SAFEGUARDING CORAL REEFS

with a Biorentention Area

Planning, installation and lessons learned from a Demonstration Project in West Maui:

Installing a bioretention area at the Department of Public Works (DPW)'s Lāhaina baseyard to treat vehicle washdown water

Designed and produced with support from:

CORAL REEF ALLIANCE

THE CAMPBELL FOUNDATION

Hawai'i Division of Aquatic Resources

Department of Land and Natural Resources, State of Hawaii

The Coral Reef Alliance (CORAL) is an international nonprofit that unites communities to save coral reefs. In Hawai'i, CORAL is working with local partners to improve water quality for reefs and people through its Clean Water for Reefs Initiative.

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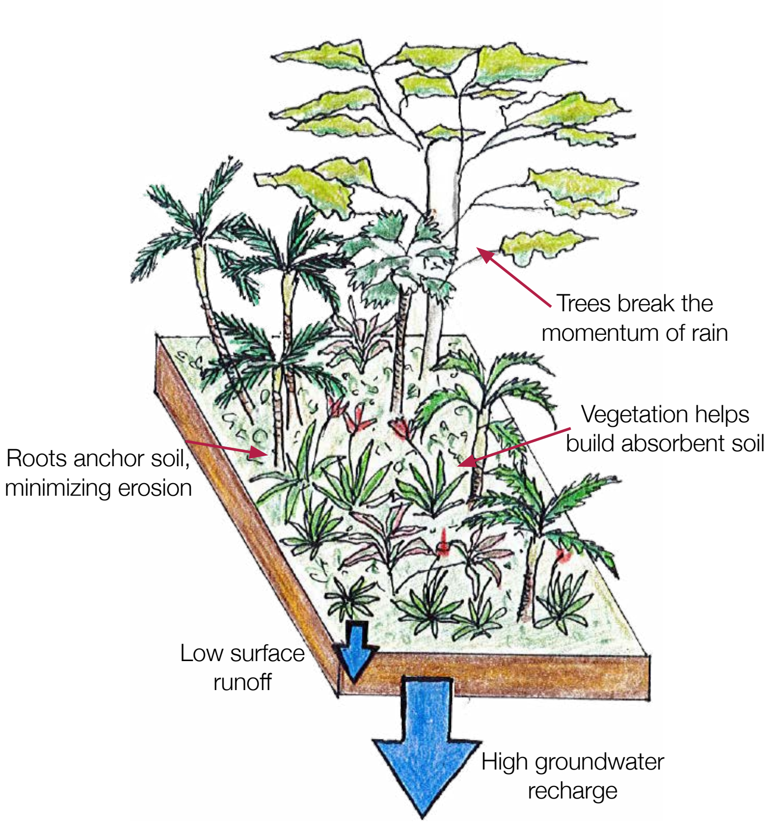
What is runoff and how does it affect coral reefs?

In an undisturbed natural landscape, trees and soil help soak up rainwater. However, in a developed or urban landscape, rainwater falls onto streets, parking lots, roofs, or other impervious (not absorbent) surfaces made of materials like concrete and asphalt. Instead of sinking into the ground or being stored in organic material, rainwater runs off the land, picking up harmful pollutants like nutrients, agrichemicals, heavy metals, and petroleum residues along the way. Eventually stormwater ends up in our oceans – either by traveling down storm drains, or by flowing into waterways like rivers and streams that lead to the ocean. When polluted stormwater flows into the nearshore environment, it poses a health threat to swimmers and causes significant harm to coral reefs and other marine life.

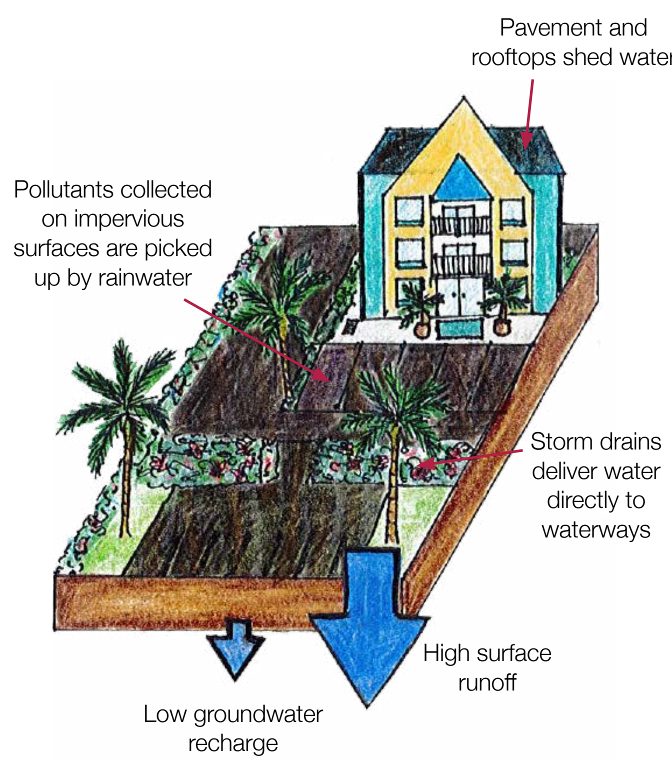
Natural Landscape

↑ percentage of **absorbent** surfaces



Developed or Urban Landscape

↑ percentage of **impervious** surfaces



Problem

When people hose down vehicles and heavy machinery, or when it rains heavily over exposed machinery, the water that drains off (runoff) contains pollutants like petrochemicals and nutrients (e.g. Nitrogen and Phosphorous). If this water goes down a storm drain, or gets diverted directly into a stream gulch, these pollutants end up flowing down waterways to the ocean. Most people don't realize that the storm drain system is separate from the sewage system, and that storm drain water in Hawaiʻi is not treated before being conveyed to the ocean. In agricultural areas, pollutants that get washed directly into stream gulches or streams also end up in the ocean. Even seemingly harmless activities like hosing leaves or dirt into the street, not picking up your pet's waste, or washing your car in your driveway – can lead to pollutants ending up in the ocean and harming coral reefs.

Solution

A **bioretention area** is an effective and affordable low impact design (LID) practice to prevent pollutants from reaching our streams and the ocean. LID practices seek to mimic natural processes that allow water to be slowed down, filtered, or sunk into the ground before reaching the ocean. A bioretention area is a landscaped depression or shallow vegetated basin with a mixed-media filter bed designed to collect, slow, and treat runoff through a series of physical and biological processes. When it rains or when people wash down machinery, the bioretention area fills up with a few inches of water. Sediment and other suspended particles then have time to settle out of the water, plants have time to take up and filter nutrients, and microbes are able to break down other pollutants. In this way, the bioretention area filters pollutants and sinks water safely into the ground instead of it running off into a water body or storm drain.

Demonstration Site

The Maui County Department of Public Works (DPW) Lāhaina Baseyard is where the County stores the area's heavy machinery and equipment to develop, operate and maintain the County's road, drainage and bridge systems. The Lāhaina baseyard is made up of about 40,000 square feet of impervious (not absorbent) surfaces like concrete or asphalt, and includes offices, storage facilities and parking areas. Directly adjacent to the baseyard is the Honokōwai Stream Gulch- a ravine-like valley that has been hardened and channelized by heavy rains. This stream gulch empties at the shoreline, about 2000 feet downstream.

The DPW has installed a series of on-site storm water Best Management Practices (BMPs) at their Lāhaina baseyard to reduce the amount of polluted water being discharged from their facility, such as a secondary containment for their emergency generator, a Contech CDS Hydrodynamic Separator Unit, multiple 55-gallon spill kits, and portable containment units for oil drums. Maintenance checks for these BMPs are conducted monthly.

While these BMPs meet all necessary state, federal and local requirements and while County staff diligently uphold good housekeeping techniques, prior to bioretention installation, polluted water containing petrochemicals and nutrients continued to run off the facility during heavy rain events or necessary machinery washdowns. First the polluted water would flow off the entirely concrete Lāhaina baseyard into a fallow vegetated area → then it would channeled through a cutout in the concrete wall running along the Gulch (pictured below) → then it would flow directly into the Honokōwai Gulch travel → finally it would empty into the ocean, threatening water quality within the protected Kahekili Herbivore Fisheries Management Area (KHFMA).


Prior to bioretention construction. Direction of runoff flowing from the DPW Lāhaina Baseyard, into the bioretention area and through the cutout in Honokōwai Gulch wall.

Demonstration Project cont.

Maui County and conservation experts believe this polluted water has been contributing to poor water quality findings at Kāʻanapali Shores (located 70 yards south of the Honokōwai Gulch outlet into the ocean). Hui O Ka Wai Ola, a citizen science network that collects quality assured shoreline water quality data at specific sites throughout West and South Maui maintains a site close to the mouth of Honokōwai Stream. The three-year long dataset indicates that the geometric mean for turbidity exceeds the HDOH limits. The full dataset can be found at www.huiokawaiola.com.

Objectives

1. Collaborate with DPW managers to develop an LID practice plan for this site
2. Create a bioretention area showcasing a practical and effective example of LID in an urban setting.
3. Filter stormwater and washdown water into the ground, instead of allowing it to flow into the nearby Honokōwai Stream Gulch, which drains directly to the ocean.
4. Demonstrate how a simple LID project can be constructed using locally accessible and affordable materials.
5. Support Maui County in building its capacity to incorporate LID into stormwater management practices.
6. Provide LID training resources for Maui County developers, engineers, architects, facility managers, and staff.
7. Inspire construction of more bioretention areas island-wide.

Path of runoff flow from the DPW Lāhaina baseyard facility, through the Honokōwai Gulch and into the ocean.

Demonstration Project (cont'd)

Choosing the most effective LID Practice

There are several types of LID designs that can be chosen based off of land use, treatment objectives, and specific site characteristics. To select an appropriate LID practice for the site we consulted information provided in (a) NOAA's Storm Water Management in Pacific and Caribbean Islands: a Practitioner's Guide to Implementing LID; (b) Hui o Koʻolaupoko's Hawaiʻi Residential Rain Garden Manual; and (c) the Coral Reef Alliance (CORAL) Stormwater Treatment the Natural Way: Low Impact Design & Development Guide (see Additional Resources). The following steps will ensure that you choose the most effective LID practice for your site.

Step 1: Understand the environmental characteristics of your site

(a) Determine the Contributing Drainage Area (CDA)

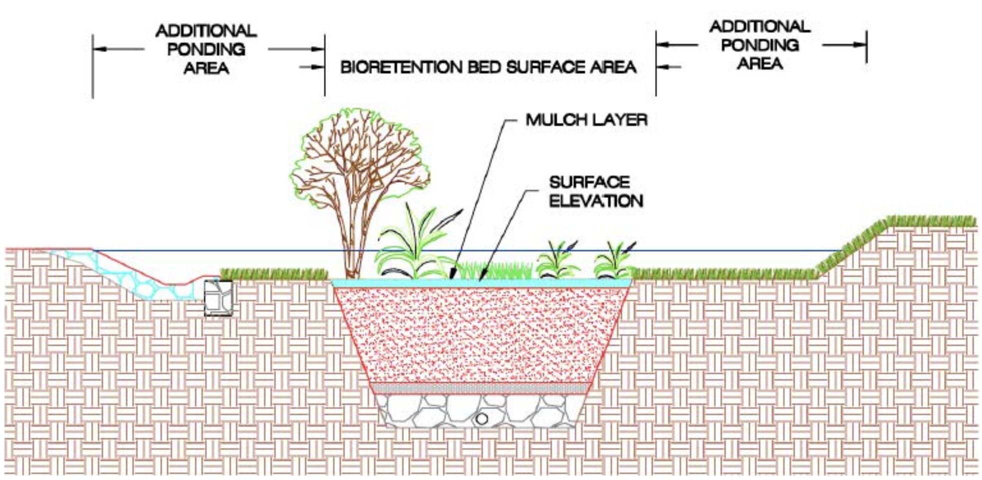
Contributing drainage area (CDA) refers to the area of impervious surfaces that contribute polluted water and/or stormwater to your project location. LID practices are designed to capture this predetermined volume of water. We measured the CDA using Google Earth and on-site measurements and found it to be about 40,000 square feet.

(b) Determine rainfall data according to performance standards

The performance standards required for your LID practice dictate the type of rainfall data needed. Since we were primarily concerned with water quality treatment and polluted runoff reduction, we needed to know the rainfall depth for the 90th or 95th percentile storm events. A 2012 analysis of the Lāhaina rain gauge by Dr. Neil Berg found that the majority of storm events in the area are relatively small; 90% of all storms rain 1.54 inches or less. This is valuable information to account for when determining the size of your LID practice. For updated site-specific rain gauge data, visit the website for NOAA Atlas 14 Point Precipitation Frequency Estimates.

(c) Determine the soil drainage characteristics

The rate at which water drains through the soil will determine whether or not your proposed location is a good candidate for LID. For example, compacted clay soils do not allow infiltration and are, therefore, not suitable for LID practices. Soil drainage characteristics will also help determine the overall LID size needed to effectively infiltrate water from your CDA. To test the infiltration rate, we used a shovel to dig a 12" deep hole in the center of our proposed LID project area. In triplicate, we filled the hole with water and allowed to drain. To mimic saturated soil conditions after heavy rains, we recorded the time it took to drain after the third filling and divided the distance the water dropped over the time it took to drop/drain. We were looking for a rate of 0.5 inches per hour or more, which is the minimum standard for a good LID location. The infiltration rate at our proposed LID location was good, at 4.5 inches per hour.



(NOAA, 2014)

Step 2: Consider the socio-political landscape of your site

We knew that at the Lāhaina baseyard, we had the support of DPW staff and their willingness to help with project installation. The area was also very accessible. Although the land proposed for creating the LID is not owned by DPW, we were able to obtain an Occupancy & Use of State Highway Right-of-Way Permit for Landscaping through the Highways Division of the Hawaiʻi Department of Transportation, and were granted Right of Entry from the private landowner.

Step 3: Select the most appropriate LID Practice

We ultimately identified an Infiltration Bioretention design (hereafter referred to as a bioretention area) as the most appropriate LID practice for the following reasons:

1. It had the greatest potential to mitigate DPW's polluted runoff.

2. It did not require any physical changes to the baseyard's operational footprint, especially as the fallow vegetated area was already receiving runoff.

3. The CDA and rainfall data showed us that a Rain Garden LID was insufficient for our treatment needs. The depth and soil amendments typical for a Rain Garden does not provide enough retention time for microbial activity or settling potential.

4. The infiltration rate was suitable enough to not require an underdrain, which is a component of Filter Design Bioretention LIDs. The overall cost and long-term maintenance of a LID practice can be minimized if engineered parts are not required for project success.

5. The depth to groundwater was great enough to provide a low risk of groundwater contamination.

6. All materials could be locally sourced and relatively low-cost.

7. It would be low-maintenance

8. It would add a beautiful landscape feature to the land.

Construction of the Bioretention Area

Step 1: Choose the exact location for the bioretention area

Successful bioretention areas should be near the runoff source(s), well-drained, and not too steep. We positioned our LID about 30 feet away from the Lāhaina baseyard, between the baseyard and the Honokōwai Gulch.

Step 2: Calculate the right size for your bioretention area

The right size for a bioretention depends upon three factors: the CDA, the infiltration rate, and the rainfall data plus other sources of water (e.g. vehicle washdowns). Using the sizing chart and formula from the Hui o Koʻolaupoko's Hawaiʻi Residential Rain Garden Manual, an infiltration rate of 4.5 inches per hour and a CDA of 40,000 square feet equates to a bioretention size of approximately 1800 square feet. However, this calculation assumes a maximum depth of 1 foot. To account for heavier storm events, machinery and vehicle washdown water, and the growing intensity and frequency of storms due to climate change, we decided to allow for extra retention capacity and determined a total volume of about 2075 cubic feet was effective.

Demonstration Project (cont'd)

Step 3: Design the shape and slope of the bioretention area

The bioretention is broken into three chambers to increase water retention time: 1) inlet channel 2) main retention basin 3) overflow outlet channel. Using the base of the Honokōwai Gulch cutout as "zero", the inlet channel and overflow outlet channel were excavated to depth of about 1 foot and the main retention basin was excavated to a depth of about 2 feet. The reason for different channel depths is so that water entering the inlet channel and is slowly guided to the deeper basin area that has increased volume capacity and retention time. If there is a heavier rain event, water can then overflow the basin area into the outlet channel where it can only access the Honokōwai Gulch cutout during significantly heavy rain events.

Step 4: Clear and excavate the area

DPW staff cleared the overgrown weeds of the fallow area and excavated the bioretention to design specifications using their excavating machinery. After machinery excavation was complete, we used tools to 'fluff up' the soil to improve percolation and manually refine the slope of each chamber and overall length of the bioretention.

DPW staff excavating the bioretention area.

Step 5: Backfill the excavated area

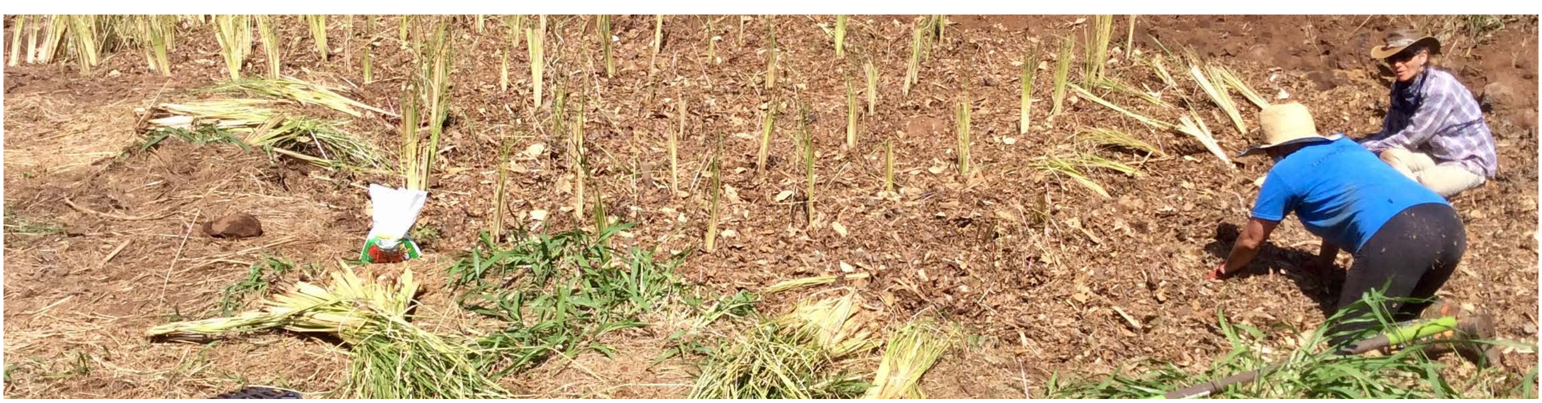
Although backfilling the excavated area could have been accomplished using manual labor, DPW staff expedited this process by using their machinery to help us backfill and spread the materials. To maximize nutrient uptake, water storage and microbial activity to filter pollutants, we backfilled the excavated area with a semi-layered mix of wood chip mulch, soil from excavation, and kiawe wood biochar. Biochar is charcoal from plant material that has gone through a pyrolysis (burning) process in the absence of Oxygen. Biochar improves soil quality by retaining nutrients such as Carbon, Phosphorous and Nitrogen, and can retain heavy metals and other contaminants. It also increases water retention and cation exchange capacity (CEC), with results in soil fertility and microbiota. Biochar made up about 5% of our backfill. The final backfilling step was to cover the soil mixture with a six-inch layer of wood chip mulch to help retain moisture in the soil and subdue weed growth.

Mechanically sand manually spreading backfill materials.

Step 6: Plant locally-appropriate plants

Plants for a bioretention area should be chosen based their moisture tolerance, ability to uptake nutrients, ability to handle contaminants, and on the site's light availability and soil characteristics. Beyond that, plant species can be chosen to match the existing landscape aesthetic. This demonstration site is out of the public eye and, therefore, functionality and low-maintenance were prioritized over aesthetics. We augmented the nutrient capture ability of the bioretention by planting sterile vetiver grass (Chrysopogon zizanioides). Vetiver has been approved by the United States Department of Agriculture (USDA) for use in Hawaiʻi. Although non-native, it is sterile (cannot propagate on its own) and has several advantages, such as being able to tolerate wet and dry conditions and being able to absorb significant amounts of nutrients through its extensive root system.

We planted vetiver grass in rows running perpendicular to the flow of runoff as it moves through the bioretention area. In most places throughout the bioretention area, plants were spaced about one foot apart, with closer spacing closer in the outlet channel. Leaving space between plants reduces the likelihood of debris or sediment building up and, therefore, decreases long-term maintenance requirements. After planting, an irrigation system and watering schedule was set up to ensure vetiver plants were watered at least twice per week while becoming established over the first two months.



Planting vetiver grass amongst top mulch layer.

Step 7 (Ongoing): Conduct general maintenance of the bioretention area

Little maintenance is required over time, but generally includes:

-Replacement of dead vetiver plants

-Watering twice per week for the first two months and then occasionally during the dry season

-Weed control

-Potential need for removal of debris buildup after heavy storm events

Completed bioretention.

Project Costs

Item	Cost (approx.)
Vetiver grass (*Chrysopogon zizanioides*)	$2.50 /plant
Biochar	$500 /yd³
Wood Chips	$20-35 / yd³
Soil	$0 (from excavation)
100' hose	$45
75' hose	$40
Irrigation supplies	$88
River Rocks	$270 /ton
Total Materials cost	**~$2100**

Results

-This bioretention area safely absorbs and filters the polluted water from heavy rains and daily machinery washdowns, thereby preventing it from running unfiltered into streams and the ocean

-The demonstration project has contributed to Maui County's goal to incorporate LID into stormwater management practices.

-Generated awareness and provided LID training for Maui County developers, engineers, architects, facility managers, and staff through their participation in the project.

Thank you

Mahalo to those that helped make this project a success, including

-John Smith, Eugene ("Mike") Tihada, and the Lāhaina baseyard staff of Maui County Department of Public Works

-Department of Transportation, Highways Division

-Kāʻanapali Land Management Corporation

-Tova Callender, West Maui Ridge to Reef Initiative

-John Astilla, Sunshine Vetiver Solutions

-Paul Sturm and Phal Mantha, Ridge to Reefs

-Kihei Compost, LLC

-Ruel Ibuos, HC&D LLC

-Charley Dofa, Napili Community Garden

THANK YOU!

Additional Resources

Learn more about ways to reduce water pollution in Hawai‘i’s marine environment at coral.org/maui

Learn more about low impact design (LID) at coral.org/LID

To visit the demonstration site, or to learn more about this LID practice, contact maui@coral.org

Sources

Hui o Ko‘olaupoko (2012). Hawai‘i Residential Rain Garden Manual, Available here: http://www.huihawaii.org/resources.html

NOAA Coral Reef Conservation Program (2014). Storm Water Management in Pacific and Caribbean Islands: a Practitioner’s Guide to Implementing LID. Prepared by: Horsley Witten Group, Inc. and Center for Watershed Protection, Inc.

Photos by CORAL Staff

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