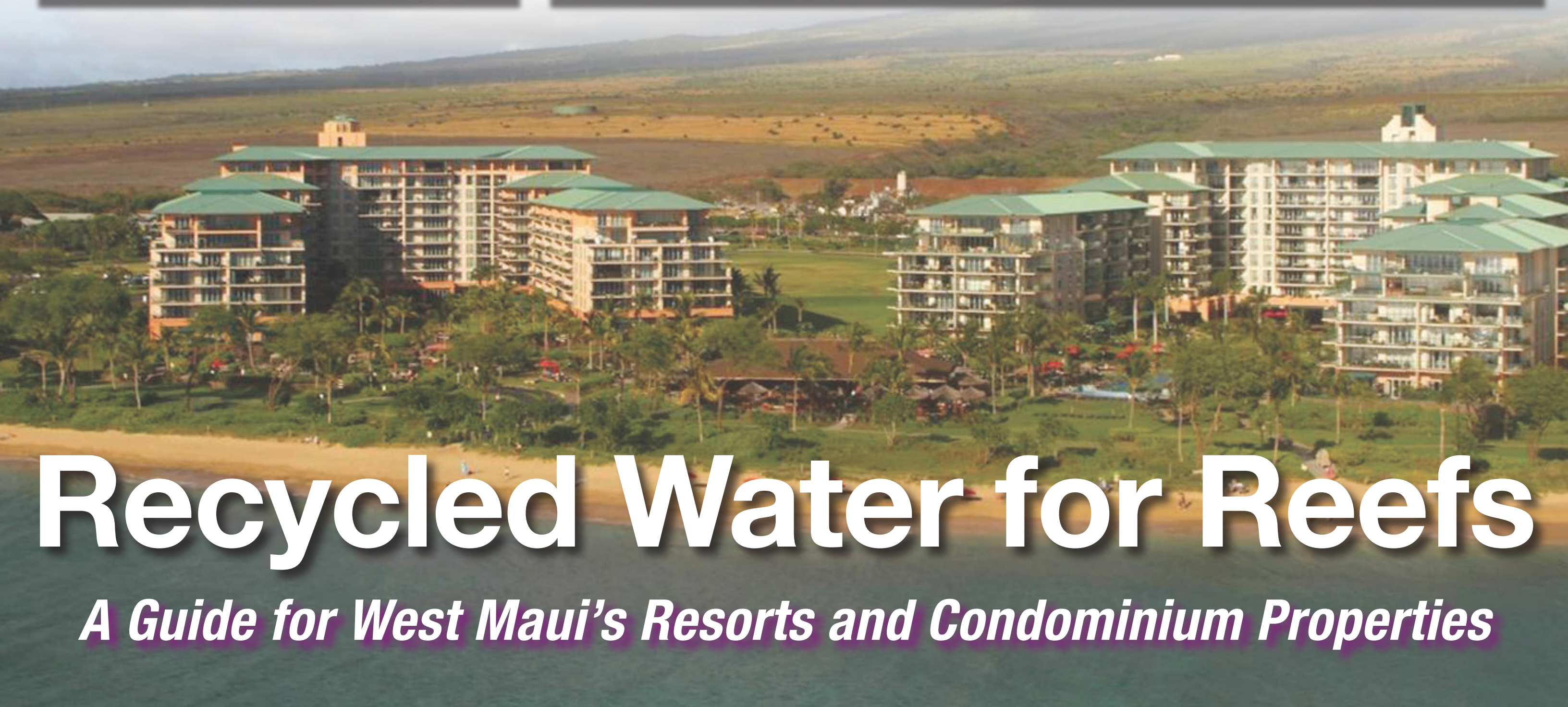

Recycled Water for Reefs

A Guide for West Maui's Resorts and Condominium Properties

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This photo (and top left photo on cover) by Jim Petruzzi

About this Guide

This resource guide was developed by the Coral Reef Alliance (CORAL) to assist West Maui’s resort and condominium properties in transitioning to recycled water for irrigation.

CORAL would especially like to thank Steve Parabicoli and Scott Rollins, both with the County of Maui, for their assistance and technical expertise, not only in the development of this resource, but throughout all of CORAL’s work.

This project would not have been possible without the support of Lance Gilliland of the Honua Kai Condominium Association, Inc., and CORAL extends our gratitude and appreciation. Stephen Crowell of SGS Hawai‘i also deserves special recognition for the technical consultation he and his team provided based on their experience with recycled water in managing the Honua Kai’s irrigation and landscaping.

CORAL would also like to acknowledge all the support and guidance we received from the West Maui Ridge to Reef (R2R) Initiative during the course of this project, particularly from Coordinator Tova Callender and the members of the R2R working group.

The West Maui Resort and Condominium Water Use Survey was developed and its outcomes analyzed and presented by Robin Knox, Water Quality Consulting, Inc. Survey administration support was provided by Liz Bogdanski. CORAL extends its appreciation to the property managers who participated in the survey and graciously provided us with the time and attention it required. We also appreciate the support of Wayne Hedani of the Kā‘anapali Operations Association.

Funding support was provided by the Harold K. L. Castle Foundation, the National Fish and Wildlife Foundation, and NOAA’s Coral Reef Conservation Program.

This is the second edition of this resource guide; revisions and updates may be completed at a future time, and this guide should be considered a “living document.” The most current version, along with supporting resources, can be found on CORAL’s website, at www.coral.org/hawaiiwater.

Please feel free to provide any feedback or content suggestions, as well as proposed edits or corrections, to info@coral.org.

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Photos: All by CORAL staff unless otherwise indicated

CORAL REEF ALLIANCE

Section I: Background

Overview

Water Quality and Maui's Coral Reefs

The coral reefs found within the Hawaiian Islands account for over 80 percent of the reefs under United States jurisdiction. Coral reefs are extremely valuable to Hawaiʻi: they are significant culturally, ecologically, and socially, providing food, shoreline protection, and major economic benefits from recreation and tourism. An economic study conducted in 2002 estimated the value of coral reefs at $10 billion, with direct economic benefits of $360 million per year (Cesar and van Beukering, 2004).

However, reefs worldwide and in Hawaiʻi face a suite of threats that includes impacts from global climate change, unsustainable and destructive fishing, invasive species, coastal development, land- and marine-based pollution, and other direct human impacts such as unsustainable marine recreation activities.

A healthy reef inside the KHFMA, Kahekili Beach Park.

A recent publication by the World Resources Institute, Reefs at Risk Revisited, presented the results of a global analysis of reef threats, which found that the majority (60 percent) of the world's reefs are threatened by human activities, and that coastal development and watershed-based pollution threaten a quarter of all reefs (Burke at al., 2011).

Maui's reefs have been studied for decades. Over a 13-year timespan, a quarter of West Maui's reefs were lost, primarily due to human-related causes; the Kahekili reef within the region of North Kāʻanapali lost 40 percent of its living coral cover between 1999 and 2006 (Walsh et al. 2010). As a response to this degradation, the Kāʻanapali-Kahekili region (Wahikuli and Honokowai watersheds) was designated as a state priority for coral reef restoration in 2010. In 2011, the area was designated as a federal priority by the US Coral Reef Task Force. In addition, the Kahekili Herbivore Fisheries Management Area (KHFMA) was established in 2009 to protect herbivore populations in a first-of-its-kind management strategy (see pg. 6).

While many people intrinsically understand the value of Hawaiʻi's reefs, an increasing number of residents and visitors are becoming aware of the threats reefs face, and are able to recognize signs of local reef decline. As visitor numbers continue to increase, and as Hawaiʻi is increasingly promoted as a world-class destination, it becomes all the more important that the visitor industry take steps to recognize its role in promoting and implementing sustainable solutions to local reef threats.

On Maui, reefs face threats including unsustainable fishing, poorly-planned coastal development, and land-based runoff, which can send sediments, hydrocarbons, pesticides, other chemicals, and excess nutrients into the nearshore marine environment. No single factor is solely to blame for reef decline in any particular area, but rather most threats are interconnected and have the ability to exacerbate one another. However, in West Maui, some factors appear to have a greater relative contribution to reef decline than others, such as nutrient pollution from wastewater that has been injected into wells and eventually seeps onto the reef. By using recycled wastewater and taking measures to conserve water in general, Hawai'i's resort and condominium properties can help address water quality issues and improve the health of Hawai'i's reefs. This resource guide provides technical support and practical tips to help you use recycled water; it focuses on the specific issues related to transitioning to recycled (R1) water. Several West Maui properties will have access to Maui County R1 water within the next few years, and others once new infrastructure is funded and constructed in West Maui.

You will also find economic information gathered through a water use survey of 11 hotels as well as background about nutrient pollution, coral reef ecology, and lessons learned to date about using R1 water.

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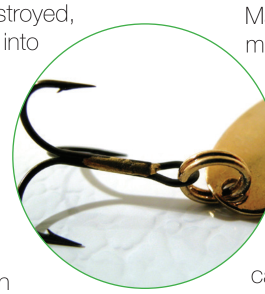
CORAL developed this guide as a part of the larger multi-agency West Maui Ridge to Reef Initiative. The West Maui Ridge to Reef (R2R) Initiative is an all-encompassing approach across multiple agencies and organizations to address adverse impacts to coral reefs in West Maui. The State has recognized that an integrated and comprehensive approach to reducing land-based sources of pollution is one of the most important steps to help restore coral reef ecosystems. The R2R Initiative builds on already established efforts that are underway and leverages resources across a number of agencies and community groups to implement actions to reduce one of the key sources of reef decline—land-based sources of pollution. www.WestMauiR2R.com

WEST MAUI Ridge 2 Reef INITIATIVE

What is a Coral Reef?

Coral reefs are ecosystems that rival tropical rainforests in diversity. They grow over thousands of years, as individual animals—coral polyps—slowly deposit layers of calcium carbonate to form a skeleton. The polyps live in colonies, and obtain the energy they need to build reefs by consuming small floating organisms and photosynthesizing. Over time, they create an elaborate three-dimensional habitat that is key to the functioning of the whole ecosystem. Corals provide food and shelter for hundreds of species of fish and invertebrates along Maui's west coast, enabling amazing biodiversity and astounding scenery. The beneficial products and processes that coral reefs provide, known as their "ecosystem services," are numerous: fishing grounds, gathering areas, habitat for important species, coastline protection, potential medicinal compounds, and, of course, tourism opportunities.

Although coral reefs are ancient, extensive, and vibrant, they are fragile ecosystems that can only exist under very specific conditions. Corals require crystal clear water that transmits sunlight so the algae housed within their tissues can photosynthesize and feed the colony. If the water contains suspended sediment, making it cloudy enough to block the sunlight, the corals will not be able to produce enough energy to build their skeletons. When reef building stops, burrowing invertebrates, coral-eating fish, and storm damage can then erode the reef. When corals cannot regrow the material lost to these forces, they are eventually destroyed, and reefs break down into lifeless rubble.

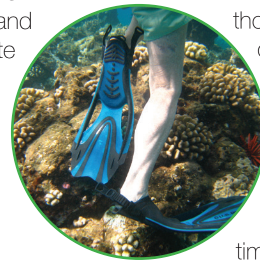


Other Threats to Reefs

Unsustainable Fishing

Growing human populations that rely on fisheries for food and income have a short-term incentive to remove more fish than is sustainable in the long-term. Overharvesting of herbivorous fishes and urchins, which eat fast-growing algae that can outcompete and kill corals, is especially problematic.

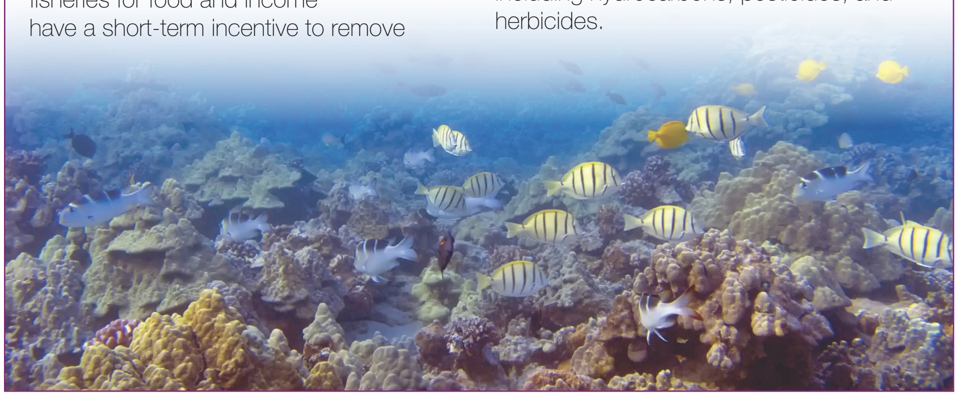
Direct Impacts from Marine Tourism



Hawai'i's tourism industry brings thousands of people into contact with its reefs. Uninformed and unsupervised divers who touch or accidentally trample living corals have a cumulative and significant impact over time, especially when concentrated in small areas, such as with resorts' marine recreation operations. In addition, marine tour operators may cause anchor damage with careless practices, destroying coral that will take decades to centuries to recover.

Sedimentation

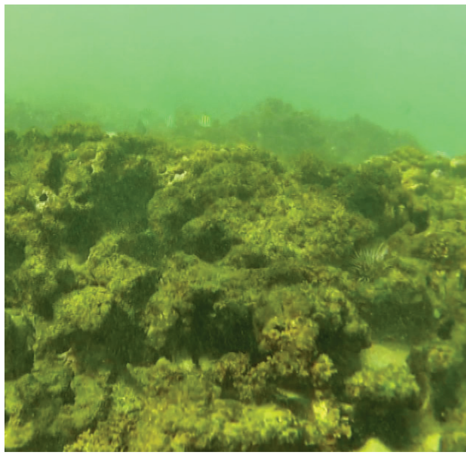
Many human activities produce sediment that eventually makes its way into the coastal zone: for example, deforestation, construction, road-building, and improper agriculture and landscaping practices. Sedimentation, along with nutrient input, is a key contributor to land-based pollution affecting West Maui's reefs. Sediments not only create murky and aesthetically undesirable coastal waters, which hinder marine recreation and negatively affect visitor experience, but also disrupt photosynthesis and reduce the corals' ability to obtain food. Sediments also can settle on and smother the corals. Finally, sedimentation is problematic because of chemicals and toxins carried with the particles, including hydrocarbons, pesticides, and herbicides.



Water Quality and Degraded Reefs

Implications for Hawai'i's Tourism Industry

Hawai'i tourism is absolutely dependent on the state of Hawai'i's natural environment. While we can see beaches eroding, and respond with resources to restore them, the degradation of our coral reefs and coastal water quality is not always as apparent. Yet healthy reefs and clean water are arguably as much of a draw for visitors as expansive sandy beaches. Healthy and intact reefs support healthy communities, protect beaches, and help perpetuate cultural practices.



Degraded reef

Healthy reef

Long-term monitoring by state and federal agencies demonstrating significant reef declines, coupled with the number of sites in West Maui that consistently fail to meet state water quality standards and that are deemed "impaired," is a call to engage in solutions.

If West Maui's reefs continue upon their current trajectory of decline, Maui's reputation as a "brand" is at risk, along with the ability to market the West Maui region to the increasing numbers of visitors who seek sustainable travel opportunities.

Fortunately, an increasing amount of research suggests that reefs can recover, particularly those in areas with effective management where local stressors are sufficiently reduced. A recent study examining historical data uncovered examples from Hawaiian pre-history of reef recovery following over-exploitation of resources. The recovery was attributed to improved and effective resource protection measures (Kittinger et al. 2011). Then, as now, resource condition depended on our ability to manage our collective impact.

The KHFMA: A Case Study in Effective Management

In 2009, in response to the increasing amounts of algae documented on the reefs in the North Kā'anapali area, coupled with a marked decline in living coral cover, the Hawai'i Department of Land and Natural Resources' Division of Aquatic Resources established the Kahekili Herbivore Fisheries Management Area (KHFMA), a first-of-its-kind type of protected area. In this relatively small area extending from just south of Pu'u Keka'a (Black Rock) north to Honokowai Park, key herbivorous marine life (surgeonfishes, parrotfishes, rudderfishes, and sea urchins) are protected from harvest; and recreational feeding of fish is also prohibited. The theory behind the KHFMA is that by allowing grazing herbivores to rebound, they can perform their "ecosystem services" and help reduce the algae growing on the reef. The grazing benefits of algae-eating species like these have been documented, and are increasingly important as non-native or invasive algae further threaten the reef (Williams et al 2006). While resource managers are confident that this unique strategy will help restore the reef's health, and in the four years since the site's establishment signs of recovery are starting to be detected, they also recognize that protecting herbivores alone will not be sufficient to save the reefs found within the KHFMA. Watershed conservation efforts, as seen with the West Maui Ridge to Reef Initiative, are necessary to address threats on a scale from mauka to makai.

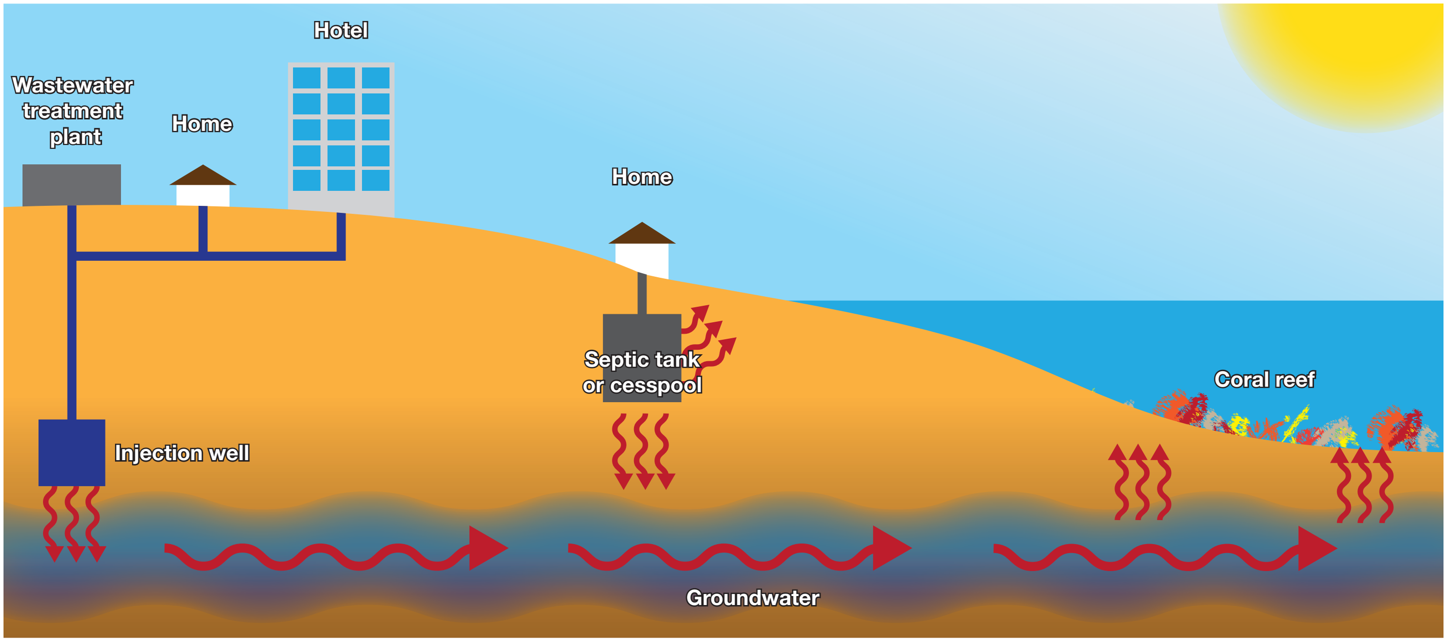


Fig. 1: Wastewater from hotels and homes is treated at the Lahaina plant then fed by gravity into wells. From there it can make its way to the reef. Untreated wastewater from septic tanks and cesspools can also seep onto the reef. Not to scale.

Fresh Water and Nutrient Impacts on Hawai'i's Reefs

Nutrients such as nitrogen and phosphorous from a variety of land-based sources have multiple ways of reaching the nearshore marine environment; when excessive, they can harm coral reefs. Since corals grow slowly, they cannot compete with algae (seaweed, or *limu*) that can more efficiently absorb nutrients and grow rapidly. Coral reefs are adapted to environments with very low nutrient levels and thrive under those conditions. When nutrient levels are too high, algae can grow quickly, overgrow the living coral, and sometimes form periodic "blooms." Turf algae can also outcompete and overgrow the reef, killing coral. Turf algae is not one particular type of algae but rather a multi-species assemblage of small algae that forms a fuzzy looking mat over the reef. Recent and ongoing research has indicated that turf algae play a significant role in chronic, or ongoing, reef degradation (Ross et al. 2012).

When a reef is subjected to ongoing or chronic nutrient inputs over time, it will degrade from a healthy system dominated by living coral to an algal-dominated system, with a decrease in biodiversity and marine life. This is known as a "phase shift." One example is Maʻalaea Bay.

Considerable state and federal resources (along with private foundation support) are being devoted to studying and restoring the reefs off the Kāʻanapali coast with the goal of preventing this phase shift from happening like it did at Maʻalaea Bay in Central Maui.

Maui

On Maui, treated—but nutrient-rich—wastewater is disposed of in gravity-fed injection wells, from which it has been found to emerge as early as 84 days later through nearshore submarine springs (also known as seeps), among the coral reefs (Glenn et al., 2013; see Appendix 1).

"Nuisance" algal blooms in West Maui (concentrated in the Kāʻanapali region) began to be observed and documented in the 1980s, and were observed periodically again in subsequent years. These observations and concerns about the frequency and extent of the blooms triggered significant federal and state funding to support research into the problem, in order to begin describing the issue and identifying causes and solutions (West Maui Watershed Management Advisory Committee 1997, Smith et al. 2005, see also Appendix 1).

It had long been suspected that a major contributing factor to West Maui's nuisance algal blooms and reef degradation was the millions of gallons of treated wastewater effluent that the Lahaina Wastewater Reclamation Facility disposed of into injection wells on a daily basis. Early efforts to detect the exact location of wastewater effluent emerging along the coastline were unsuccessful, but as researchers refined their approaches and utilized more sophisticated technologies, an increasing number of studies began to provide more thorough and compelling evidence that wastewater effluent

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Fresh Water and Nutrient Impacts on Hawai'i's Reefs ....

from the Lahaina treatment facility was reaching the nearshore reefs in Kāʻanapali. See Appendix 1.

Since the late 1990s, the County has used Biological Nutrient Removal (microbes) to reduce nutrients in its effluent. Although those efforts have reduced total nitrogen and phosphorus to far lower levels than those in most treated wastewater, the effluent being injected is still rich in nutrients and of sufficient volume to cause continued concern about its effects on reefs.

Over the past decade, as more attention has been given to wastewater pollution from injection wells, scientists, local resource managers, wastewater operators, and a growing number of community groups and individuals have been making efforts to raise awareness and promote a solution: reuse more wastewater. By recycling wastewater, your property can play a significant role in transitioning towards more responsible and sustainable use of our water resources.

Since hotels are major consumers of potable water—needed to support thousands of visitors to West Maui each year—they also produce a large amount of wastewater, which is sent to the Lahaina Wastewater Reclamation Facility and treated. Much of this wastewater ends up being disposed of in injection wells at the facility, and as we now know, ultimately makes its way onto the reef that fronts several resorts' properties. This nutrient-rich wastewater then continues south down the Kāʻanapali coastline. Hotels and condominium properties in West Maui, with their extensive grounds, are ideal clients for reusing recycled water, since they have the potential to use large quantities for landscape irrigation. Such use can prevent thousands of gallons of treated wastewater from being disposed of in injection wells.

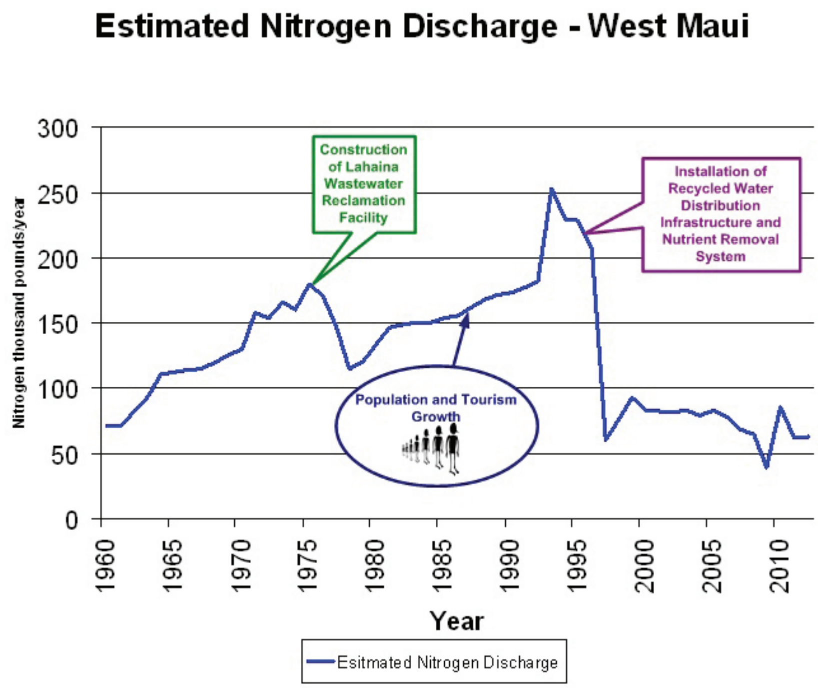

Fig. 2 The County of Maui has improved wastewater treatment and lowered the total nitrogen load over time. These nitrogen loads are further reduced as the effluent travels through the ground. However, almost all of the remaining nitrogen is in the form most available to plants. When this nutrient-rich fresh water is gravity-fed into wells, it can threaten the health of coral reefs. If used for irrigation instead, it can fertilize landscape plants. Graph from County of Maui.

Guidance from the Division of Aquatic Resources

"From a resource management perspective, we need to address as many of the stressors to our reefs as we can. So the protection of grazing fishes and urchins in place through the Kahekili Herbivore Fisheries Management Area (KHFMA) will help, but we need to reduce the nutrient pollution from the injection wells as well as all the other non-point sources. We also need to address the sedimentation from fallow upland fields, and be aware of the legacy pollutants from the past century of sugar cane and pineapple farming.

Other than the obvious concerns with nutrients, we need to be aware of the impact that 3-5 million gallons a day of treated wastewater with its freshwater composition may have on a reef that evolved in the absence of that water. The chemical changes to the salinity and perhaps even localized acidification that this water may cause could be a major stressor to the reefs in the area. With this in mind, we can't simply reduce the nutrients in the water and be assured it will help, but we need to work to reduce the volume of injected water."

—**Russell Sparks**, Division of Aquatic Resources Aquatic Biologist

Section II: Benefits of Recycled Water

Reclaimed Water is Good for Business and the Environment

Economic

The benefits to the accommodations sector of reusing wastewater are many. In addition to direct economic and environmental benefits, the indirect effect of promoting greater water security for Maui has widespread implications for society and the local community.

Because recycled water costs less than potable water and is exempt from sewer fees, resorts will save money in the long-term once they gain access to it and recoup the costs incurred in making the transition.

In addition, since recycled water contains more nutrients than potable water, the need for fertilizer is expected to decrease. The Honua Kai Condominium Association's seaside grasses thrive on the saltier recycled water, reducing the need for—and costs of—fertilizer.

Environmental

Diverting hundreds of thousands of gallons of wastewater that are now sent into injection wells every day will benefit reef health and water quality, including places where people swim and snorkel. By using recycled water instead of potable water to irrigate landscapes, more water will remain in the aquifer to support West Maui's current and future water supply needs. As with many islands and even mainland areas, Maui has a limited potable water supply. Current high consumption rates are depleting clean water resources that took millennia to form. The threat of drought conditions is already a concern in West Maui, with water challenges ranking "moderate to severe" according to the U.S. Drought Monitor.

"Irrigating this way is the right thing to do for our reefs, community, and, business. Without the reef, there is no business."

— **Lance Gilliland**, Honua Kai Condominium Association Inc.

Results of Our Water-Use Survey

In order to assist with large-scale watershed management efforts and prepare West Maui's accommodations community for planned increases in reclaimed water supply, CORAL conducted a "readiness" and water use survey with the assistance of Water Quality Consulting, Inc. The survey focused on water usage patterns (cost, volume, source and purpose), best management practices to conserve water and reduce pollution, and assessing properties' needs and readiness to make the transition from potable to R1 water for their landscaping and irrigation systems. The results of the survey highlight a general lack of knowledge about the permitting and infrastructure requirements necessary to access and utilize R1 water. They also highlight opportunities for increasing water reuse and improving potable water conservation.

Several key findings are noteworthy, primarily those concerned with properties' readiness for the transition to recycled water, as well as the emergence of a useful metric, the Effective Water Resource Rate (EWRR). Excluding the properties that are already using R1, the majority of respondents reported being "not ready at all," or only "moderately ready" to access and use R1 water. Additionally, several properties indicated they were not engaged in broader watershed management activities. This indicates a need for further and ongoing education and facilitation regarding the permitting process, infrastructure retrofitting requirements, and landscaping and irrigation requirements and best practices.

We surveyed 22 properties along the Kāʻanapali coast with half responding fully. Based on this sample, the annual total 2012 usage for the properties that responded exceeded 472.78 million gallons (Table 1). R1 water use totaled 84.2 million gallons, or 29 percent of the total annual volume of publicly sourced water used.

2012 Water Usage

Table 1: Annual volume (millions of gallons per year) of water used in 2012 by 11 hotel or condominium properties.

Water Source	2012 Annual Volume (millions of gallons per year)
Public potable water	202.98
Private potable	185.60
Public recycled water (R1)	84.20
Total for all sources	**472.78**

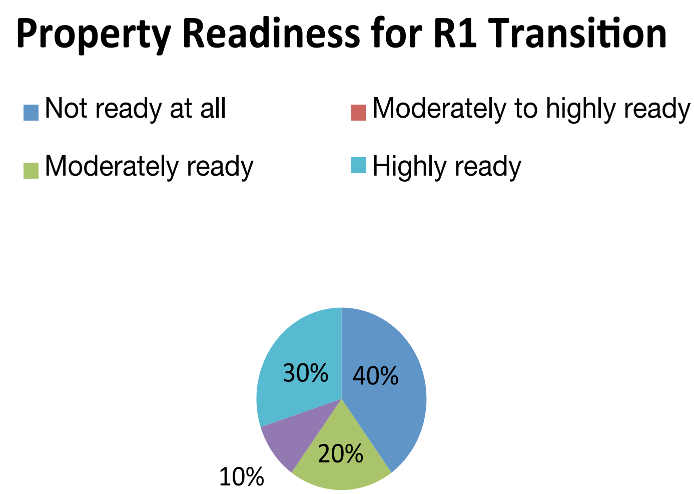

Fig. 3

The current levels of potable water use from both public and private water supply, indicate that replacing potable water with recycled wastewater will significantly reduce overall water costs by replacing higher-priced potable water with lower-priced R1 water. For properties using public potable water, this switch will also reduce overall costs by reducing associated sewer disposal (wastewater) fees, which are based largely on potable water consumption.

Water rates vary considerably based on factors such as property use (commercial versus residential), size, and volume of water used. Because the fees and rate structure vary, we derived an Effective Water Resource Rate (EWRR), which is the total water resources cost (including sewage disposal fees) divided by the total water volume consumed by a property from all sources. The EWRR more closely reflect the "true" cost of water. Based on this calculation, water costs ranged from just under \$5/1000 gallons to almost \$25/1000 gallons.

Presently R1 water is used only for landscaping and only on three of the properties in the region (including two resorts and the Kāʻanapali Golf Course). In looking at the water usage patterns (see Table 1), it is apparent that significant opportunity exists within the accommodations sector to conserve drinking water resources by replacing potable water supply with reclaimed wastewater

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Results of Our Water-Use Survey

for approved uses beyond landscaping and irrigation. Those include toilet flushing, commercial laundry, cleaning, HVAC cooling systems, water features, fire protection and other non-potable uses. A two-pronged strategy of replacing potable water with R1 water, while identifying and implementing general water conservation strategies, will result in a reduced EWRR and therefore significant cost savings to West Maui properties.

Forty percent of hotel and condominium properties surveyed indicated they were not ready to shift towards using reclaimed water. They indicated they were not aware of permitting requirements and had not investigated infrastructure improvement requirements. These properties were also unable to respond to our questions about pollution and runoff on their properties. Figure 3, on page 11 indicates the readiness of hotels and condominium properties to shift to R1 water.

This survey represents a fraction of the Option 1 and 2 properties within the expansion plans for public reclaimed water. These results suggest additional work is needed to ready the accommodations sector and shift their water use practices towards increased use of R1 water.

Water rates for publicly sourced water in Maui vary by volume consumed, so the more potable water used the more expensive it becomes. Similarly, the sewage disposal fee is based on the volume of potable water used, and this fee can be significant. Using reclaimed water is not only cheaper but also reduces the amount of potable water needed thereby reducing the water rate and sewage disposal fee. Using reclaimed water is also cheaper than private potable water, offering significant savings as a replacement (where appropriate) for public or privately sourced potable water.

Current vs. Projected Costs

Table 2. Annual values reported by a property using private potable water and public recycled (R1) water.

Property X	Private Potable	Public R-1	Sewage Fees	Total
Vol. (1000 gal)	16,421	55,790	—	72,211
Annual Cost	$92,158	$70,335	$195,606	$358,099

EWRR (Annual cost/volume) Using R-1=$4.96/1000 gals

We wanted to determine what the annual cost would be if R1 water was not used by this property. The following table presents the calculations for determining the cost savings for using R1 water.

Example of savings due to R-1 use:

Property X: If we substitute private potable water rate for volume of R-1 used, R-1 volume = 55.79 MG = 55,790 kgals

Cost of Phase 1 Private potable water to replace R-1 = 55790 kgals X $3.73/1000gals= $208,096.70
Savings=$137,762.08

Cost of Phase 2 Private potable water to replace R-1 = 55790 kgals X $3.90/1000gals = $217,581.00
Savings: $147,246.38

Property X	Private Potable	Sewage Fees	Total
Vol. (1000 gal)	72,211	—	72,211
Annual Cost	$309,738.91	$195,606.05	$505,344.96

EWRR Without R-1=$7.00/1000 gals

The cost savings of using public potable R1 water for properties currently using only public potable water would be even greater than the example above. Given that both water supply rates and sewage fees are calculated based on consumption of potable water, using R1 water where appropriate significantly reduces overall cost and the EWRR.

Recycled Wastewater on Maui—Current Capacity and Planned Improvements

Wastewater reuse is not a new initiative on Maui; the County of Maui's Wastewater Reclamation District has had a water recycling program since the early 1990s (Parabicoli, 2008). However, the capacity for water reuse is limited by infrastructure, which in turn is limited by funding to support it.

While the South Maui Wastewater Reclamation Facility has full R1 water production capacity, and is able to support an average reuse rate of nearly 50 percent of its wastewater through R1 production, the Lahaina plant is currently a partial R1 facility, and its average level of reuse is about 37 percent.

Current uses for recycled wastewater in South Maui are extensive, with R1 water supporting beneficial uses such as landscape irrigation for golf courses, schools, parks, shopping centers, road shoulders and medians, as well as residential complexes. R1 water is also used for agricultural irrigation, industrial purposes, dust control, composting, toilet flushing, fire control, and drinking water for cattle. On Molokai, recycled water supports wildlife habitat for the endangered Hawaiian coot and stilt.

In West Maui, due to current infrastructure limitations, access to recycled water is at present limited to the Kāʻanapali Golf Course, the Hyatt Regency Maui Resort & Spa, which can access the Golf Course's supply, and the Honua Kai Condominium Association, Inc. The Honua Kai was designed and built to accommodate R1 access and use as a condition of development. R1 water is used on all of the Honua Kai's landscaped areas and for its water features. These uses save enough potable water to support 500 homes per day (Lance Gilliland, PersComm.). According to Lance Gilliland, Association General Manager. "We have thirty-eight acres, with millions of dollars in ornamental and native plants on our property, and all of them thrive on R1 water. Irrigating this way is the right thing to do for our reefs, community, and business. Without the reef, there is no business."

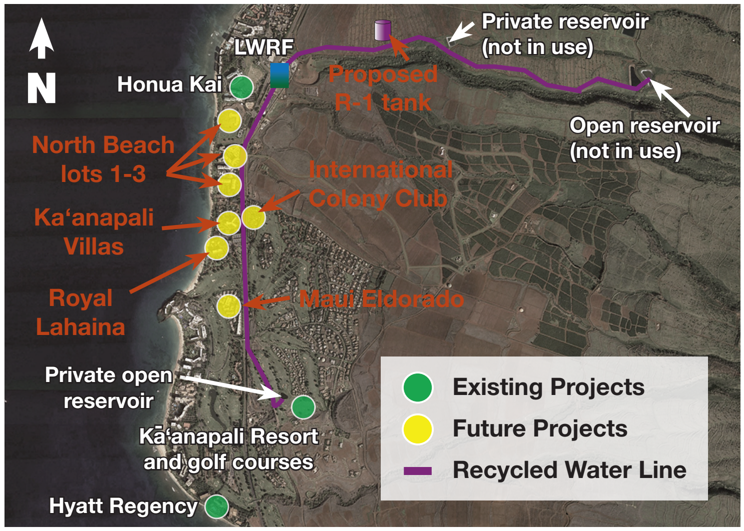


Fig. 4: Existing and Future Recycled Water Infrastructure in West Maui. Image adapted from County of Maui/Google Earth

The Three "R's"

The LWRF uses primary, secondary and tertiary effluent treatment methods to remove the physical, chemical, and biological contaminants in wastewater influent and produce fluid and solid waste (sludge) that are environmentally safe for disposal or reuse (Sustainable Resources Group International, Inc. 2012).

There are three categories of recycled water, based on regulatory definitions. R-1 has the highest quality standards of the three levels: the water must be treated by oxidation, filtration, and disinfection with ultraviolet light (UV) to significantly reduce bacteria and viruses. R-2 water has undergone secondary treatment and is of a lower quality relative to R-1 recycled water, with only a minimal level of disinfection occurring; thus it can only be used under restricted circumstances where human contact is minimized.

R-3 water has the lowest quality relative to the other two categories. It receives secondary treatment but is not disinfected. R-3 water can only be used where there is no potential for human contact. For more information, refer to the State of Hawaiʻi Department of Health's publication, *Guidelines for the Treatment and Use of Recycled Water.*

How Much is 3.3mgd?

The average amount of water disposed of on a daily basis via the Lahaina injection wells could fill up the Grand Wailea's massive Canyon Pool more than 5 times over.

In 2012, the County of Maui treated an average of 11.5 mgd (million gallons per day) of wastewater from all of its wastewater facilities; of that, 7.9 mgd was disposed of via injection wells in South and West Maui, while about 3.6 (or 32 percent) was reused. The amount of wastewater disposed of through the Lahaina injection wells on a daily basis over the past several years has averaged 3.3 million gallons (Steve Parabicoli, Pers. Comm.).

Assuming an average total nitrogen concentration of 7 mg/L, 175-292 pounds of nitrogen per day, or 32-53 tons of nitrogen per year, is disposed of through injection wells (Robin Knox, Pers. Comm.).

Past, Present and Future Upgrades to the Lahaina Wastewater Reclamation Facility

Fig. 5: Current capacity and proposed expansion of water reuse infrastructure in West Maui, and the properties served. At present, funding for design and construction of Option/Phase 1 and design for Option/Phase 2 properties has been secured; additional funding is necessary to further expand West Maui reuse capacity. Graphic adapted from County of Maui/Google Earth.

Potential distribution line **Current distribution line**

Existing Irrigation

Option (Phase) 1 Properties

(R1 availability: early 2015)

- Westin Kāʻanapali Ocean Resort Villas (North Beach Lots 1-3)
- Aston Maui Kāʻanapali Villas
- Royal Lahaina Resort
- International Colony Club

Total Impact: ~190,000 gal/day or 6% reduction in injected wastewater

Option (Phase) 2 Properties

(R1 availability: ~ 2017)

- Outrigger Maui Eldorado
- Hyatt Regency Maui
- Kāʻanapali Aliʻi
- Kāʻanapali Beach Hotel
- Marriott's Maui Ocean Club
- Westin Maui
- Aston at the Whaler
- Sheraton Maui
- Kāʻanapali Royal
- Whaler's Village

Total Impact: ~375,000 gal/day or 12% reduction in injected wastewater

Option (Phase) 3 Properties **(R1 availability: late 2018)**

- Aston at Papakea
- Aston Kāʻanapali Shores
- Kāʻanapali Beach Club
- Maui Kai
- Aston Mahana
- Honokowai Shopping Center

A blueprint or roadmap outlining these and other potential upgrades to the LWRF can be found within a report, the *West Maui Recycled Water Verification Study*, prepared by the Department of Environmental Management in 2012.

This report includes details on the infrastructure improvements and costs of expanding water reuse capacity in West Maui, and breaks up these potential improvements into Options, or Phases linked to specific properties along the distribution lines. These properties will sequentially benefit from the access to R1 water once the infrastructure improvements are in place.

Injection wells have been in use in Lahaina since the early 1980s. Concerns about their environmental impact were present since the beginning, given their proximity to the coastline, and the volume of wastewater and its characteristics. Water disposed of in injection wells was treated, though not to R-1 standards. This lower standard of treatment understandably promoted concerns over impacts to human health, in addition to the suspected environmental impacts. The latter issue was addressed in the 1990s through upgrades to the system. These changes in the facility's operation led to nutrient concentrations in the injected wastewater being reduced by more than half by the late 1990s (Sustainable Resources Group International, Inc. 2012). While this improvement certainly made a difference, millions of gallons of wastewater with elevated nutrients were still being disposed of in the wells on a daily basis.

Since October 2011, as a result of a consent order from the Environmental Protection Agency, as a precaution, the effluent disposed of through injection wells has been disinfected using chlorine. This additional treatment, though an improvement, is not an optimal disinfection method due to concerns over the impacts of chlorine on the marine environment. Chlorine disinfection does address human health concerns, however, and Department of Health sampling of the water emerging from the submarine springs (conducted in conjunction with a tracer dye study; see Appendix 1) found that bacterial levels were within the range deemed safe for humans (Glenn et al. 2013). The LWRF is currently upgrading its facility to increase its capacity for ultraviolet (UV) disinfection, which will

Mandatory Recycled Water Use Ordinance

In order to extend potable water supplies and reduce the use of injection wells, a Maui County ordinance was passed in 1996 requiring any approved commercial property within 100 feet of a recycled water source to access and use the recycled water within one year of it becoming available (Maui County Code, Chapter 20.30.050). In order to access this new source of recycled water, commercial properties will need to make modifications to their irrigation systems. This means that the Option/Phase 1 properties will need to be prepared to access and use R1 water by the end of 2015/ early 2016, and Option/Phase 2 properties by the end of 2017, assuming current infrastructure improvements are completed within the anticipated timeframe.

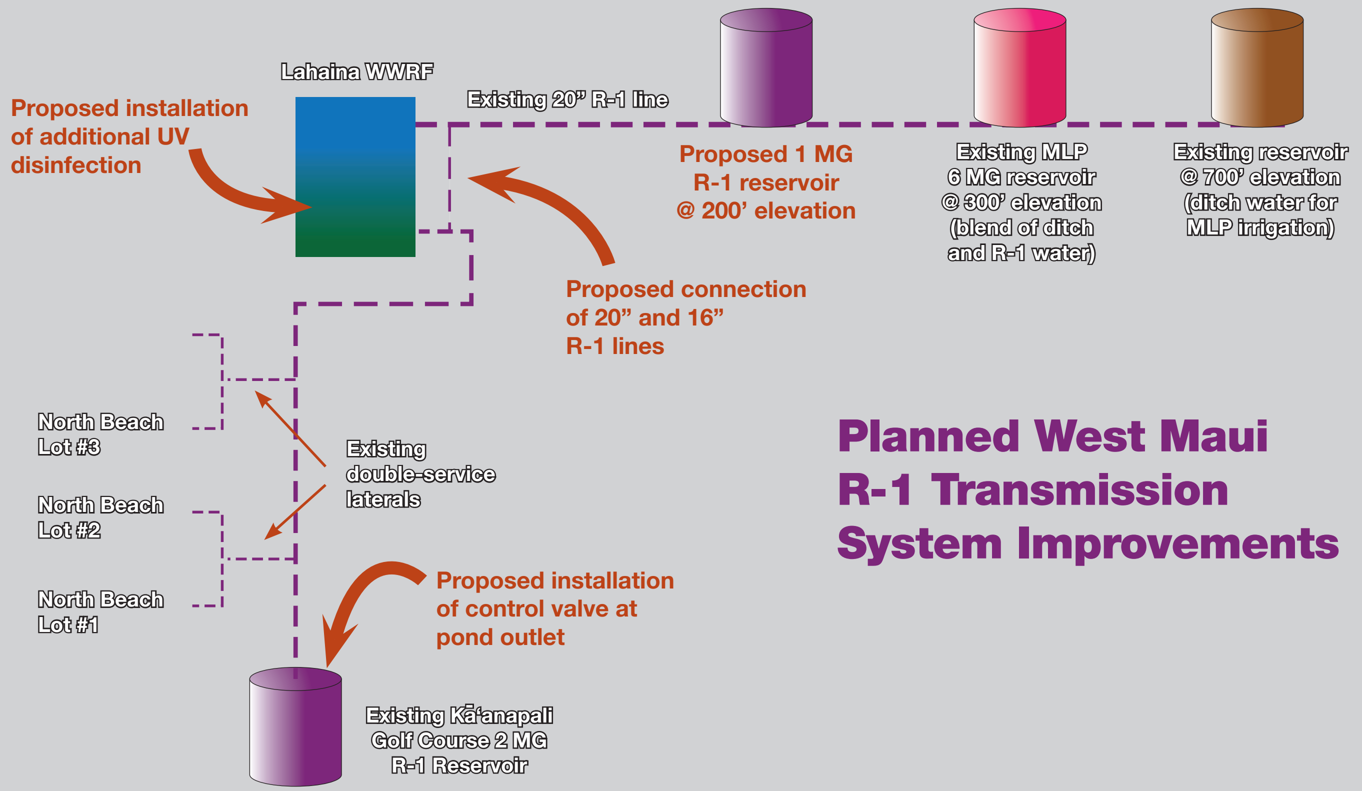


Fig. 6: Improvements to the LWRF currently underway to support the Option/Phase 1 infrastructure upgrades and expansion of reuse capacity. Image adapted from County of Maui.

allow for all the wastewater disposed of through injection wells to be treated to full R1 standards. These upgrades are expected to be completed by the end of 2013, and represent a significant step forward in reducing environmental impacts from pathogenic microbes in the treated wastewater. Future upgrades to wastewater treatment processes may be needed to further reduce the load of nutrients and other pollutants reaching the ocean. However, water reuse can reduce pollutant loads to the ocean without any additional treatment other than UV disinfection.

Additional upgrades to the LWRF in recycled water treatment, distribution, and storage capacity are either underway or planned, and in various stages of being funded. Those upgrades will significantly expand reuse capacity, affecting a number of West Maui hotel and condominium properties over the next few years.

A one million gallon elevated storage tank is slated for construction in 2014. The tank will enable the system to be pressurized and as a result, provide a continuous supply of R1 water to the Option/Phase 1 properties located along existing distribution lines. This storage tank is expected to be built by the end of 2014, and able to provide R1 water to the first suite of properties (see Figures 5 and 6).

Funding for the infrastructure to support R1 distribution to the Option/Phase 2 properties is being secured, and these expansions to the distribution capacity will include a loop system that will bring recycled water to Kāʻanapali Resort properties. Design for this system will begin in 2014, and construction is expected to commence in July 2015, with properties gaining access to the water around the end of 2016.

Section III: Getting Ready to Use—and Using—Recycled Water

Connecting Your Property to Maui's R1 Water Supply

The following section describes the process you will need to undertake to gain access to County R-1 water, and make the necessary preparations and changes to your systems in order to use it, primarily: 1) obtaining the required permits; 2) retrofitting your irrigation system; and 3) adjusting your landscaping practices.

The sooner you begin to take these steps, the better prepared you will be to address the economic and environmental considerations associated with this transition. The permitting process in particular can take a significant amount of time to complete. This guide was designed to assist you in navigating this process.

Cost to Retrofit Clause

There are expenses involved in retrofitting your system and making necessary changes in irrigation and landscaping practices. Recognizing the financial burden that properties would incur to retrofit their irrigation systems to accommodate R1 water, the County of Maui established a program that allows properties to receive R1 water at a rate reduced by 50 percent until the time that the costs associated with the retrofit are recouped (Maui County Code Section 20.30.080C). The cost to retrofit clause supports any type of equipment that will enable your property to "accommodate" the use of recycled water, such as a backup potable water connection with an air gap (required) to ensure no cross-contamination, or a fertigation system; it will not cover expenses such as those incurred to complete the required permit applications.

Navigating the Permitting Process

In order to use the County's R1 water, you will need to prepare and submit permit applications to both the Hawai'i Department of Health (DOH), and the County of Maui Wastewater Reclamation Division. After you submit your permit application, your property will be subject to construction inspections before being granted a permit and approval to use the water.

Department of Health Permit

The Department of Health's permit process is very technical, and the reports that are currently required as part of the application must be prepared by a professional engineer. The permit requirements are based on the DOH's Guidelines for the Treatment and Use of Recycled Water (http://health.Hawai'i.gov/wastewater/files/2013/06/reuse-final.pdf), which have in turn become incorporated into the State of Hawai'i's Revised Statutes (HAR 11-62), and thus constitute state law. It is important to note that the DOH Guidelines currently in use are from 2002 and are in the process of being reviewed; the outcomes of this process will affect permitting requirements. When complete, the new and revised guidelines are expected to significantly streamline the process, which may result in less time and expense. They may also allow for the permit to be prepared in-house rather than by a professional civil engineer.

Three reports are required as part of the DOH permit submittal: a Basis of Design report, an engineering report, and construction plans. The Basis of Design Report is to include extensive information about your property's Approved Use Area, as well as your irrigation schedule and available supplemental water supplies. It also requires information to be provided by the County regarding the reclamation facility and its transmission and distribution system.

Other information now required but that may be subject to revision in the guidelines' review process includes technical details about vegetation consumptive rates, evaporative losses, precipitation, and percolation rates. The engineering report requires a number of plans, including those for irrigation, management of reuse, public education, employee training, and vector control.

Finally, as part of the DOH permit, you must submit construction plans that document your compliance with

“Safety Purple” aka “OSHA Purple” is the required color for piping and fixtures for R1 water. The official color designation is Pantone 512.

Summary of Costs that can be Reimbursed

- Costs (material, equipment and labor) to connect an existing irrigation system to a new service lateral/meter.
- Initial costs (material, equipment and labor) of fertigation systems to condition water for irrigation use when excess salinity or other acknowledged water quality factors would be detrimental to the landscape.
- Initial costs (material, equipment and labor) for construction of a back up potable water connection with an air gap.
- Costs (material, equipment and labor) to install additional filtration devices to remove plastics, algal solids or other problematic debris present in the supplied water.

the Design Standards of the County of Maui’s Department of Public Works and Water System Standards, and a description of the irrigation system components along with a plan for identifying and color coding piping and appurtenances.

Please note that the above information is subject to change; future editions and revisions of this resource guide will provide relevant updates as they become available.

County Permit

Compared to the Department of Health permit, the County of Maui’s permit application is quite simple and will not require a professional engineer to prepare, though it does require that the three reports from the DOH permit be attached. A labeled map is also required showing the boundaries of the proposed R1 use area, and the irrigation and buffer zones within it along with their dimensions. It must also identify property features such as roads or structures. The County of Maui’s Form RW-1, Application for Recycled Water Service, is included in Appendix 5, along with a helpful checklist (Form RW-2).

Please note: permit applications and requirements are subject to change. The County RW-1 application can be obtained from the County of Maui Department of Environmental Management (the current—as of September 2013—version is included in Appendix 5), and the State of Hawai‘i Department of Health has plans to make a revised and simplified form available online at a future date, at http://health.Hawai‘i.gov/wastewater/home/forms/.

A Quick Look at the Process

- Obtain permit applications from County of Maui Department of Environmental Management and the State of Hawai‘i Department of Health (expected to be available online late 2013, see Appendix 5)
- Turn in applications to the Department of Health and Maui County
  - Submit connection fee to County with RW-1 application (charge is based on expected daily usage)
- DOH review of permit
- Approval to Construct is issued by DOH; construction can begin
- As-built drawings submitted to County
- Schedule construction inspection by County and DOH
  - Examine grounds together—check for construction, cross connections, signage, runoff, overspray, etc.
- DOH issues final approval letter—Approval to Operate
- County issues a user’s permit
- Ongoing performance and compliance inspections
- DOH/County Wastewater Reclamation Division—periodic inspections of storage reservoirs, distribution system, and approved reuse areas

Retrofitting Your System

You don't have to wait to prepare some aspects of your system prior to getting access to reclaimed water—start now and when doing scheduled maintenance or repairing or replacing parts, install R-1 ready irrigation components.

▪ If you plan to put in a backup potable flushing system, you need to install an air gap to separate the potable and R1 sources—cross connections are not allowed and check valves are insufficient.

  ▪ Air gap: needs vertical distance that's at least twice the diameter of the supply pipe—at least 1" or more

▪ Potable system needs a storage tank and pump to be delivered into the irrigation system.

▪ Your meter box needs to be big enough to accommodate maintenance (someone from the County will come and clean the screen on a quarterly basis and need to be able to get in to the box); your meter box must have a stainless steel cover.

▪ A meter box and meter will be installed as part of the County's improvement project. The box must meet Water System Standards as the meter must meet standards set by the Wastewater Reclamation Division.

Guidance from the County of Maui

"All properties in Option 1 and 2 without an existing R-1 lateral should begin assembling a plan of their existing irrigation system in order to determine where the recycled water connection should be and where the irrigation system needs to be altered to avoid cross connections with the potable water system. The County will do its best to accommodate a preferred connection point near the property line that fronts the mainline distribution system. Existing utilities, hardscape improvements, topography, landscape, traffic and other factors may affect what can be constructed, therefore, alternative locations on the frontage should also be investigated. The County will be contacting these properties early [2014] for information needed for the design of the County distribution system improvements. This will include preferred and alternative lateral/meter locations, the last two years of irrigation water usage, current irrigation practices (usage days, times etc.) and requested/required Meter size."

— **Scott Rollins**, CE-VI, County of Maui, Planning Section Supervisor, Department of Environmental Management, Wastewater Reclamation Division

Purple Fixtures And Labeling

Anything above ground must be purple and labeled (e.g. valve boxes, pipes). Signs must be installed wherever R-1 water is being used.

▪ The covers of your irrigation boxes can be painted purple, but the paint

typically doesn't last more than a year—you can buy durable long-lasting purple covers at Irrigation Systems.

▪ You are not expected to rip pipes out of the ground and to put in purple pipes—you can use what you've got, but if you make any improvements or replace pipes you should put in the purple.

▪ Irrigation Systems carries snap-on labeling for your components*.

▪ You can also use purple caution tape over pipes.

▪ You need to change out driplines; Badger makes them in all purple or with a purple stripe and "Do Not Drink" label.

Transmission Lines

County Wastewater Reclamation Division personnel will work closely with resort properties to identify the optimal spot for bringing transmission lines in (typically where the potable meter is located, near the main line, usually in the corner of the property). Tell them where you want it, and they will do their best to accommodate you.

**CORAL is not endorsing any specific products.*

Using R1 Water for Landscaping

Recycled wastewater has a different chemical composition than potable water, so there are some considerations and adaptations to be made when it comes to your property's irrigation and landscaping practices. R-1 water from the Lahaina Wastewater Reclamation Facility has elevated and fluctuating salt content due to brackish groundwater from seawater infiltration along the collection system (Sustainable Resources Group International, Inc. 2012). The chloride levels in the LWRF's R-1 water are approximately 400-500 mg/L. These salts can cause wilting and burning and reduced flowering of plants, as well as soil compaction. These impacts can be reduced by periodically flushing the soils using potable water (or with an effective rain storm) and adding gypsum as a soil amendment. Tilling soils is also recommended.

Nutrient Management

Using recycled water for irrigation prevents the disposal of hundreds of thousands of gallons of wastewater into injection wells, but direct runoff of this water can have an environmental impact and contribute to coastal nutrient inputs. While research surrounding this issue is lacking, Glenn et al. (2013) noted that "R1 irrigation water and possibly fertilizer appear to contribute to N and P loading in groundwater supplying Black Rock lagoon." The Wahikuli-Honokowai Watershed Management Plan also notes that, "due to the extensive grass covering the two Kāʻanapali golf courses, erosion and sediment generation are minimal. Some fraction of total amount of nutrients in fertilizers and pesticides applied to the courses are suspected to leach into soils and groundwater, and/or be carried during overland flow events. However, it is unknown how much, if any, nutrient runoff is being generated and carried to the ocean" (Sustainable Resources Group International, Inc. 2012).

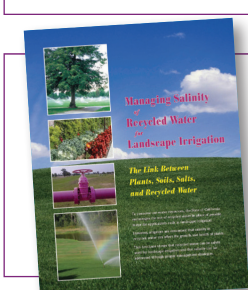
While direct runoff is always a concern when fertilizers are being applied, the potential nutrient loading reaching the ocean from R1 water is expected to be lower than that from injection wells, since irrigation water is spread across resort grounds and golf courses.

One way to address these concerns

Photo courtesy of Honua Kai

Fertigation

The Honua Kai designed a two-tiered water conservation program to keep nearly 40 acres of beautifully landscaped gardens and grounds healthy and green without wasting precious water. Honua Kai Condominium Association, Inc. worked in partnership with the county wastewater department to develop a landscape irrigation system that is fed solely by recycled R1 water, which provides the highest quality of recycled water. That water is then enhanced through a process known as "fertigation," which delivers small daily doses of organic fertilizer through the irrigation system. Computers monitor ambient moisture at key locations around the resort to activate the sprinklers that keep the grounds and gardens healthy. Unlike traditional broadcast or drop fertilizer methods, fertigation allows increased nutrient absorption by plants, and the daily feeding reduces the amount of fertilizer and chemical needed, while also reducing water usage. Fertigation can also distribute pest repellants. The combination of daily micro-dosing combined with organic products helps mitigate negative impacts to ground water or from run off. Source: Honua Kai.



Managing Salinity

This brochure (see coral.org/hawaiiwater), *Managing Salinity of Recycled Water for Landscape Irrigation: The Link Between Plants, Soils, Salts, and Recycled Water* shows that recycled water can be safely used for landscape irrigation and that salinity can be addressed through proper management strategies.

Continues on next page

Using R1 Water for Landscaping

is to ensure that best management practices are in place to control erosion and reduce runoff from your property. As irrigation water infiltrates soils, nutrients and other constituents of the water are taken up by plants and microbial action, resulting in less pollutant load reaching the ocean.

Careful management of runoff on your property should be coupled with increased attention to the amount of fertilizer used. The elevated nutrients found in R1 water have been likened to a "vitamin pill" for your plants (Steve Parabicoli, Pers. Comm.). Using R1 water, you should expect the need for fertilizer to be reduced along with its associated costs, and you should seek to develop or revise your existing nutrient management plan.

An effective nutrient management plan ensures that your plants receive adequate nutrients for growth, while nutrient loss through runoff or leaching from the root zone is minimized. A typical nutrient management plan includes an evaluation of site environmental concerns, an evaluation of available soil nutrients, a calculation of nutrient application amounts based on realistic plant needs and available soil nutrients, and appropriate nutrient application methods (Silva et al. 2000).

The University of Hawai'i College of Tropical Agriculture and Human Resources (CTAHR) is an excellent resource for guidance on fertilizer use, with many helpful publications and fact sheets available on their website (http://www.ctahr.Hawaii.edu).

Nutrient Management Tips

- Hawai'i Grower Products (HGP) can help with soil testing and make recommendations on how much (and what type) of fertilizer to use.
- Use mulch provided by Maui Eco-Compost (it is made using LWRF's deactivated sludge).

Plants

While the County notes in its permit application that "recycled water may not be compatible with certain types of vegetation because of its chemical composition," you need only to take a walk around the Honua Kai's grounds to see that R1 water and an appealing landscape are not incompatible.

The elevated salt content of the R1 water may not support plants that are especially sensitive to salinity, such as flowering ornamentals and shade-loving tropicals. This presents an opportunity to begin incorporating more native plants into your landscaping—native plants are naturally salt-tolerant and require less water, which will save you money. They are also more culturally appropriate, allowing your property to genuinely and respectfully promote a sense of place. The Kā'anapali Golf Course is switching to native plants, and the Honua Kai has incorporated native plants into its landscaping as well.

- Seashore paspallum grass responds well to R1 (but doesn't do well in the shade); St. Augustine grass is the most shade-tolerant.

- Lauae ferns don't do well with R1 if water is delivered through spray and show signs of shock; ferns do much better with drip irrigation.

- Clump natives and ornamentals together (and separately from each other) in order to account for their differing needs for care and response to R1 water.

In Fall 2013, the West Maui Ridge to Reef Initiative will begin working with select coastal properties and a local consultant to develop property-specific plans for maintaining world-class grounds while reducing harm to our fragile coastal ecosystems. While plans will be tailored to each site, this first phase of the project will culminate in a forum that will share helpful information for all landscaped grounds managers in the area. Please contact the watershed coordinator Tova Callender (Tova@west-mauiR2R.com, (808) 214-4239) if you are interested in participating in the fully funded pilot phase of the project.

Coming Soon From R2R

Reef-Friendly Landscaping Plans for Resorts!

Landscape Management

Irrigation Practices

- Irrigate at night.

- Consider switching to drip irrigation —lack of spray will prevent "burning" of plants and reduce damage to those that are sensitive to salinity. Drip irrigation also addresses issues with windblown aerosols.

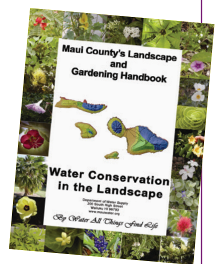
- To avoid runoff or overspray, check sprinkler heads from time to time.

- Make sure there is no ponding of water, to prevent pathogens from having a place to accumulate.

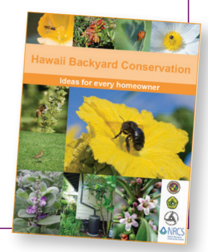
R1 water supports beautiful landscapes.

Knowing Natives

A resource for identifying native plants that will thrive in specific areas is **Maui County's Landscape and Gardening Handbook**, produced by the Department of Water Supply. This resource guide can be downloaded at www.mauiwater.org.



Another helpful publication, **Hawai'i Backyard Conservation** produced by the Honolulu Board of Water Supply (www.boardofwatersupply.com/cssweb/display.cfm?sid=1619), also provides guidance on native plants, as well as nutrient management, integrated pest management, and water conservation.



▪ Keep water on grass, not on walkways or vehicles (R1 can cause spotting to vehicle finish).

▪ Use boron-free detergents (boron destroys soil structure).

▪ Use push mowers (or battery powered mowers)—they are more environmentally friendly, and their lack of noise allows your crew to start earlier. Plus, there won't be green waste to haul if you leave your clippings on the lawn. Grass clippings fertilize new grass and improve the soil.

Maintenance

▪ Due to (current) R1 characteristics, systems tend to clog more frequently, so you should clean filters on a regular basis. Jets and heads also require more maintenance due to buildup of particles. (A planned upgrade to the LWRF's recycled water filtration system is expected to remove more floatable plastics, which are causing problems with sand filters at the facility and distribution system. This project is planned to be complete before the distribution system improvements are completed.)

Irrigation System Components*

▪ Order your fixtures well in advance, especially those that will need to be manufactured, due to the time required to make the large quantities you'll need.

▪ Rainbird has a whole line of R-1 specific technology and components.

▪ Turbo Meters are easier to fix and change the heads.

▪ Badger makes a meter in purple that has integrated plate strainers.

▪ Manholes:
  - M12 – 2" is cheaper and OK with the County to use
  - Stainless is necessary due to rust; Walker Industries carries them.

▪ Use a Weather Station such as the one produced by Maxicom, which provides useful data on rain levels to optimally control the system and conserve water.

▪ Hose bibs are not allowed to be used with recycled water.

Planning

▪ Each property needs a "Reuse Advisory Committee." It can consist of a supervisor and landscaper.

▪ Have a Contingency Plan—what to do in the event of runoff or spills" (not considered a spill unless in state waterways like gulches or the ocean). Keep spill-response equipment on hand. Use a squeegee, spread something absorbent, or in the event of a large spill, use a vacuum truck.

▪ A Vector Control Plan is especially important if your property has water features.

Signage and Education

▪ Use signage to demonstrate to your guests and the public that your property is proud to be using R1 for irrigation—more support and visibility by users leads to more support for funding by decision-makers.

▪ Signs need both text and an image.

▪ It's better to have too many than too few signs. They easily get overgrown; ensure they are maintained and visible.

▪ Employee training and education—take advantage of LWRF's tours and upcoming open house opportunities, to involve and educate your staff.

▪ Your property will need to put out a press release; feel free to contact CORAL for assistance if you want to incorporate reef or water quality themes.

**CORAL is not endorsing any specific products.*

More Ways to be Green

Using recycled water for landscape irrigation is one way of conserving potable water, but there are more things you can do to cut back on water use and save money while helping coral reefs:

- Install a rain garden or join the R2R rain garden hui and help others establish this low impact design solution to polluted runoff;

- Get involved in the Reef Friendly Landscaping Planning project;

- Join the Curb Inlet Basket Project and agree to maintain this pollution reduction device purchased and installed with federal funding;

- Host Ridge to Reef educational presentations on your property;

- Get involved in a Storm Water Smart Baseyard Assessment project;

- Help promote the power of individual action to improve ocean health by hosting West Maui Kumuwai events. For more information, please visit www.WestMauiR2R.com

Hawai'i Green Business Program

The Hawai'i Green Business program is a free certification program for Hotels and Resorts, coordinated by the State of Hawai'i Department of Business, Economic Development and Tourism. The performance measures found in the Hawai'i Green Business Standards Checklist For Hotels and Resorts provide excellent guidance on ways your property can reduce solid waste, facilitate recycling, and purchase recycled products, conserve energy and water, and prevent pollution. The checklist also addresses cultural practices.

Pool water can contain chlorine, which can harm wastewater treatment systems.

A list of hotels that were awarded the certification is also available through the website—http://energy.Hawaii.gov/green-business-program/hgbp-awardees. You can download a document with case studies, and learn about the specific conservation measures various hotels have implemented.

For more information, contact Gail Suzuki-Jones at (808) 587-3802 or GSuzuki@dbedt.Hawaii.gov

A Green Leader

In 2013, the Westin Ka'anapali Ocean Resort Villas was given the Hawai'i Green Business Program award from Governor Abercrombie as well as with the Maui No Ka Oi Magazine's Aipono Award for Excellence in Sustainability. Says Tom Florin, Manager, Events, "Recently, we created a Sustainability Vision for our resort. We adopted goals for conserving electricity and water and community outreach. Our associates and management team are pleased to assist local partners in their efforts to achieve island sustainability. We will inspire Hawai'i's hospitality industry by leading by example and working with the community to achieve island sustainability."

Pool Water Discharge

You should never allow pool water to enter streams, the ocean, or storm drains without an NPDES permit from DOH. Pool water typically contains chlorine, which is damaging to the marine environment (even when dechlorinated, pool water can have chemicals that harm surface and ocean waters). When sent to the sewer system, chlorinated pool water can also harm the microorganisms within wastewater treatment systems. Additionally, the volume of pool water is a concern to treatment facilities. Many hotel and condominium pools are quite large and can cause capacity issues for treatment plants. In the state of Hawai'i pool water discharge is regulated by the Sanitation Branch and the Clean Water Branch of the State of Hawai'i Department of Health. Penalties for noncompliance of up to $25,000 can be levied by the DOH Clean Water Branch.

Pool water may be used for irrigation on your grounds as long as there is no ponding or runoff to surface waters. Its constituents will be taken up by plants. Subsurface disposal requires an underground injection control permit or other approval from the DOH Safe Drinking Water Branch.

Discharge of Pools Into the Sewer System is Prohibited via Maui County Code

14.25A.040 - Prohibited connections. No person shall make a connection to a building wastewater system or building drain that is connected directly or indirectly to a public wastewater system for any discharges including but not limited to, roof downspouts, exterior foundation drains, areaway drains, or other sources of surface runoff or groundwater, cooling systems, swimming pools, vehicle wash waters or decorative fountains or ponds.

Section IV:
Stormwater Management the Natural Way: Low Impact Design & Development— An Overview for the Accommodations Industry in Hawaiʻi

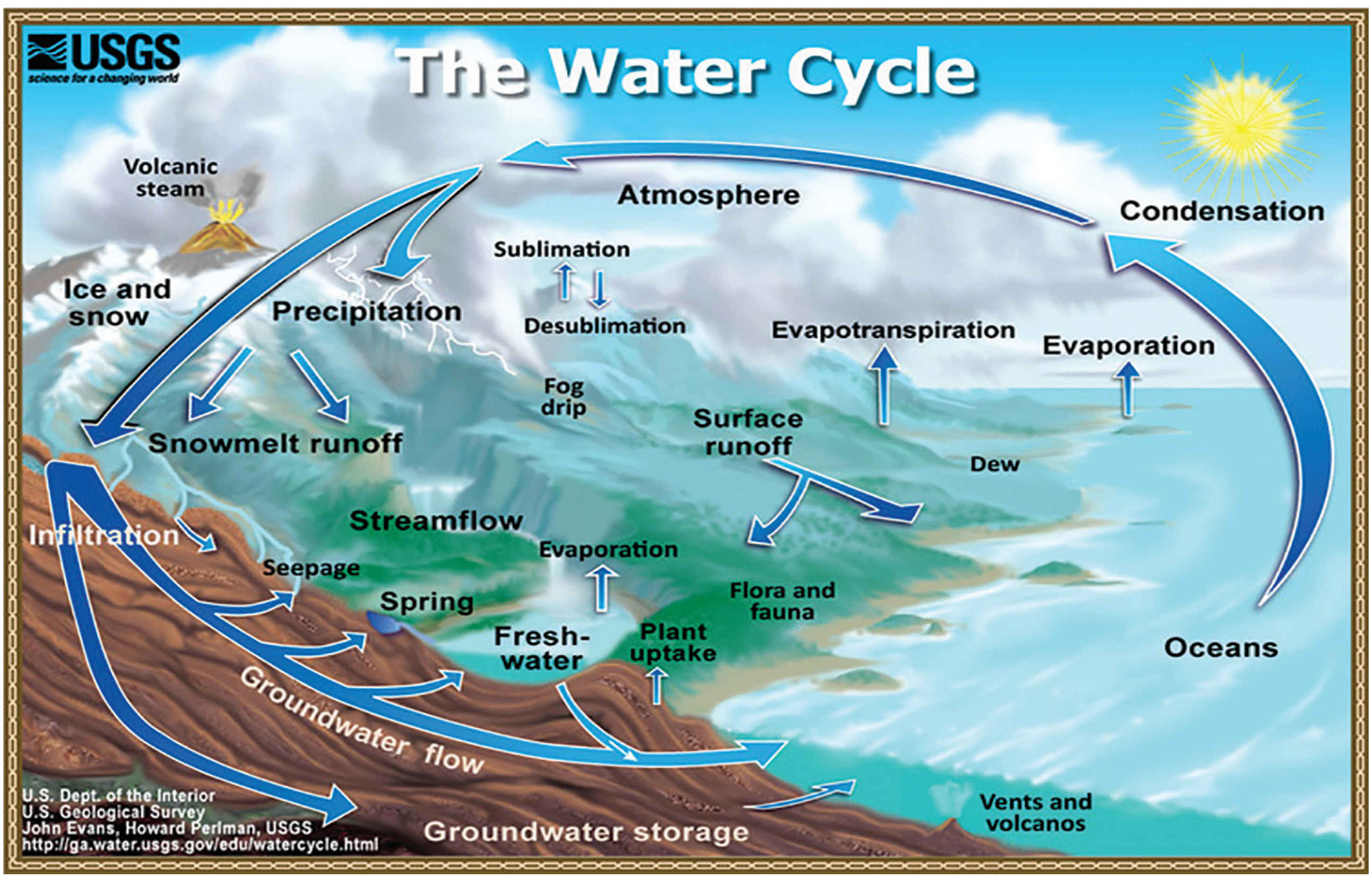
This content was developed by Lauren Roth Venu, Matt Moore M.Sc (Roth Ecological Design Int'l LLC), and Wesley Crile (Coral Reef Alliance; CORAL)

Low Impact Design & Development

About this Section

Low Impact Design and Development (LID) is an environmentally-friendly approach to managing stormwater. Hotels, condominiums, and resorts that use LID principles can significantly lower infrastructure costs, solve flooding, pooling, or runoff problems, increase marketability, add aesthetic value, and protect valuable marine ecosystems found in Hawaiʻi. This overview is intended to provide a practical introduction to LID principles and describe their specific relevance and uses within hotel and resort properties in Hawaiʻi. Topics covered in this section include:

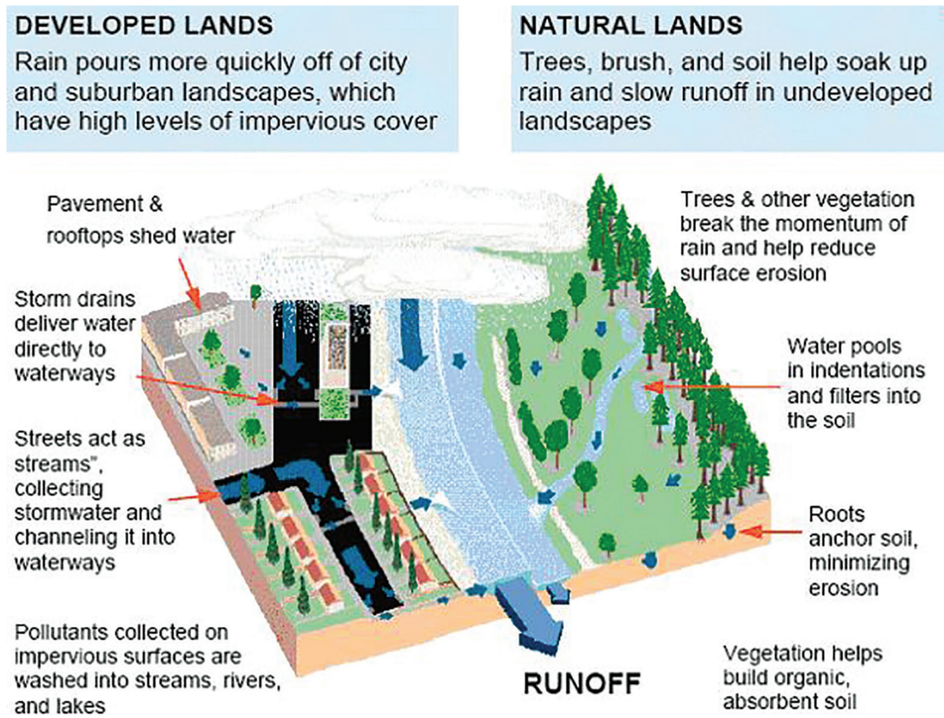
- A description of how LID affects watershed health
- Economic, social, and environmental benefits of LID
- Descriptions of specific LID projects hotels can implement
- Case studies of LID projects in Hawaiʻi
- How to get started with LID (permitting, site planning, etc.)



The Role of Low Impact Design in Watersheds

When it rains, the water that falls on land does so within a watershed. A watershed is an area of land that catches, stores, and conveys rainwater that will ultimately flow into the ocean (EPA, 2014). Within a watershed, stormwater is conveyed above ground in bodies of water like rivers and streams, stored in organic matter like plants or forest leaf litter, or sunk into underground aquifers. Topography, soil type, and the amount and type of vegetation present are all factors that influence how water moves through a watershed.

In an undisturbed forested or natural Hawaiian watershed, some rainwater is captured on the leaves of trees where it later evaporates or gradually flows toward the ground. The water that reaches the ground is drawn up by plant roots and utilized for growth, and organic matter such as leaf litter stores and releases water slowly over time into streams and rivers. These rivers flow down into wetlands or estuaries, where plants and animals take up and filter nutrients and organic materials. Finally, the water enters the ocean where it supports coastal ecosystem processes. Within a natural system, water remains a valuable resource throughout its journey through the watershed. LID principles seek to mimic these hydrologic and natural processes by allowing water to be slowed down, stored, filtered, or sunk into the ground on its way to the ocean so that stormwater remains a resource instead of a liability.



In a developed or altered landscape, water falls onto streets, parking lots, roofs, or other impervious areas and becomes stormwater runoff. This water runs off the land instead of sinking into the ground or being stored in organic material. The more impervious surface there is, the greater the amount of runoff. Stormwater runoff can erode the landscape, washing away topsoil and ground cover and picking up loose materials as it flows across the land. These materials can include oils, fertilizers (nitrogen and phosphorous), pesticides, sediment, paint particles, tire treads, and other pollutants harmful to coral reefs and marine ecosystems. In this case, the stormwater is no longer a valuable resource, but a polluted and potentially damaging liability. LID principles manage stormwater by slowing it down, sinking it into the ground, filtering it, or storing it as close as possible to its source: that is, as soon after it hits the ground as is feasible.


Multicopter Maui

LID Worksheet:
Accompanying this overview is the LID Property Assessment Worksheet. The worksheet is a questionnaire and checklist that can be used to assess a particular hotel or resort's potential for installing or incorporating LID systems into the property.

Why LID?

LID is able to serve multiple functions when used on a hotel or resort property, and can therefore provide a variety of economic, social, and environmental benefits.

A Less Expensive Option (Economic)

Conventional stormwater management systems are designed to convey stormwater as quickly as possible off of the property or to the nearest body of water. Accomplishing this requires paved channels, culverts, large diameter piping, and underground storm drains. This infrastructure involves high labor costs for land excavation, clearing, and grubbing. LID, on the other hand, often requires minimal piping, reduced paving, and less hard infrastructure, as well as significantly less excavation and grubbing. A cost comparison study conducted by the EPA examined 17 LID case studies and found that "… in the vast majority of cases, significant savings were realized during the development and construction phases of the projects due to reduced costs for site grading and preparation, stormwater infrastructure, site paving, and landscaping. Total capital cost savings ranged from 15 to 80 percent when LID methods were used…" (EPA, 2007 pg. 2)

It is also important to note that because LID systems serve multiple functions, they can present significant cost savings over time.

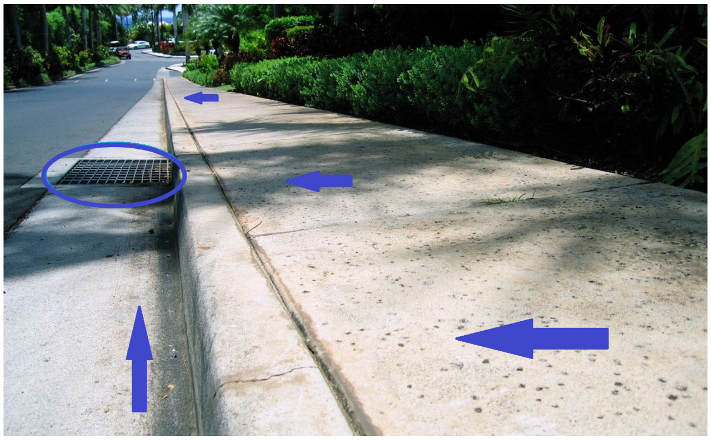
Conventional stormwater management requires complex and expensive infrastructure. Lower left photo by Lauren Roth Venu.

Reduced Maintenance Costs (Economic)

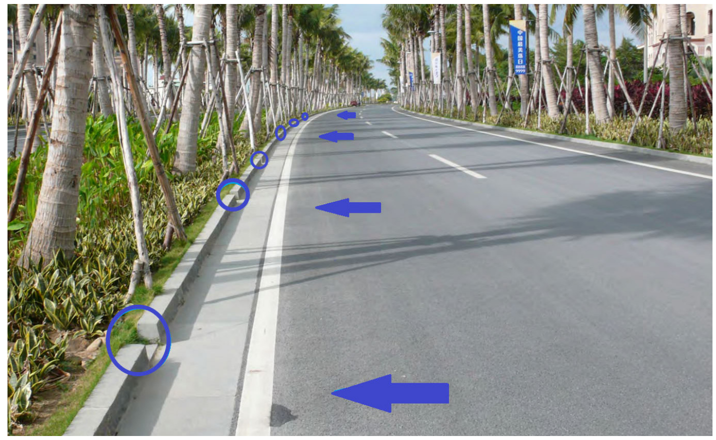
Stormwater often contains fertilizer (primarily nitrogen and phosphorous). Although these nutrients are essential for plant health and growth, when misplaced they wreak havoc on coral reef and other marine ecosystems. Capturing these nutrients within appropriate planted LID systems enables plants to utilize the nutrients and can reduce or eliminate the need for fertilization over time. Additionally, LID systems utilizing appropriate native plants that are well adapted for the soils and climates of Hawaiʻi generally require less intensive maintenance and irrigation when compared to exotic landscape plants.

Free Irrigation Water (Economic)

Providing potable (drinkable) water



When it rains on this property, stormwater runs off of the sidewalk, into the street, and down the storm drain with no filtration along the way. Proper planning using LID would reverse this flow, and chanel water into the nearby landscape features. This would allow water to sink into the ground providing valuable irrigation to the plants and natural filtration of the stormwater. Arrows in the photo indicate the direction of stormwater flow.



Along this road, curb cuts and a central bioswale convert a roadway median into a highly effective stormwater control device. Stormwater running off the road enters the bioswale through curb openings. The bioswale then filters and sinks the stormwater into the ground. This particular bioswale, located on a tropical island in Southern China, was able to handle a large volume of water when a typhoon struck the region shortly afer the project was constructed. Photo by Green Earth Operations.

Potentially free irrigation water runs off this parking lot every time it rains; meanwhile, expensive potable water is used to irrigate this bed. Curb cuts and a lower grade could allow stormwater to run into the bed.

to residents and businesses in the Hawaiian Islands is a very expensive and energy intensive process. For example, roughly $10 million annually is spent on the electricity alone that is needed for pumping, purifying, and distributing water to Maui's population

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Guidance From the EPA

"…in the vast majority of cases, significant savings were realized during the development and construction phases of the projects due to reduced costs for site grading and preparation, stormwater infrastructure, site paving, and landscaping. Total capital cost savings ranged from 15 to 80 percent when LID methods were used…"

Why LID?

(MCEA, 2009). With energy costs and water rates expected to rise in upcoming years, LID practices that reduce the amount of water purchased from public utilities make strong financial sense. Rainwater harvesting, for example, stores water that can then be used at a later time for irrigation or other non-potable uses.

Help with LEED Certification (Economic)

Leadership in Energy and Environmental Design (LEED) certification is intended to encourage sustainable green building and development. LEED certifies new projects and major renovations, and to qualify, a project must earn a minimum number of 'points' based on five categories of environmental standards. For hotel and resort projects—whether new or a retrofit—seeking LEED Certification, LID can significantly contribute points to each of these five categories and greatly assist with reaching LEED targets and goals (SEMCOG, 2008) (see LEED Certification Standards: www.usgbc.org).

Increased Marketability (Economic)

There are increasing trends in consumer support of green, environmentally friendly, and sustainable businesses. This is especially true within the hotel and resort sector (GSTC, 2012). The Global Sustainable Tourism Criteria (GSTC) has set internationally recognized 'sustainability criteria' for hotels and resorts and this has led to the development of a number of certification programs for the sector, including Sustainable Travel International, Rainforest Alliance Accommodation Certification, and, in Hawai'i, The Hawaiian Green Business Program (see: http://energy.hawaii.gov/green-business-program). Recently released Hawai'i travel guide books contain 'green accommodations' sections, and trends point to a growing number of discerning tourists who are asking the places they stay to demonstrate environmental and social sustainability. LID is an excellent way to show a property's commitment to environmental sustainability, and can go a long way toward helping a property meet sustainability certification standards.

Opportunities for Hotel Guests and Community Engagement (Social)

Sharing and explaining the functions of LID elements to guests, through interpretive signs, sustainability tours, and marketing materials, is an excellent way to highlight a property's commitment to sustainability and increase the market share of this discerning demographic. When

implementing LID, a social component can also be included that highlights the unique aspects of Hawaiian and Polynesian culture and history. For example, a rain garden could be planted as a 'canoe garden' that includes culturally significant plants such as kalo (taro), kukui (candlenut), mai'a (banana), and 'uala (sweet potato) and interpretive descriptions of each plant's significance can be provided (White, 1994). Partnering with schools, nonprofits, and residential and neighborhood groups to create and maintain rain gardens

Compare

A conventional flower bed...
- Aesthetic benefits

Vs.

...a rain garden
- Aesthetic benefits
- Stormwater management
- Reduced irrigation and maintenance costs
- Reduced fertilization costs
- Environmental benefits

Low Impact Design has the potential to eliminate much of the stormwater pollution currently flowing into the ocean and onto coral reefs in Hawaiʻi. Each square foot of pavement that is replaced with a pervious alternative, or each flower bed that is replaced with a rain garden or other appropriate LID, directly results in less pollution reaching the ocean, and more protection of the unique coastal ecosystems in Hawaiʻi.

and other LID elements is also an excellent way to involve the community and showcase a business as a model of community and environmental stewardship.

TRAVEL FOREVER
GLOBAL SUSTAINABLE TOURISM COUNCIL

Protecting Natural Resources (Environmental, Economic)

Tourists come to Hawaiʻi to experience the unique natural beauty these islands have to offer. Many of their activities, including snorkeling, swimming, diving, and relaxing on the beach, center around the ocean. When ocean water turns brown from sediment runoff, or blooms of noxious algae—caused by fertilizer runoff—cover a beach, tourists can become dissatisfied and may be less likely to choose Hawaiʻi as their vacation destination in the future. Protecting the marine ecosystem is essential for protecting our tourism economy.

Types and Examples of LID

LID systems can provide a number of uses and benefits to a hotel or resort property, while simultaneously saving money and protecting the environment. While each site has its own unique characteristics, LID can be used everywhere. Some LID principles are designed to store water for later use, others are designed as treatment systems, and some are meant to sink water into the ground. A mixture of LID systems should be spread throughout a property so their collective benefits can overlap and complement one another. The following are examples of LID systems that can be readily adopted by hotels and resorts, and have the potential to make profound positive impacts on the fragile ecosystems found in the state of Hawaiʻi. (Note: this list is not exhaustive. For more information and examples of LID, see the resources section.)

1. Pervious Pavement

sink

Removing pavement and replacing it with a surface that allows stormwater to pass through will greatly reduce the amount of stormwater runoff a property has to deal with in the first place, and reduce its potential to negatively affect the property and nearby coastal ecosystem. A careful examination of a property's paved areas can often identify 'dead pavement,' or areas that are paved but don't necessarily need to be (see LID Assessment Worksheet). These could be prime locations for pavement removal and replacement with plant beds, bioswale median strips, or another LID component, adding to a property's beauty and keeping water from pooling or flooding.

This "dead pavement" is a prime location for a bioswale or other LID system that could treat runoff from the parking lot.

In areas that must be paved, consider using hardscapes that allow water to pass through. Examples of "pervious pavement" include a wide variety of gravel, bricks, pavers, grass paving cells, or even "pervious concrete." Footpaths are often easy targets, but pervious pavement products or grass paving cells manufactured today can also handle the design and load requirements for heavy truck and car traffic. Pervious concrete can be poured and shaped exactly like standard concrete and can be used in most of the same situations (see: http://www.perviouspavement.org/).

2. Bioswales

slow, filter, sink

Consisting of a shallow planted depression with gently sloping sides, a bioswale acts like a trap to stormwater flowing across the landscape.

3
Lauren Roth Venu


4
Lauren Roth Venu

Bioswales are positioned in a property to slow and impede the flow of stormwater before it is discharged into a receiving environment. By slowing the stormwater down, sediment and suspended particles can settle out of the water, thereby reducing the impact on nearby marine environments. Plants within the bioswale take up and filter these nutrients and pollutants. Parking lots and other impervious surfaces are prime locations for bioswales, where they can catch and treat water flowing off the pavement. They can also serve as buffer strips around sensitive natural waterways, capturing and filtering stormwater before it flows into a body of water.

3. Rain Gardens

slow, filter, sink

Rain gardens are engineered to capture a predetermined volume of water when it rains, treat that water using plants, and allow it to sink into the ground where it will recharge groundwater. A rain garden is typically shallower in depth than a bioswale, and is often used as a stand-alone garden bed or landscaping element. The depth and size of a rain garden are determined by how much water it can effectively filter and sink into the ground over a 24 hour period. This is calculated by determining the area of impervious surface (roof, pavement, etc.), the average rainfall amount for a particular property, and the 'infiltration rate,' or how fast the water sinks into the soil where the rain garden is to be located (see the LID Assessment Worksheet for a detailed description). Often, engineered soil mixtures of sand and compost replace the native soil to allow for hydrologic consistency within rain gardens. Rain gardens may not be as effective in areas of clayey soils as these soils easily compact and impede drainage.

4. Constructed Wetlands

slow, store, filter, sink

Constructed wetlands (sometimes referred to as "artificial wetlands") are designed to filter and treat larger volumes of stormwater by mimicking a natural swamp or wetland. Constructed wetlands, incorporate aerobic and anaerobic water treatment into their construction. The aerobic section functions like a rain garden, as an intermittently wet region that treats stormwater through the biological uptake of nutrients and pollutants. The anaerobic section uses low oxygen biological processes to further treat stormwater within organic matter or soil layers. A wetland can be designed to retain water, thereby creating extra storage for larger rain events. Constructed wetlands may also be applied as 'edge' landscaping, whereby plants are strategically placed around ponds or other waterways to treat stormwater runoff before it enters the waterway or to treat the waterway itself. This practice maintains good water quality within the water feature. Also, constructed wetlands, like other vegetated stormwater filters, contribute to the

Continues on next page

Types and Examples of LID

aesthetics of a landscape.

Water features on golf courses can provide excellent rainwater-storage systems.

5. Rain Catchment

store, use

Capturing stormwater and storing it for non-potable use at a later time is an excellent way to utilize this water resource and reduce the money spent purchasing potable water. Stormwater can be stored in tanks above or below ground, in open ponds, or in other water features such as those on golf courses. A rain catchment storage vessel is sized according to the area of impervious surface that will be feeding it, and should take into account daily water demands of the site, rainfall amounts, and frequency. (See the LID Assessment Worksheet for instructions for calculating the amount of potential water that can be collected from a particular surface area.)

Water flowing from gutters, downspouts, or storm drains can be directed into a storage vessel. A filtration device is used prior to the water entering the storage vessel to keep out leaves or other debris. For new developments, a rain harvesting system can be incorporated during the project planning stage. With retrofits or redevelopment, or where space is a limiting factor for above ground storage, underground tanks can be placed beneath parking lots during a repaving project or when excavation is necessary for another reason. In some cases, existing storage tanks, cisterns, or other unutilized infrastructure can be repurposed to capture and store rainwater. Stored water is most commonly used for irrigation, however upon the State of Hawaiʻi's acceptance of the most recent Uniform Plumbing Code (2012), this water may become available for use in cooling towers, flushing toilets, and fire suppression systems (see local county plumbing codes). It is important to note that large above-ground tanks will require a building permit, and below-ground tanks likely a grading and grabbing permit (see permitting section for details).

6. Vegetated Roof

filter, store, use, evaporate

Rooftops represent a substantial portion of the impervious surfaces found within a hotel or resort property, and are often viewed as useless or unappealing spaces. Few visitors to hotels or resorts are looking for a "rooftop view" of a tar or gravel covered expanse punctuated by pipes, vents, and AC units. Creating a vegetated roof can turn this unappealing space into a usable and visually pleasing landscape while also providing energy and cost savings for the building below. There are many sizes and types of vegetated roofs, from small rooftop planters and trellises to fully landscaped rooftop courtyards and garden parks. Plants and the planting media that occupy a vegetated roof absorb and evaporate stormwater, and can also help cool a building by providing a reflective and insulating layer to the roof. This is especially beneficial in Hawaiʻi where indoor cooling costs can be significant.

LID in Practice

Case Studies in Hawai‘i

Case Study 1

University of Hawai‘i Maui College (UHMC)

Rain Garden

UHMC's Sustainable Living Institute of Maui (SLIM) partnered with the Water Institute for Sustainability Education (WISE) and Tri-Isle Resource Conservation and Development to install a rain garden on campus; the purpose: to treat and infiltrate rainwater from a culvert that collects water from the Kupa'a and Science Buildings, along with some site drainage. It is estimated that the rain garden will treat and recharge up to 270,000 gallons of stormwater annually. The rain garden sits within the SLIM Community Garden which is open for use by the students and community. The goals of the community garden are to increase awareness of food security and to teach the importance of sustainably managing stormwater. The SLIM rain garden team also hosted a workshop for Maui County educators to share details about the project with schools around the island.

Case Study 2

Sheraton Waikiki

Rain Catchment

The Sheraton Waikiki is planning on installing a rain catchment system to harvest rainwater from the roof of the hotel. The collected rainwater will be placed in above ground storage tanks and used for irrigation. Below is an interview with the Eric Au, C.E.M, Area Director of Engineering and Sustainability—Hawai'i for the Starwood Hotels and Resorts Hawai‘i.

Q: Why did Starwood choose this particular hotel?
A: Primarily due to the size of our flat roofs (upper and lower roofs) and the ease of tying in the existing roof drains into a central location.

Q: What motivated Starwood to implement a LID catchment system?
A: At Starwood, doing the right thing for the environment and our communities is more important than ever. Our customers and owners are asking for it, our guests expect it, and our associates are passionate about it. Conserving water via rainwater catchment is one of many initiatives we'll be addressing to help preserve our precious resource.

Q: How will the rainwater be used?
A: Irrigation

Q: Does Starwood plan to provide outreach to its guests about the green feature?
A: Yes, most definitely, via in room collateral, TV, and staff.

Case Study 3

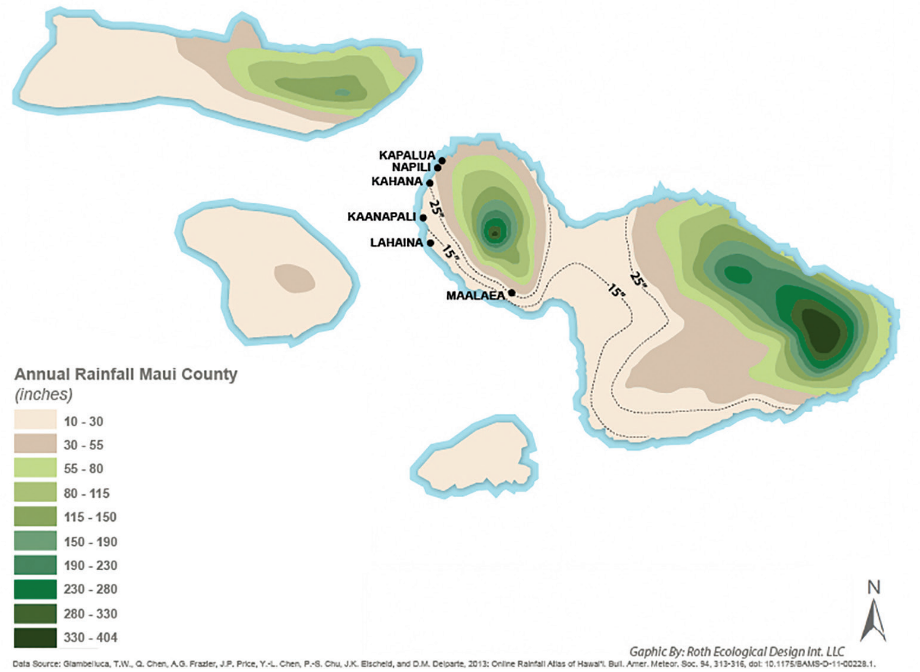
Grand Wailea

Green Roof

The Grand Wailea took a unique approach by designing a vegetated roof atop one of their centrally located buildings. The roof, which consists of flowering shrubs, a grassy lawn, seating areas, and sculptures, was primarily designed to improve the view from many of the rooms at the luxury hotel, and to create a usable space with a striking view for additional guest activities; however, this green roof also helps to reduce stormwater runoff through the plants' uptake of rainwater, and provides cooling benefits to the building below.

Getting Started with LID

LID principles can be incorporated into the site plan of a new development project and utilized effectively with redevelopment or retrofit projects. There are several questions to consider when deciding the best options for using LID elements within a particular property.



1. Is the Site Disturbed or Undisturbed (Brownfield vs. Greenfield)?

Undisturbed sites typically have mature foliage and topsoil that are naturally designed to retain stormwater and recharge it into the ground. Grading the site with heavy equipment will affect this drainage ability by removing vegetation and compacting the underlying soil. The grading process can result in semi- to completely impervious surfaces depending upon the soil type. For this reason, careful site planning is critical. After pervious areas for minimal drainage have been optimized, strategic placement of structures, roads, and parking lots should be considered and, when feasible, placed in areas where disturbance to the natural drainage of the site is minimized.

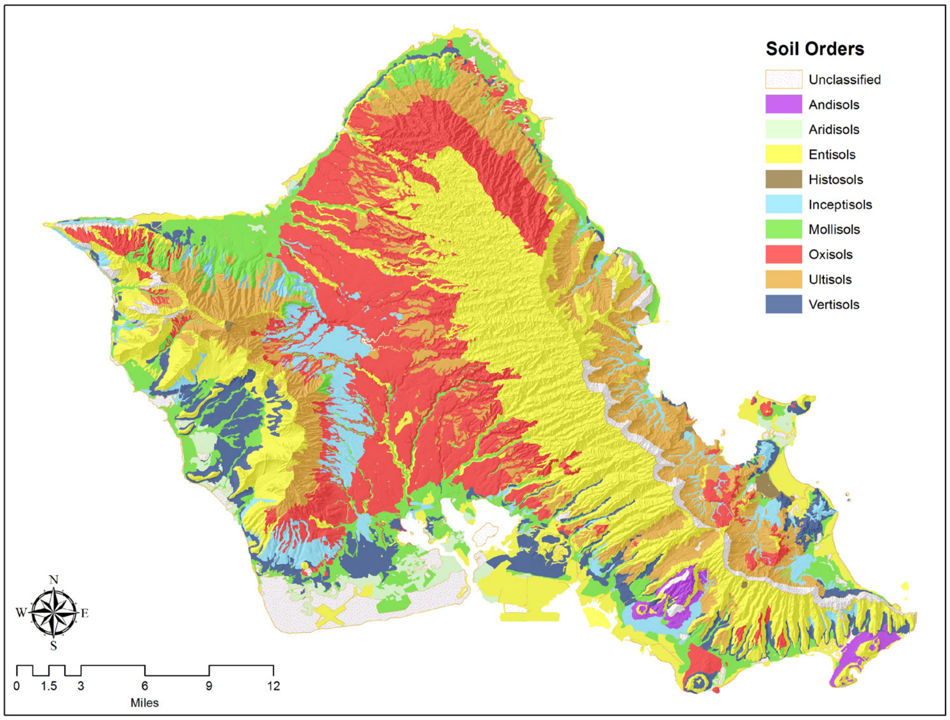
Redevelopments and retrofits typically occur on already disturbed sites; however, a careful examination of the natural environment currently present on a site is still advantageous. Any trees or vegetation will provide stormwater management services, and can conceivably be integrated into the retrofit or remodel plan. It is important to test the drainage ability of the site for permeability before choosing an LID system (see LID Assessment Worksheet). For example, if the soil's ability to sink water has been compromised by soil compaction or the site has inadequate potential to capture rainfall, there may still be opportunities to add underground water storage tanks. For sites with adequate permiability, implementing bioretention systems, such as bioswales or rain gardens, in areas next to impervious surfaces often makes sense. If there are planted landscapes, raised medians, or gardens, these can often be converted into functional planted LID systems. Other retrofit opportunities include above ground storage, permeable pavements, and green roofs.

2. How Much and How Often Does it Rain?

Stormwater management takes into account both water quality and water quantity. Although LID systems can be designed to store water and manage water quantity, they typically are sized to manage and treat the Water Quality Volume (WQV), or the amount of water an LID system must effectively filter or treat in order to remove the majority of pollutants. Most pollutants in stormwater runoff are concentrated in the 'first flush' which occurs at the beginning of a rain storm. LID systems can be designed to capture, filter, and treat the first flush, and then allow excess water to overflow into an additional LID or conventional stormwater system.

The WQV is determined by calculating the 90 percentile rain event, the area of impervious surface, and the total percentage of impervious surface versus pervious surface on the site (runoff coefficient). The 90 percentile rain event is determined by conducting a precipitation frequency analysis to identify the single 24-hour rain event that is bigger than 90 percent of all other rainfall events over a representative period of time. To effectively calculate the WQV requires collecting rainfall data, ideally directly on the site with a rain gauge, and by keeping detailed records. Where rain gauges are not available on the site, the next best option is to identify the closest rain gauge with available data. If rain fall data is unavailable for a representative period of time, models developed by the University of Hawai'i at Manoa Geog-

Major Soil Types of Oahu



University of Hawai‘i

raphy Department and NOAA can help determine monthly and annual averages, as well as rainfall intensity.

Because various counties have different requirements and the 90 percentile rain event varies substantially in different parts of Hawai‘i due to the state's high climate variability, accurately calculating a site's 90 percentile rain event is crucial to maximizing the treatment potential of an LID system (Maui County, 2012). For managing larger, more intense storm events such as the '10-year; 2-hour event' (a measurement often needed for permitting with the various counties) or the even larger '100-year event', LID systems can be coupled with conventional stormwater systems to handle large water volume storm events. For example, overflow devices from an LID system could connect to a municipal storm drain, seepage pit, or detention basin.

When LID systems are designed to have stormwater storage capacity (such as storage tanks, rain catchment systems, or constructed wetlands) these storage volumes can be accounted for and deducted from the overall storage needs of the site. Accounting for the storage capacity of an LID system reduces and minimizes the size requirements needed for a conventional system. This can mean smaller pipes or smaller detention basins can be used, providing significant cost savings.

3. How Much Impervious Surface is There?

The site's total area of impervious surfaces (roofs, roads, parking lots, impacted soils, etc.), together with the rainfall data, will provide an accurate calculation for exactly how much stormwater runoff a particular LID system must be capable of handling.

4. What Kind of Soil is There, and How Well Does it Drain?

The Hawaiian Islands are formed of porous volcanic rock; however, within each island there are a number of soil variations with distinct characteristics and drainage patterns. Maui Island, for example, is generally characterized by dark, iron-rich/quartz-poor rocks, but includes seven distinct types within this one category. Shorelines (at least where hotels and resorts are usually located) are dominated by sandy soils. Sandy soils allow water to sink in quickly, and are generally well-suited for bioswales, rain gardens, and other LID systems designed to sink water. Clayey soils are particularly poor at allowing water to sink, and are thus better suited for catchment and storage.

To determine the type of soil and drainage at the proposed site location, a percolation test should be done. For most commercial projects requiring permitting, this must done by a licensed geotechnical professional. However, for small projects, a simple do-it-yourself test may be adequate; this simple test consists of digging a hole of a specific volume in the area of the proposed LID system, pouring in a measured amount of water, and timing how long it takes for the water to sink into the ground (see LID Assessment Worksheet).

Extensive use of heavy equipment on a site quickly compacts the underlying soil. When soils are compacted, they behave like impervious surfaces and lose their ability to absorb stormwater (City & County of Honolulu, 2011)

Rainfall Resources

University of Hawai'i at Manoa Geography Department Rainfall Atlas:
http://rainfall.geography.hawaii.edu/

NOAA's National Weather Service, Hydrometeorlogical Design Studies Center, Precipitation Frequency Data Server:
http://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_hi.html

Regulations & Permitting

Most LID system installations will require some form of a permit. For new developments, the plans and permit applications will be submitted with the overall project. For redevelopment or retrofit, it is prudent to time the design and installation of LID systems with additional remodeling or renovation to minimize repetition of surveys and applications. The following section provides an overview of the basic permits and plans that may be required when installing an LID system as a new development or redevelopment/retrofit project in Maui County. Each county in Hawai'i has unique regulations, so it is best to inquire with the local jurisdictions. Consult with a planner or engineer if you are unsure of any aspect of the permitting process.

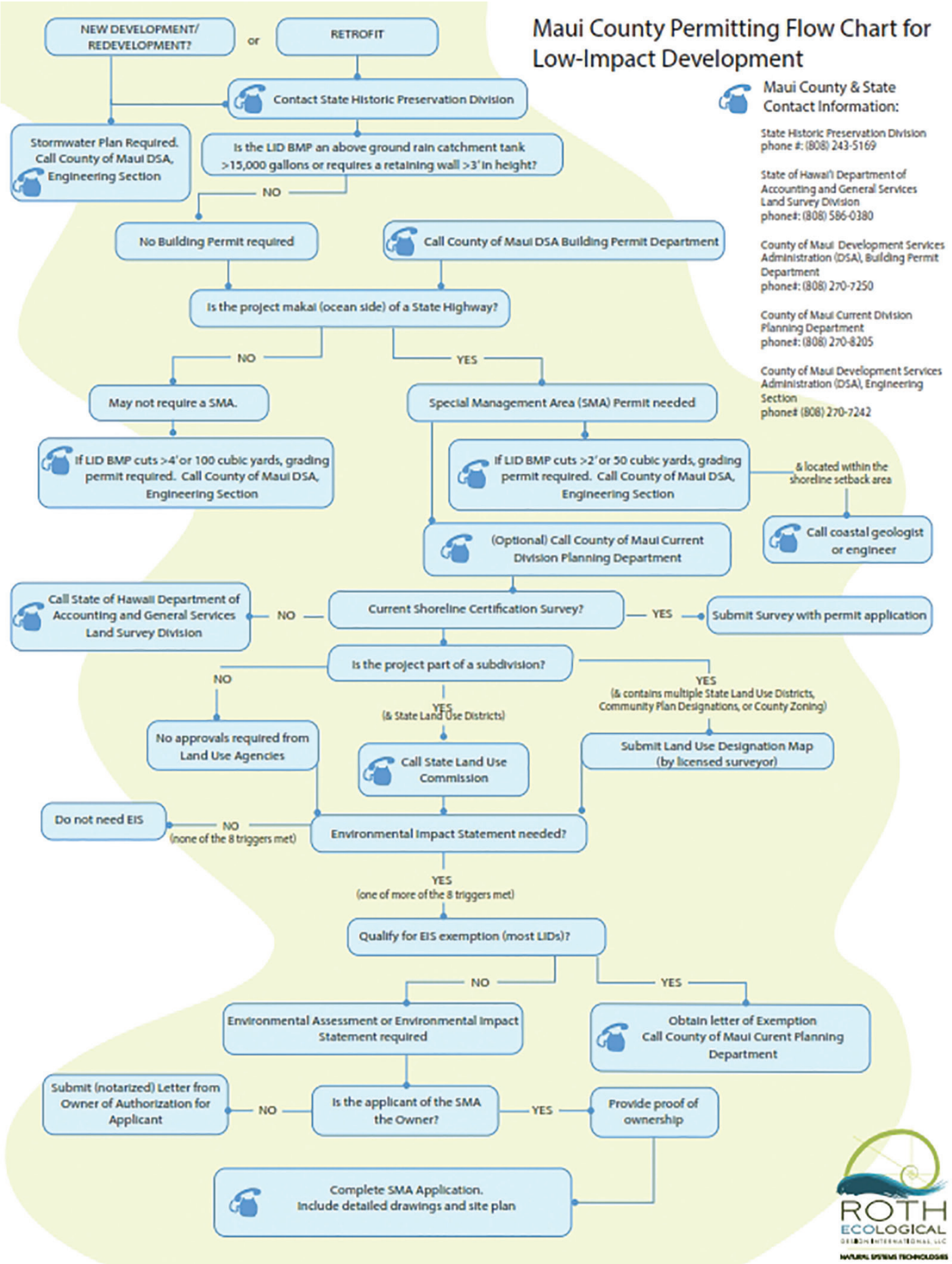
Volunteers install a rain garden at Wahikuli Wayside Park.

Stormwater Plan

For new development projects, the County of Maui Department of Public Works (CMDPW) requires a comprehensive stormwater management plan for development projects disturbing more than one acre or, for those that are less than one acre, a "site-specific Best Management Practice (BMP) plan" for managing stormwater quality. A licensed civil engineer is required to stamp the plan and include a 'maintenance plan' for the BMP(s) selected. Design and engineering details for the plans can be found in Chapter 15-111, *Rules for the Design of Stormwater Treatment Best Management Practices.* (County of Maui Department of Public Works). If a project is not a new development, it is likely that the submission of these plans will not need to be submitted to CMDPW (see County of Maui's Department of Public Works website: www.co.maui.hi.us/index.aspx?nid=124).

State Historic and Preservation Division (SHPD)

Both new developments and retrofits will require contacting the State Historic and Preservation Division (SHPD) to ensure that the project does not impede on historic structures. Projects being developed on previously disturbed land will likely receive a letter of clearance from SHPD and should then be able to proceed. Call (SHPD) with the proposed project's Tax Map Key (TMK) to check if the project site has clearance. This process could take up to three months. The letter of clearance request to SHPD should be from the owner of the property or from a County of Maui Planner. If the project is found to be within a historic site, a site survey may be required by a licensed professional. Additionally, if it is a new development



Special Management Area (SMA) Permit

If the proposed project is located on the ocean side (makai) of the State Highway, it is likely in a Special Management Area (SMA). See the SMA map (http://maps.hawaii.gov/PropertyInSMA/) to determine if your property falls within the SMA zone. Occasionally there are TMKs that fall within SMAs on the mountain (mauka) side of the highway.

Call the local county department of planning office with the project TMKs if you are unsure. For projects that do fall within an SMA, an application to the CMDP is required. This application is available online at: http://www.co.maui.hi.us/documents/17/111/SMAAssessmentApp_7-11_WEB.PDF.

Contact Information:

- County of Hawai'i
  Planning Department
  SMA Permits
  East Hawai'i Office 808.961.8288
  West Hawai'i Office 808.323.4770

- County of Kaua'i
  Planning Department
  SMA Permits 808.241.4063

- County of Maui
  Planning Department
  SMA Permits 808.270.7735

- City and County of Honolulu
  Department of Planning & Permitting
  SMA Permits 808.768.8014

within the shoreline area, an archeological survey may be required.

Building and Grading Permits

Some LID systems will require a building, grading, or grubbing permit. A building permit is a certificate of approval from a local county authority approving the design and construction of typically above ground structures. For example, an above ground rain catchment tank greater than 15,000 gallons or exceeding a 2 to 1 ratio of height to width requires a building permit. Plans for these types of catchment tanks need to be stamped by a Hawai'i licensed structural engineer or architect. Tanks set below grade do not require a building permit, however they may require either a grubbing or a grading permit. Grubbing permits are typically required when any vegetation is removed, and grading permits are required for the excavation of fill, or for the temporary storage of soil or rock-like materials exceeding defined quantities. In Maui County, for example, a grading permit is required if more than 100 cubic yards (4' of cut) of fill is excavated in a non-Special Management Area (SMA) or more than 50 cubic yards (2' of cut) within the SMA. Additionally, if the project is within the shoreline area and is removing greater than 50 cubic yards of material, a coastal geologist or engineer must write a letter that designates the limits of the coastal dune. A grading permit requires two sets of detailed drawings by a State of Hawai'i licensed civil engineer, including a construction BMP plan preventing soil migration offsite. Cost of the grading permit is dependent on the amount of earthworks.

Concluding Remarks

LID is more than a collection of stormwater management systems. It is a design philosophy and a different way of looking at stormwater. It's a way of ensuring that stormwater's value as a vital natural resource is maintained. This overview was intended to provide an introduction to LID, and it is our hope that property owners will use it as a tool and begin to view their properties within the larger context of the watershed.

The next time that it rains on your property, we invite you to grab an umbrella and the LID Assessment Worksheet and take a look around. Observe what is happening to stormwater on your property. Is there pooling or erosion? Does a footpath turn into a stream? Is water pouring off of a roof? Where does that drain lead to? These observations can become the basis for installing LID systems that will slow, sink, filter, or store stormwater, enhance the beauty and functionality of your property, save money, and protect Hawai'i's unique and valuable marine environment that draws so many visitors to our islands each year.

Additional Resources on LID:

water.epa.gov/polwaste/green/
Includes links to several cost benefit studies on LID versus standard stormwater practices and reports addressing perceived barriers to LID use

www.lowimpactdevelopment.org
Includes a number of resources on LID use from the Low Impact Development Center, a non-profit organization dedicated to the advancement of Low Impact Development technology

files.hawaii.gov/dbedt/op/czm/initiative/lid/lid_guide_2006.pdf
Links to "Low Impact Development: A Practitioner's Guide," a "Hawai'i specific" discussion of LID use in the Islands developed following an LID conference held in June 2006

www.honoluludpp.org/Portals/0/SiteDevelopmentDivision/DPP%20Storm%20Water%20BMP%20Guide%20(Dec-2012).pdf
Links to City and County of Honolulu's Department of Planning and Permitting's "Storm Water BMP Guide December 2012," offering detailed descriptions of a number of stormwater best management practices, including technical schematics and drawings

www.usgbc.org
Includes details about Leadership in Energy and Environmental Design (LEED) Certification Standards

keolamauloa.com/2013/04/our-canoe-garden
Provides a good example of a "canoe garden"

www.perviouspavement.org
Details pervious concrete uses, prices, and applications

www.nrmca.org/certifications/pervious/Search/PERVIOUS/ShowPERVIOUSTablePage.aspx
Links to the National Ready Mixed Concrete Association (NRMCA) database of certified pervious concrete technicians; could be used to locate a pervious concrete specialist or contractor in a particular area

www.westmauir2r.com/uploads/7/5/7/6/7576120/raingardenmanual-web_3-25-13.pdf
Links to the Hawai'i Residential Rain Garden Manual which could be applied on a resort or hotel property as well; published by Hui o Ko'olaupoko in 2013

data.nodc.noaa.gov/coris/library/NOAA/CRCP/project/1906/Feb2014_IslandBMPGuide_wAppendix.pdf
Links to "Stormwater Management in Pacific and Caribbean Islands: A Practitioner's Guide to Implementing LID," documenting "island specific" examples that are very applicable within the Hawai'i context

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Note: Review does not mean that content is endorsed by the above individuals. CORAL's expertise is in reef health and ecology, not regulation. Legal questions releated to discharges and water quality should be addressed to county, state, and federal regulatory agencies, particularly as regulatory information may change over time.

Section V: Appendices

Appendix 1

A History of Key Research and Relevant Findings

West Maui's reefs have been studied extensively for decades, and the research has led to an increasingly deeper and better understanding of the status and trajectory of the reefs' health as well as the factors contributing to their decline. This Appendix is by no means a comprehensive account of all of the research pertaining to West Maui's reefs, but rather a summary of some of the key studies and findings from this region in Kāʻanapali, where recycled water use initiatives are underway and planned.

▪ University of Hawaiʻi researchers investigated an algal bloom that occurred in 2001 within the Kahekili reef area, and examined the associated biological and physical characteristics, including the nutrient environment, sediment, water chemistry parameters, and the abundance and community structure of marine life. Results suggested that the bloom was influenced by land-based nutrient input via groundwater seepage (Smith et al. 2005). Subsequent researchers observed warm, brackish water emerging from the shallow depths near Kahekili Beach Park, as well as black deposits on the bottom among the rocks and coral in these areas. These areas of evident groundwater discharge along the nearshore region of Kāʻanapali became known as "submarine springs" or "seeps."

▪ A later study was able to detect and sample these specific areas of groundwater discharge. Water chemistry analyses from these discharges indicated the presence of wastewater through the detection of wastewater constituents (such as pharmaceuticals, fire retardants, and other industrial chemicals) found in both the effluent from the plant and the ocean water sampled. The study also resulted in a preliminary delineation of the wastewater plume; however, questions about the full extent and characteristics of the wastewater plume remained (Hunt and Rosa 2009).

▪ In 2010, a study was published that arguably represented the most thorough and conclusive scientific investigation yet to provide evidence for the linkage of wastewater effluent and the brackish water emerging in the nearshore marine environment of Kāʻanapali. Researchers used a study method known as stable nitrogen isotope analysis to analyze algal samples and detect the signature of the form of nitrogen associated with wastewater. The extensive sampling and the levels detected allowed them to "confirm that the injected effluent from the Lahaina WWRF is continuously flowing through the reef at Kahekili and then subsequently flows to the south" (Dailer et al. 2010). A two-dimensional map was created to model the extent and location of the wastewater effluent plume.

▪ A followup study by the same researchers further examined the behavior of the wastewater effluent on a three-dimensional scale, and detected the effluent in surface water, "where most of the recreational users (swimmers, snorkelers, canoe paddlers, etc.) are active" (Dailer et al. 2012).

▪ The most recent and comprehensive effort to describe the characteristics and extent of the wastewater effluent entering the nearshore marine environment was conducted by researchers from the University of Hawaiʻi by adding a fluorescing tracer dye to the treated wastewater effluent injected at the Lahaina Wastewater Reclamation Facility (Glenn et al. 2013). It took 84 days to first be detected in the nearshore waters in North Kāʻanapali, emerging from the submarine springs; the average transit time was about 15 months. The study identified approximately 300 individual springs, and determined that 64 percent of the treated wastewater disposed of through wells #3 & 4 at the LWRF discharges from the submarine spring areas. Therefore, this study conclusively demonstrated a hydrologic connection between the LWRF injection wells # 3 & 4 and the nearby coastal waters of West Maui. This study was also the first to document a "thermal anomaly" of surface ocean water in the region using aerial infrared imagery, documenting that "the warmest area of the entire coastline mapped corresponds to the geographic location where effluent enters the ocean through submarine springs." In addition to the temperature differing from surrounding waters, the salinity of the surface water is also much lower in the area due to the brackish water emerging from the springs. This level of detail further supports the linkage between the Lahaina WWRF, and provides the basis for further investigations into the water quality in this region, and its potential impact upon the reef system.

As extensive research continues to be conducted on West Maui's reefs, we expect that our understanding of the complex dynamics and interconnectedness of the many factors affecting reef health will continue to increase, as will our ability as a community to find and implement solutions.

Appendix 2

History of West Maui Watershed Management Efforts

Scientists, resource managers and conservationists have long recognized that in order to protect and restore ocean ecosystems, attention and effort must extend beyond the nearshore environment into the watershed as a whole, and address the land-based impacts through a process known as integrated watershed management planning. In West Maui, there have been several ongoing efforts to employ this approach, beginning in the 1990s with the West Maui Watershed Management Project, which developed the West Maui Watershed Owners Manual (1997), a "collection of recommendations for protecting and improving water quality and ocean resources in West Maui." (downloadable at hawaiicoralreefstrategies.com) Since that time, multiple conservation strategies, efforts, programs, and projects, including research and monitoring, have been conducted in the West Maui region, by an extensive array of public and private agencies, institutions, organizations, landowners, and individuals, some working collaboratively, some working in parallel. As coral reefs and marine resources continued to decline, new management plans were developed that focus on coral reefs, the most recent examples being the Hawai'i Coral Reef Strategy (2010), the Wahikuli-Honokowai Coastal Conservation Action Plan (2012), and the Maui Coral Reef Recovery Plan (2013); these documents provide a "road map" that outlines and prioritizes strategies to reduce threats to reefs.

In 2012, the multi-agency West Maui Ridge to Reef Initiative was launched, representing a large-scale marshaling of resources to consolidate watershed management planning efforts and implement solutions. As an initial step to guide this effort, the Wahikuli-Honokowai Watershed Management Plan (WHWMP) was developed. This two-part plan characterizes the condition of and outlines conservation strategies for the two priority watersheds of Wahikuli and Honokowai. The plan focuses on land-based pollutants, primarily in the form of sediments and nutrients, which are known to cause impairment and degradation of nearshore water quality and coral reef health in West Maui. Nutrients enter the marine environment through both natural and human-caused/assisted mechanisms, via surface water and groundwater transport. The WHWMP identified the major categories of nutrient pollution sources in West Maui as urban runoff, failing septic systems, croplands, nurseries, orchards, livestock operations, gardens, lawns, forests, fertilizers, agriculture construction soil losses, and wastewater effluent. The WHWMP also identified nutrient generation hotspots, and assigned the highest priority to the Lahaina Wastewater Reclamation Facility's injection wells; landscaping activities associated with the two Kā'anapali golf courses and those associated with resort, commercial, and residential uses were also identified as nutrient generation hotspots, though ranked at a lower priority (Sustainable Resources Group International, Inc. 2012).

Watershed management in West Maui has a robust history, and as efforts continue to improve watershed health and water quality, it becomes imperative that all stakeholders recognize their role and take part.

Appendix 3 A Deeper Dive Into the Science: How Nutrient Pollution Leads to Coral Death: The Coral Holobiont

Coral reefs are particularly susceptible to nutrient pollution because they have evolved to survive in very low-nutrient environments. Corals have numerous strategies for obtaining nutrients, especially nitrogen: they feed on planktonic creatures that contain nutrients; they harbor nitrogen-fixing bacteria; and they have a complex and specialized system of nitrogen recycling, involving the coordination of multiple species of bacteria that contribute to the whole coral colony (Rohwer 2010). These mechanisms make corals excellent competitors against more typical ocean inhabitants, such as algae—but only under their chosen conditions. When human activities result in increased levels of nitrogen and other nutrients in coastal ecosystems, they change the microbial playing field for all the species competing for survival within those systems.

The mechanism by which nutrient pollution leads directly to the loss of coral reefs has only recently been pieced together by researchers. Key to understanding it is the fact that corals live in a close relationship with the multitudes of bacteria and other microbes that inhabit the water, the surface of the coral, and even coral cells. There are so many microbes living within and on the coral, contributing to its survival, that a coral colony is really best thought of as a "holobiont," a term that encompasses the coral's polyps and structure, and also its symbiotic microbial affiliates (Rohwer 2010).

Under normal coral reef conditions, the coral holobiont is an efficient entity that shares molecular resources, such as nutrients and energy-rich sugars, and defends itself against attack from the primary killer of corals: diseases (Rohwer 2010). But when conditions change due to increases in nutrient inputs, the finely-honed system begins to fall apart. Firstly, the extra nutrients disrupt the coral holobiont's in-house nitrogen recycling system, actually reducing the amount of energy that the coral polyp cells receive from their symbiotic microbes (Rohwer 2010). This decreases their capacity to calcify, reproduce, or even function. Secondly, the nutrients permit the rapid growth of algae on the reef, which releases a compound into the water that encourages the growth of disease-causing microbes. These pathogenic bacteria, viruses, and fungi multiply on the surface of the coral, producing toxic compounds and consuming oxygen (Rohwer 2010). The ultimate effect is the suffocation and poisoning of the coral holobiont. The death of a coral colony then frees up space for more algae to grow, starting a feedback cycle that, if left unchecked, can destroy entire reef systems (Rohwer 2010).

Appendix 4 Additional Resources to Explore

- Coral Reef Alliance (CORAL):
  www.coral.org

- CORAL's companion page for this Resource Guide:
  www.coral.org/hawaiiwater (links to all these resources and more)

- Hawaiʻi Coral Reef Strategy
  http://www.hawaiicoralreefstrategy.com/

- West Maui Ridge to Reef Initiative
  www.WestMauiR2R.com

Rules And Regulations, Key Guidelines

- Maui County Code, Chapter 20.30 -
  USE OF RECLAIMED WATER
  http://library.municode.com/index.aspx?clientId=16289

- Rules for Relaimed Water Service
  Download PDF at www.coral.org/hawaiiwater

- State of Hawaiʻi Guidelines for the Treatment and Use of Recycled Water (2002):
  http://library.municode.com/index.aspx?clientId=16289

Cost to Retrofit Clause

- Hawaiʻi Administrative Rules – Chapter 11-62
  http://library.municode.com/index.aspx?clientId=16289

General

- Board of Water Supply, City and County of Honolulu
  http://www.hbws.org/cssweb

- County of Maui, Department of Environmental Management
  http://co.maui.hi.us/index.aspx?nid=114

- County of Maui Water Conservation website
  http://hi-mauicounty.civicplus.com/index.aspx?NID=227

- Department of Health—What You Can Do to Prevent Polluted Runoff:
  http://health.Hawaii.gov/cwb/site-map/home/polluted-runoff-control-program/what-you-can-do/

- Hawaiʻi Green Business program
  http://energy.Hawaii.gov/green-business-program/hgbp-program-description
  - Checklist For Hotels and Resorts: http://energy.Hawaii.gov/wp-content/uploads/2011/10/Hotel-Resort-Checklist-Fillable-8.23.2012.pdf
  - Awardees: http://energy.Hawaii.gov/green-business-program/hgbp-awardees

- Hawaiʻi Energy: Hotels
  http://www.hawaiienergyefficiency.com/56/hotels

- State of Hawaiʻi, Department of Health
  Clean Water Branch
  http://health.Hawaii.gov/cwb/

- State of Hawaiʻi Department of Health
  Wastewater Branch:
  http://health.Hawaii.gov/wastewater/
  http://health.Hawaii.gov/wastewater/home/forms

- West Maui Recycled Water Verification Study:
  http://hi-mauicounty.civicplus.com/documents/11/28/456/West%20Maui%20Recycled%20Water%20Verification%20Study%20012012_201301231924456443.pdf

Landscaping And Plants

- County of Maui's Landscape and Gardening Handbook—Water Conservation in the Landscape:
  http://www.co.maui.hi.us/documents/22/90/Handbook%20Publication.PDF

- Hawaiʻi Backyard Conservation:
  http://www.boardofwatersupply.com/cssweb/display.cfm?sid=1619

- The Landscape Industry Association of Hawaiʻi's list of invasive plants and industry guidelines:
  http://www.hawaiiscape.com/wp-content/uploads/2013/04/LICH_Invasive_Plant-_List_2009.pdf

- Managing Salinity of Recycled Water for Landscape Irrigation: The Link Between Plants, Soils, Salts, and Recycled Water:
  http://www.salinitymanagement.org/Salinity%20Brochure.pdf

- Maui Association of Landscape Professionals: http://www.malp.org/

- Native Plants Hawaiʻi (University of Hawaiʻi): http://nativeplants.Hawaii.edu/

- Plant Pono: http://www.plantpono.org

Scientific And Technical Resources

- US EPA Region 9: Link to groundwater tracer study http://www.epa.gov/region9/water/groundwater/uic-permits.html#lahaina

- EPA Nutrient Pollution website http://www2.epa.gov/nutrientpollution

Books

- Wastewater Reuse for Golf Course Irrigation Lewis Publishers USGA ISBN#1-56670-090-6

Other Local Conservation Efforts

- Kāʻanapali Makai Watch
  www.kaanapalimakaiwatch.com
  www.facebook.com/KaanapaliMakaiWatch

- West Maui Kumuwai Campaign
  www.westmauikumuwai.org

Appendix 5

Application And Checklist For Recycled Water Service

RW-1, Page 1

Submit to:

County of Maui
Wastewater Reclamation Division
2200 Main Street, Suite 610
Wailuku, HI 96793

Form RW-1

County of Maui

Application for Recycled Water Service

The user completes the following: (Please print or type)

Site Name: ______________________________

Project/Site Address: ______________________________

Tax Map Key: ______________________________

Property Owner(s): ______________________________

Mailing Address: ______________________________

Telephone: ______________ Work ______________ Residence

Leaseholder's Name (if applicable): ______________________________

Address: ______________________________

Telephone: ______________ Work ______________ Residence

Recycled Water Supervisor:

Name: ______________________________

Address: ______________________________

24-hour contact telephone number: ______________________________

Legal Description of Property: ______________________________

____

RW-1, Page 2

(Check each use)

1. Type of Use:

☐ Landscape irrigation ☐ Industrial Use ☐ Construction use

☐ Commercial Use ☐ Agricultural Use ☐ Other

2. Brief description of use(s): ____

3. Total irrigated area: _____ acres Types of plant material: _____

4. Estimated demand: Total quantity:_____ gallons/year

Max at POC: _____ Total gpm

Min. pressure:_____ psi .

Hours/Day:_____

Days/Week: _____

5. Number of service connection: _____ Number of meters requested:_____

Size of meters: _____

6. This is a: ______ new _____ converted system.

7. Are there special construction requirements? ☐Yes ☐No

If yes, explain: _____

____

____

8. Date desired to initiate service:_____

9. Duration of service ☐ temporary ☐ interim ☐other:

☐ construction use ☐ permanent

10. Additional information (Include special conditions affecting service):

____

____

RW-1, Page 3

Please include the following items:

a) Items to Be Submitted with the Initial Application:

I. A map, showing (1) the exact boundaries (azimuth-distance) of the proposed approved use area, (2) the irrigated or wetted areas and buffer zones, providing dimensions for both, and (3) the name or labels (e.g., clubhouse, single residential unit)of roads and structures. The structures and fenced area shall be labeled, e.g., residential, public access restrictive access.

II. Check or money order for required fees made out to:

"County Director of Finance"

b) Items to Be Submitted Subsequent to The Approval of The Application and Submittal Dates:

I. Basis-of-design report: ______________________________

II. Engineering design report: ______________________________

III. Plans and specifications: ______________________________

I, the user, have read and understand the County's Rules and Regulations for Recycled Water Service and the State of Hawaii Guidelines for the Treatment and Use of Recycled Water and agree to restrict recycled water use for the purposes described in this application. I agree to use recycled water in accordance with these Rules and Regulations and all other applicable documents. I understand the recycled water may not be compatible with certain types of vegetation because of its chemical composition. I agree that the County has provided estimates of chemical quality and that the County will not be liable for damages that may occur to vegetation or for damages which may occur due to uses of recycled water for purposes not included in this application.

User's signature:______________________________Date:________________

FORM RW-2

COUNTY OF MAUI

CHECKLIST FOR OBTAINING RECLAIMED WATER SERVICE

	Date Completed	Initialed	
1.	________	________	The user and the County determine if the site can now or will in the future be provided reclaimed water service.
2.	________	________	The user submits a completed application (RW-1) to the County.
3.	________	________	The County reviews the application and responds to applicant.
4.	________	________	Applicant submits Basis-of-Design Report. [a]
5.	________	________	County approves Basis-of-Design Report.
6.	________	________	State Department of Health approves Basis-of-Design Report.
7.	________	________	Applicant submits Engineering Design Report. [a]
8.	________	________	County approves Engineering Design Report.
9.	________	________	State Department of Health approves Engineering Design Report.
10.	________	________	Applicant submits plans and specifications. [a]
11.	________	________	County approves plans and specifications.
12.	________	________	State Department of Health approves plans and specifications.
13.	________	________	County determines appropriate fees.
14.	________	________	Applicant constructs facilities.
15.	________	________	Applicant submits as-built drawings to the County.
16.	________	________	Upon applicant's request, County and State Department of Health perform final inspection and operational testing, including cross-connection control inspection.
17.	________	________	Final inspection approval by the County.
18.	________	________	Final inspection approval by the State Department of Health.
19.	________	________	The County issues a user's permit.
20.	________	________	The County and the user initiate reclaimed water service.

This form is to be used by the County, the user, and the State Department of Health to track the process for obtaining reclaimed water service. County Wastewater Reclamation Division personnel should date and initial each step in the process.

[a] Documents must be submitted separately to the State Department of Health.

CORAL REEF ALLIANCE

www.coral.org