Kaneohe Medical BLDG	B-2	0.37	95.21	L	54.06"	1.15"	B	0.266	174	261	1055	25%	105	0.1	0.88	29	**70**
45023015	Kaneohe	WW Fam Guidance Center	AG-2	4.1	N/A	L	74.30"	1.23"	B	0.904	3702	3299	3299	100%	1320	1.66	14.34	463	**70**