Olowalu Town
Wastewater Management Plan

August 2011

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Prepared for

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August 2011

THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION

	April 30, 2012
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List of Abbreviations

BNR	biological nutrient removal
BOD_5	5-day biochemical oxygen demand
DOH	State of Hawaii Department of Health
EIS	Environmental Impact Statement
FWS	free water surface
gpd	gallons per day
gph	gallons per hour
LEED	Leadership in Energy and Environmental Design
MBR	membrane bioreactor
MF	multi-family
ND	Neighborhood Development
NTU	nephelometric turbidity units
R-O-W	right-of-way
SF	single family
SCADA	supervisory control and data acquisition
TN	total nitrogen
TSS	total suspended solids
WWTP	wastewater treatment plant

Section 1

Introduction

1.1 Olowalu Town Master Plan

The Olowalu Town Master Plan is proposing to re-establish the once thriving village of Olowalu, located on the west side of the island of Maui. The subject property encompasses the lower coastal reaches of Olowalu ahupuaa; between the base of the south-west facing slopes of West Maui Mountains and the shoreline of Olowalu. Olowalu Town will be a small-scale and mixed-use community designed to be a pedestrian-friendly community which will allow residents to live within walking distance of corner stores, schools, parks, employment opportunities, community centers, beaches, and social and civic resources, ultimately reducing reliance on automobiles. The Master Plan is guided by values and principles of sustainability by balancing the needs of Maui's growing population; yet maintaining and respecting our cultural, historical and natural resources.

At final build-out, Olowalu Town will consists of approximately 1,500 residential dwelling units to be built concurrent with appropriate infrastructure in phases spread out over a period of approximately 10 years. There will be a wide variety of single-family and multi-family dwelling types, including houses, apartments, live-work units, cottages, rural homes and farmsteads, to be offered at a wide-range of income levels, including both rental and fee-ownership. A substantial portion of the homes are planned for much-needed affordable housing and senior living.

The design of Olowalu Town incorporates smart growth and sustainable land use principles of New Urbanism. As a result, Olowalu Town's spatial layout of land uses, varying density, connective transportation, parks/greenways, civic/social facilities, housing, employment and other land uses are balanced to create a mixed-use community. Neighborhood town centers provide economic sustainability with a range of business and employment opportunities. Olowalu Town is also designed to meet the certification requirements of *Leadership in Energy and Environmental Design for Neighborhood Development* (LEED ND). As such, the Master Plan will be built using strategies aimed at improving performance in regards to energy savings, water efficiency, reducing CO_2 emissions, improved indoor environmental quality, and stewardship of resources and sensitivity to their impacts.

Olowalu Town's proposed infrastructure improvements will be constructed concurrently with the project and will incorporate innovative, efficient, and sustainable technology to minimize adverse impacts upon the natural environment. Olowalu Town's Transportation system includes the relocation of the existing high speed/high volume Honoapiilani highway away from coastal resources to a new mauka alignment, which will be designed to accommodate mass transit or light rail, if needed in future. The existing highway corridor with monkey-pod trees will be preserved and converted to low speed/low volume coastal roadway. The project includes an internal roadway network, as well as, an assortment of interconnected greenways and bikeways links community and supports overall well-being and health of residents; reducing dependency on automobiles.

Additionally, other infrastructure system improvements will require an expansion of both the existing potable and non-potable water system, the likely addition of a second ground water well to supplement the existing well; and an extensive drainage system to capture storm-water runoff.

1.2 Olowalu Town Wastewater Management Planning

The residents and businesses at Olowalu Town will generate wastewater that will be managed in an environmentally-responsible manner. Olowalu Town's location adjacent to one of the most significant, accessible coral reef systems on the island of Maui dictates that a conservative, reliable, and appropriate wastewater management system be implemented. Wastewater typically contains nutrients that can either be an asset or a liability, depending on how the wastewater is managed. There is a growing concern on Maui that nutrients from all sources (including cesspools, septic tank systems, injection wells, agricultural runoff, and stormwater runoff) may have deleterious effects on near-shore reef systems. When the effects of global warming, invasive species and overfishing are added into the environmental scenario there are legitimate concerns for the continued health and well-being of the island's coral reef resources. The combination of all of the environmental stressors put coral reefs at risk of degradation. The Olowalu Town wastewater management plan has been developed with these concerns at the forefront, and effectively and appropriately establishes a system for responsible management of the community's wastewater.

The following goals were established when developing the Olowalu Town wastewater management plan:

- Do not rely on injection wells for effluent disposal purposes.
- Provide for a high degree of water recycling to make the best use of water resources.
- Incorporate nutrient removal technology to protect the environment.
- Incorporate natural treatment systems where feasible and appropriate.
- Use conservative planning assumptions to ensure a high factor of safety.
- Meet or exceed all regulatory requirements.

1.3 Water Recycling

Recycled water is highly treated wastewater that is suitable for non-potable uses like landscape irrigation. Recycled water production, distribution and use are regulated by the State of Hawaii Department of Health to protect public health and the environment. Recycled water is distributed for use through pipes that are completely separate from the potable water supply system. The recycled water piping and appurtenances are colored purple to clearly indicate that they are part of a recycled water system.

The Olowalu Town community will have a state-of-the-art wastewater treatment system that will produce recycled water that meets or exceeds the most stringent State water recycling requirements. The recycled water that is produced will be used to irrigate parks, school fields, highway landscaping, and agricultural fields. During the course of a typical year 90 percent or more of the Olowalu Town's wastewater is expected to be recycled for irrigation purposes, and during eight months of the typical year (March through October) it is anticipated that all of the community's wastewater will be recycled.

1.4 Integrated Water Resources Management

The Olowalu Town wastewater management system will be part of the integrated water resources system that will meet the needs of the community. The integrated water resources system includes:

- Potable groundwater resources
- Non-potable groundwater resources
- Surface water resource
- Recycled water resource

These four water resources will meet the water supply needs of the community, through three separate distribution systems: potable, non-potable, and recycled water. Therefore, the wastewater management system is designed to use the community's wastewater as an integral part of the community's overall water supply portfolio.

1.5 Nutrient Management

The nutrients found in wastewater can either be an asset or a liability, depending on how they are managed. Living things need nutrients to grow. Nutrients can be an asset when they are present in recycled water that is used for irrigation purposes, because the nutrients act as fertilizer for the vegetation that is being irrigated and reduce or eliminate the need for chemical fertilization. Nutrients can be a liability if they are released into an aquatic environment, because they can support the growth of excessive amounts of algae, causing deleterious effects.

The Olowalu Town wastewater management system has been designed to use wastewater nutrients where they will be an asset, while also reducing the nutrient concentrations as needed to prevent them from being an environmental liability. The wastewater management system includes:

- Biological nutrient removal in the wastewater treatment plant to reduce nutrient concentrations in the recycled water to a level where the recycled water will meet all or most of the fertilizer needs of the irrigated vegetation.
- Natural treatment systems to provide additional polishing treatment of any excess recycled water that requires disposal.

1.6 Natural Treatment Systems

The Olowalu Town wastewater management system will include two natural treatment systems designed to protect the environment by providing additional treatment benefits in the process of disposing of excess recycled water. Natural wastewater treatment systems are processes that depend primarily on natural components (e.g., vegetation, soil, etc.) to achieve the intended results, rather than energy-intensive mechanical equipment. The natural treatment systems include a constructed wetland and a soil aquifer treatment system.

The constructed wetland will provide additional polishing treatment benefits of excess recycled water while also creating bird habitat and a public amenity. Constructed wetlands are treatment systems based on emergent aquatic vegetation like reeds, rushes, and bulrush. Recycled water will be treated as it flows through the Olowalu Town constructed wetland. The polishing treatment benefits that can be realized in constructed wetlands include reduction of nutrients, trace heavy metals, and trace organic compounds prior to disposal. Constructed wetlands can be designed with open water areas designed to attract birds. The Olowalu Town residents will also be attracted to the constructed wetland by the walking paths around the system designed to allow them to view the wildlife. Figure 1-1 is a photo of a constructed wetland in Arcata, California.

A soil aquifer treatment system will be used to dispose of excess recycled water after it has received the additional treatment benefits that the constructed wetland will provide. The soil aquifer treatment system will consist of several shallow basins with earth or sand bottoms. During most months of the year the basins will be dry, but during wet winter months there may be excess recycled water that will flow to the soil aquifer treatment system. Additional treatment benefits – including reduction of nutrients, trace heavy metals, and trace organic compounds – will be realized as the applied water percolates through the media in the bottom of the basins.

Figure 1-1. A Constructed Wetland for Wastewater Treatment

1.7 Report Organization

This report presents the wastewater management system planned for Olowalu Town. Section 2 presents wastewater flow and load projections for the community. Section 3 provides an overview of the proposed wastewater management system. The proposed wastewater treatment plant is described in Section 4. Section 5 provides important general background information on water recycling, while Section 6 provides specific water recycling analysis results for the Olowalu Town community. Section 7 outlines the management system that will be put into place to ensure water recycling program success. Section 8 outlines the natural treatment systems that will be used to treat and dispose of excess recycled water, and Section 9 provides overall conclusions.

Section 2

Wastewater Flow and Load Projections

This section contains projections of the anticipated wastewater flow and loads for the Olowalu Town development.

2.1 Basis of Flow Projections

Wastewater flow projections were developed using County of Maui Standards (County of Maui Wastewater Reclamation Division, February 2, 2006). The flow standards are conservative, and experience has shown that actual wastewater flows are generally lower than the standards suggest. However, because wastewater treatment incorporates biological treatment processes that are subject to upset if overloaded, the use of conservative flow estimates is appropriate.

Table 2-1 summarizes the unit flows applicable to the Olowalu Town development.

Table 2-1. County of Maui Wastewater Flow Standards

Description	Value	Units
Apartment/condominium	255	gallons per unit per day
Office	20	gallons per employee per day
Residence, subdivision	350	gallons per home per day
Residential occupancy	4	persons per unit
Apartment/condominium occupancy	2.5	persons per unit
Office employees	0.005	employees per square foot of floor area (1 employee per 200 square feet of floor area)
Dry weather infiltration/inflow [a]	5	gallons per capita per day
Wet weather infiltration/inflow [a]	1250	gallons per acre per day

[a] *Wastewater transmission lines laid above the ground water table*

2.2 Development Characteristics

The development plans call for a maximum of 1,500 residential units. The split between single family residential and multifamily residential will be determined by market conditions at the time of development, within the ranges established in the Environmental Impact Statement (EIS). In the interest of conservatism, the housing portfolio that results in the greatest wastewater flow (e.g., maximum number of single family residences) was used for wastewater management planning purposes, as shown in Table 2-2.

Table 2-2. Unit Count Used for Wastewater Management Planning Purposes	
Description	Value
Single family residential	920 units
Multi-family residential	580 units
Commercial, retail, business	300,000 square feet

2.3 Average Dry Weather Flow Projections

The average dry weather wastewater flow projections at buildout are summarized in Table 2-3.

Table 2-3. Average Dry Weather Flow Projections at Buildout	
Source	Flow (gpd)
Residential	470,000
Commercial, retail, business	23,000
Infiltration/inflow	32,000
Total	525,000

Figure 2-1 presents the projected increase of the average dry weather wastewater flow over time, assuming a 10-year, constant rate buildout period.

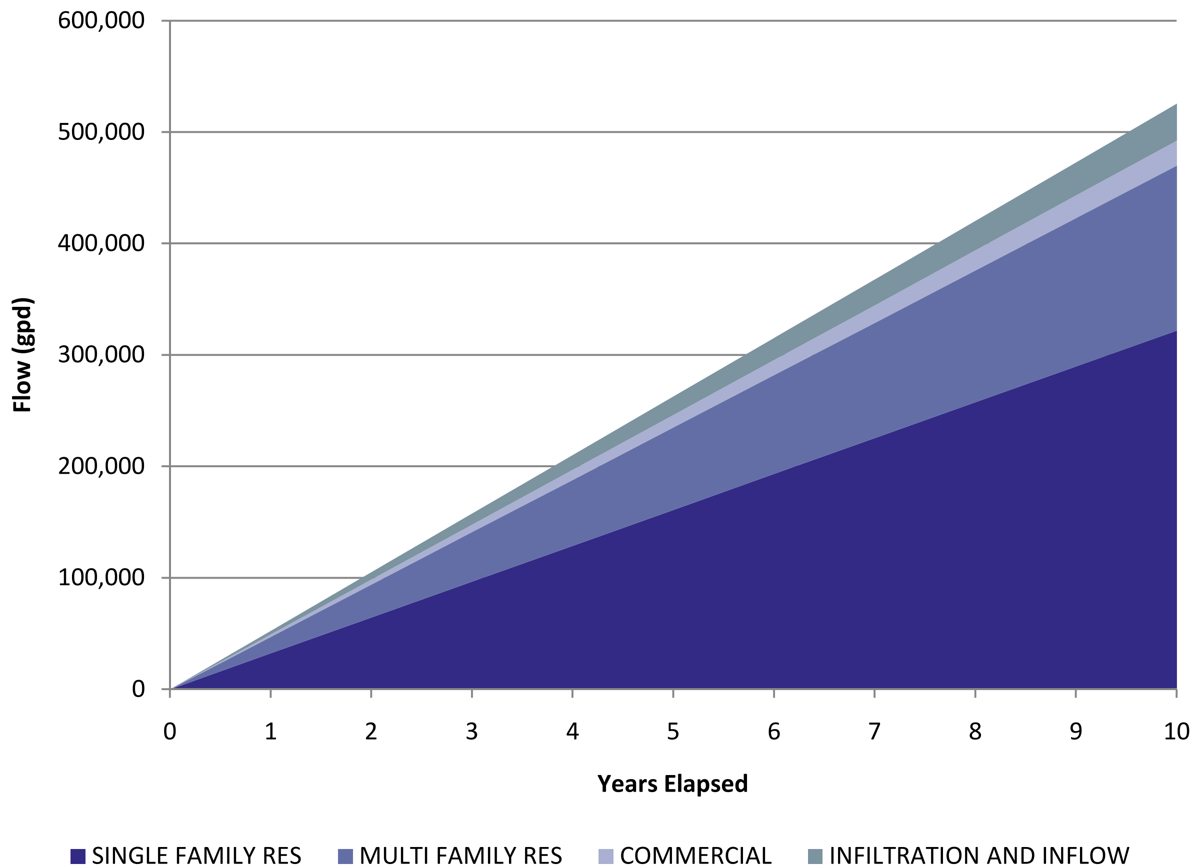

Figure 2-1. Olowalu Town Projected Average Dry Weather Wastewater Flow

2.4 Peak Flow Projections

In addition to average flows, peak day and hour flows are also important for wastewater planning and design purposes.

The peak day dry weather flow was obtained through application of an industry-accepted, published peaking factor. For Olowalu Town, a peak day dry weather peaking factor of 2.5 is appropriate (Crites and Tchobanoglous, 1998).

The peak hour dry weather flow peaking factor of the development is obtained using the Babbitt equation, as required by the County of Maui wastewater flow standards (County of Maui Wastewater Reclamation Division, February 2, 2006). The Babbitt equation is:

$$MF = \frac{5}{p^{0.2}}$$

Where: MF = Maximum flow peaking factor

p = Population, in thousands

The County of Maui wastewater flow standards (County of Maui Wastewater Reclamation Division, February 2, 2006) dry and wet weather infiltration/inflow allowances were then added to obtain the peak flow projections. The peak flow projections are summarized in Table 2-4.

Table 2-4. Peak Flow Projections	
Description	Flow (million gallons per day)
Peak day dry weather	1.26
Peak hour dry weather	1.72
Peak day wet weather	2.01
Peak hour wet weather	2.46

2.5 Wastewater Characteristics

Estimates of the strength of the wastewater entering the WWTP (influent) is important for liquid and solids treatment process design of the WWTP. Important characteristics include the concentration of 5-day biochemical oxygen demand (BOD_5), total suspended solids (TSS), and total nitrogen (TN). BOD_5 and TSS are measures of the organic strength of the wastewater. TN is a measure of the nutrient content of the wastewater, and is important for effluent management planning purposes. Table 2-5 presents the influent characteristics assumptions.

Table 2-5. Influent Wastewater Characteristics Assumptions	
Parameter	Concentration (mg/L)
BOD_5	350
TSS	350
TN	60

2.6 Summary of Flows and Loads

Table 2-6 provides a summary of the flows and loads used for planning purposes.

Table 2-6. Influent Wastewater Characteristics					
Flow Condition	Flow		Mass Loading (lbs/d)		
	(mgd)	(gpm)	BOD_5	TSS	TN
Average day dry weather	0.525	370	1,530	1,530	260
Peak day dry weather	1.26	880	3,690	3,690	630
Peak hour dry weather	1.72	1,190	-	-	-
Peak hour wet weather	2.46	1,710	-	-	-

Section 3

Olowalu Town Wastewater Management System Overview

3.1 Planning Goals

The following goals were used when developing the Olowalu Town wastewater management plan:

- Do not rely on injection wells for effluent disposal purposes.
- Provide for a high degree of water recycling to make the best use of water resources.
- Incorporate nutrient removal technology to protect the environment.
- Incorporate natural treatment systems where feasible and appropriate.
- Use conservative planning assumptions to ensure a high factor of safety.
- Meet or exceed all regulatory requirements.

3.2 Wastewater Management System Overview

Figure 3-1 is a schematic of the proposed Olowalu Town wastewater management system.

Wastewater generated by Olowalu Town will be collected and pumped to a WWTP, where the wastewater will be treated to State of Hawaii R-1 recycled water standards and TN reduced to less than 10 mg/L. The R-1 water will be pumped to a storage tank for irrigation use. Supplemental groundwater will be added to the storage tank when the R-1 recycled water supply is insufficient to meet the irrigation demands of the users.

During wet weather periods there may be excess recycled water that will require disposal. Excess recycled water will receive additional treatment in a constructed wetland, reducing the TN concentration below 5 mg/L. After the excess recycled water passes through the wetland, it will be flow to a soil aquifer treatment (SAT) system for disposal.

Each element of the wastewater management system is described in more detail in subsequent sections. Figure 3-2 shows the preliminary locations for the facilities.

3.3 Wastewater System Ownership and Operation

The wastewater system will be owned and operated by a private utility company, regulated by the State of Hawaii Public Utilities Commission and the State of Hawaii Department of Health (DOH).

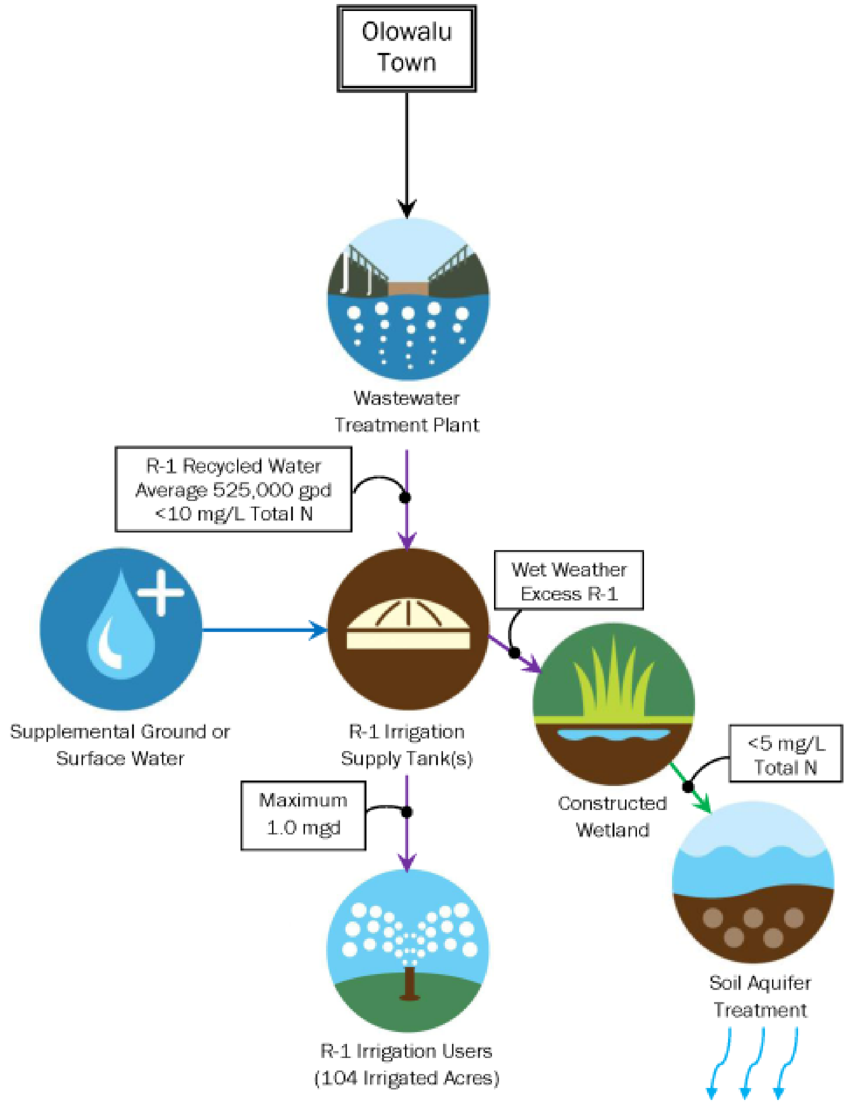

Figure 3-1. Schematic of Olowalu Town Wastewater Management System

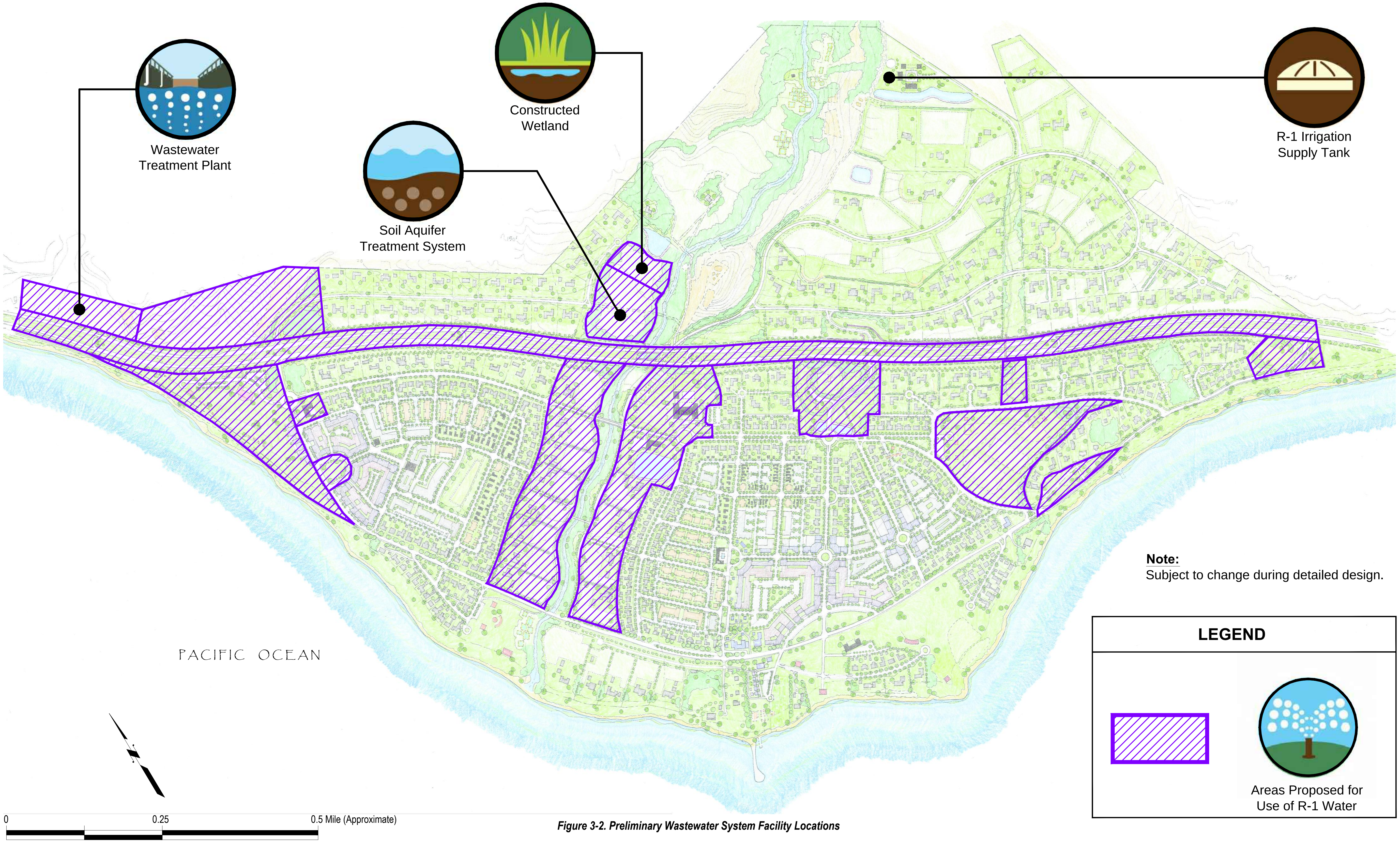

Figure 3-2. Preliminary Wastewater System Facility Locations

Section 4

Wastewater Treatment Plant

A wastewater treatment plant will be constructed within Olowalu Town to meet the needs of the community, as described in this section. The proposed WWTP location was shown in Figure 3-2.

4.1 Treatment Objectives

The wastewater treatment plant will be designed to provide a high level of treatment. The two treatment objectives are:

1. Produce recycled water that meets or exceeds State of Hawaii R-1 recycled water standards. R-1 water is treated effluent that is at all times:
    - Oxidized,
    - Filtered, and
    - Disinfected to median fecal coliform density less than 2.2 per 100 mL
2. Reduce TN concentrations to 10 mg/L or less to protect the environment.

4.2 Wastewater Treatment Processes

A number of wastewater treatment processes were considered for Olowalu Town, including:

- Membrane bioreactor (MBR) with biological nutrient removal (BNR)
- BNR activated sludge followed by coagulation and filtration
- Recirculating gravel filters
- Biotextile filters
- Vertical flow wetlands

The discussion that follows assumes that a MBR facility is constructed; however, other processes may be incorporated during the design process that can meet the treatment objectives. Figure 4-1 is a conceptual site plan for the WWTP. Each WWTP element is discussed below.

KEY

1	HEADWORKS	7	UV DISINFECTION
2	BIOFILTER	8	EFFLUENT PUMP STATION
3	EQUALIZATION BASINS	9	SLUDGE DEWATERING
4	AEROBIC SLUDGE DIGESTER	10	OPERATIONS BUILDING
5	MEMBRANE BIOREACTOR	11	EMERGENCY STORAGE BASIN
6	PLANT DRAIN PUMP STATION		

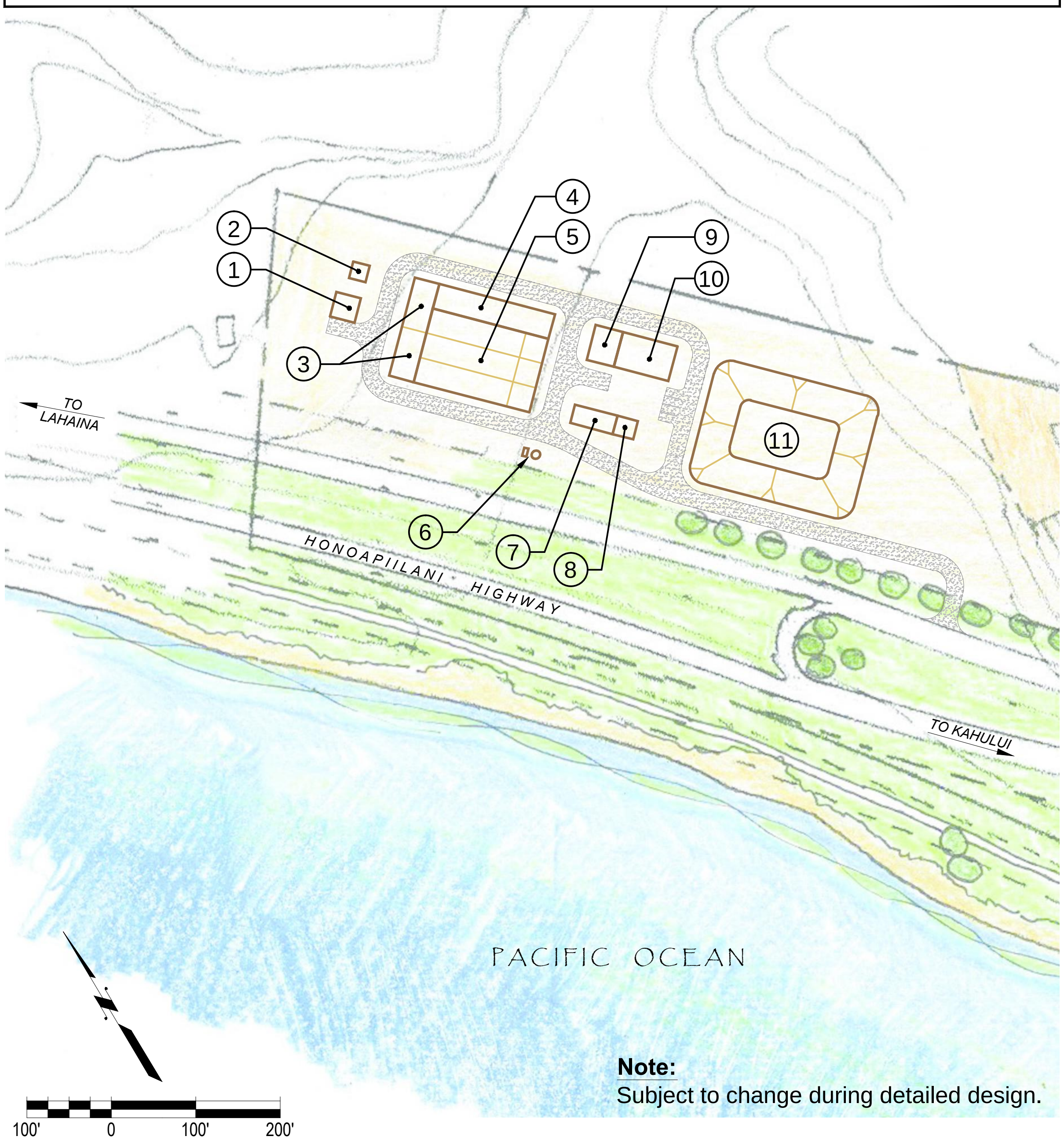

Figure 4-1 Conceptual Wastewater Treatment Plant Site Plan

4.3 Liquid Treatment

The liquid treatment processes are described below.

4.3.1 Headworks

Raw wastewater will enter the WWTP at the headworks, where it will receive preliminary treatment, including:

Influent flow measurement: Continuous influent flow measurement using a Parshall flume, magnetic flow meter, or another suitable device.

Influent sampling: A refrigerated automatic sampler will be provided to allow flow-paced influent composite or discrete sampling.

Coarse screening: Coarse screening to remove large debris.

Fine screening: Fine screening to remove hair and other small debris that can foul the downstream MBR process.

Grit removal: Grit removal to inorganic particles (e.g., sand, coffee grounds, etc.) that can cause premature wear of downstream equipment.

The headworks will be enclosed to facilitate foul air collection. Screenings and grit will be disposed at the Central Maui Landfill.

4.3.2 Equalization Basins

Aerated basins will be provided to equalize the flow rate through the downstream processes.

4.3.3 Membrane Bioreactor

The membrane bioreactor will provide secondary, tertiary, and BNR treatment functions. The MBR process consists of tanks with aerobic and anoxic zones to facilitate biological nutrient removal. Naturally-occurring microorganisms oxidize carbonaceous matter and provide nitrification and denitrification functions. The clean water is separated from the treatment biomass (activated sludge) using microfiltration membranes. The effluent from the MBR process will contain 10 mg/L of TN or less and will have turbidity less than 2.0 nephelometric turbidity units (NTU). Effluent turbidity levels will be continuously monitored to comply with DOH requirements, and if turbidity rises above regulatory limits the effluent will be automatically diverted to the emergency storage basin and an alarm condition will alert the WWTP operators.

4.3.4 UV Disinfection

The treated effluent will be disinfected using UV light. The water will flow through a channel containing UV light bulbs. The UV dose will be sufficient to reduce the median fecal coliform density to less than 2.2 per 100 mL. The UV intensity will be continuously monitored to comply with DOH requirements, and if the UV dose decreases below required levels the effluent will be automatically diverted to the emergency storage basin and an alarm condition will alert the WWTP operators.

After the water has passed through the disinfection process it will meet the R-1 recycled water standards and will contain 10 mg/L or less of TN.

4.3.5 Effluent Pump Station

An effluent pump station will be used to transport the R-1 water to the storage tank. The pump station will include and effluent flow meter and refrigerated composite sampler.

4.3.6 Emergency Storage Basin

A lined open basin will be provided to store water that does not meet R-1 water recycling specifications. Water that enters the emergency storage basin will be pumped back to the treatment process for reprocessing after the deficient treatment condition(s) have been corrected.

4.4 Solids Treatment

Treatment of the residual solids is described below.

4.4.1 Aerobic Digester

Waste solids from the MBR process will be pumped to an aerobic digester, where the solids will receive additional aerobic stabilization and will be thickened via periodic settling and decanting. The solids residence time in the aerobic digester will be 20 days or greater.

4.4.2 Solids Dewatering

The aerobically digested solids will be mechanically dewatered using centrifuges, belt filter presses, screw presses, or other suitable dewatering technology. The dewatered solids will be hauled by truck to the Central Maui Landfill for co-composting with green waste.

4.5 Ancillary Systems

Ancillary systems are described below.

4.5.1 Operations Building

The WWTP will include an operations building to provide employee work space, restrooms, a small process control laboratory, and an electrical equipment room. The solids dewatering system and emergency generator will likely be located in the operations building.

4.5.2 Control System

A supervisory control and data acquisition (SCADA) system will be provided to control the WWTP processes and alert the WWTP operators when an alarm condition occurs.

4.5.3 Emergency Power

An emergency generator will be included to power the WWTP processes in the event of a power failure.

4.5.4 Plant Drain Pump Station

The process tank drains, operations building sewer, and emergency storage basin will be connected to the plant drain pump station that will pump the liquids to the headworks for treatment.

4.5.5 Utility Water Pump Station

A utility water pump station will be provided to deliver R-1 water for in-plant uses like foam sprays, grit and screenings washers, and landscape irrigation.

4.6 Other Considerations

Other important considerations for wastewater treatment plants include odor control, drainage and flood protection, tsunami protection, and visual mitigation.

4.6.1 Odor Control

Wastewater treatment plants can be a source of nuisance odors to the surrounding community if not properly designed and/or operated. Not all processes with a wastewater treatment plant generate odors; nuisance odors are most commonly associated with anaerobic (without oxygen) conditions and with residual solids processing.

The headworks is commonly an odorous process area at wastewater treatment plants because incoming raw wastewater can be anaerobic and the screening and grit removal processes involve solids processing. The Olowalu Town wastewater treatment plant headworks will be enclosed to facilitate foul odor collection. The air removed from the building will be treated in an odor control biofilter (or similar process). Biofilters consist of an engineered bed of compost with distribution piping. The foul air is treated as it flows through the compost media. Biofilters are capable of removing hydrogen sulfide (H_2S) and a wide variety of other odorous compounds from the air.

The liquid treatment processes within the wastewater treatment plant will not be a source of nuisance odors because the process tanks will be aerated to maintain dissolved oxygen concentrations at approximately 2.0 mg/L or greater at all times. Waste solids will be pumped to an aerobic digester for stabilization. The dissolved oxygen concentration in the aerobic digester will be maintained at 2.0 mg/L or greater at all times by aeration. The WWTP will include at least one redundant blower for each aeration system to ensure that aeration air can be provided at all times.

The solids dewatering process is another potential source of odors. The dewatering equipment will be enclosed in a room to facilitate foul air collection. The foul air will be routed to a biofilter for treatment.

4.6.2 Drainage and Flood Protection

Stormwater originating mauka of the wastewater treatment plant parcel will be routed around or piped under the facility to preclude flooding. Stormwater originating on the wastewater treatment plant parcel will be collected and held in an onsite retention basin or will be connected to the stormwater system that is developed for the rest of the Olowalu Town development project.

The tops of the wastewater treatment plant process tanks will set above the 100-year flood elevation to prevent stormwater from entering the tanks, in accordance with State regulations.

4.6.3 Tsunami Protection

The Olowalu Town wastewater treatment plant will be constructed outside of the tsunami inundation zone.

4.6.4 Visual Mitigation

The Olowalu Town wastewater treatment plant will be designed to mitigate visual impacts from the adjacent highway. The visual mitigation measures may include:

- Installation of landscaping like trees and/or hedges
- Visual mitigation berms or walls
- Enclosing process equipment or tanks within structures that are architecturally-consistent with the community.

Section 5

Water Recycling Background

The Olowalu Town Wastewater Management System will incorporate a high level of water recycling. This section introduces recycled water concepts and State DOH recycled water requirements.

5.1 Recycled Water Terminology

The term "recycled water" refers to treated wastewater that is suitable for beneficial use. The term "recycled water" is synonymous with the terms "reclaimed water" and "treated effluent."

The terms "water recycling", "water reclamation", and "water reuse" all refer to the use of recycled water for appropriate beneficial purposes. The terms "recycled water" and "water recycling" will be used in this report from this point forward for consistency with general industry practice and DOH regulations.

5.2 Types of Recycled Water

DOH has developed regulations and guidelines to ensure the protection of public health and the environment when recycled water is used. DOH has established three classifications for recycled water within Hawaii, based on the level of treatment provided as summarized in Table 5-1. Recycled water meeting the R-1 requirements has received the highest level of treatment of the three categories. The water recycling assessment presented in this section is based on treatment of Olowalu Town wastewater to meet or exceed R-1 recycled water standards.

Table 5-1. Recycled Water Classifications

Classification	Alternate Designation	Summary of Required Treatment
R-1	Significant reduction in viral and bacterial pathogens	• Oxidized • Filtered • Disinfected to median fecal coliform density less than 2.2 per 100 mL
R-2	Disinfected secondary-23 recycled water	• Oxidized • Disinfected to median fecal coliform density less than 23 per 100 mL
R-3	Undisinfected secondary recycled water	• Oxidized

5.3 Recycled Water Uses

The acceptable uses for recycled water are directly linked to the amount of treatment the water has received; higher levels of treatment results in fewer restrictions on use. Acceptable uses for R-1 water are summarized in Table 5-2.

Table 5-2. R-1 Recycled Water Uses

Landscape Irrigation	Agricultural Irrigation	Industrial	Other
• Golf courses • Parks • Playgrounds • School yards • Athletic fields • Road sides and medians • Residential property (if managed by an irrigation supervisor)	• Food, fodder, and fiber crops • Ornamental crops • Pasture, including milking animals • Drinking water for animals (except dairy animals) • Vineyards and orchards	• Fire fighting from outdoor hydrants, fire trucks, or aircraft • Cooling saws while cutting pavement • Spray washing of electric insulators on utility poles • High pressure water blasting to clean surfaces • Commercial and public laundries • Industrial cooling • Industrial process water • Fish hatchery basin supply	• Toilet and urinal flushing in buildings with dual water systems • Decorative fountains • Restricted recreation impoundments (non-body contact activities) • Washing of parking lots and sidewalks • Street sweeping • Dust control • Water jetting of pipelines during construction • Earthwork

5.4 Regulatory Requirements

The production and use of recycled water is regulated by the DOH. The DOH has established requirements applicable to facilities producing recycled water and for systems used to convey recycled water to points of use. In addition, the DOH has established requirements applicable to sites where recycled water is used. Applicable requirements are briefly summarized below.

5.4.1 Recycled Water Production Requirements

The DOH has established minimum requirements for wastewater treatment facilities that produce recycled water, as briefly summarized in Table 5-3.

Table 5-3. Summary of Recycled Water Production Requirements

Category	Summary of Requirements
Treatment process design	Specific requirements are established for unit process design, including: • Chemical mixing • Flocculation • Filtration • Disinfection
Permitting	A permit must be obtained from DOH to construct and operate a recycled water facility. The application process includes submittal of a basis of design report that describes the facility in detail.
Monitoring and reporting	Process monitoring is required to demonstrate compliance with recycled water quality requirements. Results must be periodically reported to DOH.
Reliability	Requirements are established to ensure the reliability of the recycled water production facility, including: • Multiple process units are required to ensure continued operations when units are taken out of service for maintenance • Standby power is required to ensure continued operation if the primary power source fails • Emergency storage or disposal provisions must be provided to manage water that does not meet R-1 standards
Alarms	Appropriate alarm systems must be provided to alert the facility operators of abnormal conditions.

Source: DOH, May 15, 2002

5.4.2 Recycled Water Distribution Requirements

Recycled water is distributed in piping systems that are completely separate from potable water distribution piping systems. The DOH has established requirements for piping systems used to distribute recycled water to the points of use. The requirements are designed to reduce the risk of accidental cross-connection between potable and non-potable systems. The requirements are briefly summarized in Table 5-4.

Table 5-4. Summary of Recycled Water Distribution Requirements	
Category	Summary of Requirements
Piping materials	Pipes carrying recycled water are colored purple or are marked with purple identification tapes.
Separation distances	Minimum horizontal and vertical separation distances between potable and non-potable distribution piping have been established.
Valve boxes	Valve boxes for recycled water distribution systems must be shaped and labeled differently from those for potable water distribution systems.
Above ground appurtenances	Above-ground piping and appurtenances for recycled water distribution systems are colored purple or are clearly marked to differentiate them from potable water systems.
Supplemental water connections	An air gap must be provided where potable water will be used to supplement recycled water supplies. The air gap prevents recycled water from entering the potable water system.
Hose bibs	Hose bibs are not allowed on recycled water systems. Quick couplers may be used on recycled water systems, but they must be of different design than those used on the potable water system, and appropriate signs must be provided. Hoses used with recycled water systems must be colored purple and will not be used with potable systems.

Source: DOH, May 15, 2002

5.4.3 Recycled Water Use Requirements

DOH also regulates recycled water at the point of use. Table 5-5 provides a brief summary of some of the requirements.

Table 5-5. Summary of Recycled Water Use Requirements	
Category	Summary of Requirements
Permitting	A permit must be obtained from DOH to construct and operate a recycled water project; i.e., a site where recycled water will be used. The application process includes submittal of report(s) that describes the reuse area, systems, and procedures in detail.
Irrigation	An irrigation plan must be submitted to DOH. The amount of irrigation water applied must be tailored to the needs of the vegetation. Runoff and ponding must be minimized. Recycled water spray must be kept away from drinking fountains and food preparation and eating areas.
Management	A management plan must be submitted to DOH. The management plan delineates the responsibilities for operation and maintenance of the reuse system. The management plan includes designation of the recycled water user supervisor for the site.
Public education	A public education plan must be prepared. The public education plan establishes how persons at the site will be informed of the use of recycled water, including appropriate signs, public information tours, etc.
Employee training	An employee training plan must be prepared. Employees must be trained in recycled water use procedures.
Vector control	If recycled water is to be stored in an impoundment or constructed wetland then a vector control plan must be prepared that addresses mosquito control measures.

Section 6

Olowalu Town Recycled Water Irrigation Analysis

The primary use of recycled water at Olowalu Town will be for irrigation purposes. This section provides a detailed analysis of irrigation with recycled water at Olowalu Town.

6.1 Irrigation Needs Estimates

Irrigation is the most common use for recycled water. Irrigation needs are a function of the site climate and the type of vegetation that is irrigated. Recycled water will be used to irrigate Olowalu Town park fields and landscape, school fields and landscape, streetscapes, and agricultural lots. The vegetation for these areas will consist largely of native plants, turf and ornamental plantings. Vegetation uses water to survive and grow, through a process called "evapotranspiration". Irrigation water must be applied to meet the evapotranspiration rate of the vegetation, minus any precipitation. During wet years less irrigation water is required, compared to average or dry years. Average and wet year irrigation needs are developed below.

6.1.1 Average Year Irrigation Needs

Table 6-1 presents the estimated Olowalu Town irrigation needs during an average precipitation year. Evapotranspiration estimates are developed by applying appropriate coefficients to pan evaporation data obtained from weather stations. The irrigation need for a given month is the estimated evapotranspiration minus the precipitation, multiplied by appropriate factors to account for irrigation distribution efficiency and the need to slightly over-irrigate to leach applied salts below the root zone of the crop.

Table 6-1. Average Precipitation Year Irrigation Demand					
Month	Precipitation [a] (inches)	Pan Evaporation [b] (inches)	Evapotranspiration [c] (inches)	Estimated Irrigation Needs [d]	
				(inches)	(gpd/acre)
January	3.16	5.95	5.36	3.02	1,927
February	1.86	5.95	5.36	4.81	3,867
March	1.40	6.80	6.12	6.49	4,866
April	0.54	6.80	6.12	7.67	6,098
May	0.35	8.50	7.65	10.0	7,768
June	0.03	7.65	6.89	9.43	7,579
July	0.05	8.50	7.65	10.5	8,129
August	0.08	8.50	7.65	10.4	8,093
September	0.15	7.65	6.89	9.26	7,430
October	0.81	6.80	6.12	7.30	5,576
November	1.43	5.95	5.36	5.40	4,144
December	2.40	5.10	4.59	3.01	2,023
Totals	**12.26**	**84.15**	**75.74**	**87.28**	**77,824**

[a] *Source: NOAA, April 2005. Station 296.1, Olowalu. Period of record 1971-2000.*

[b] *Source: Engott and Vana, 2007.*

[c] *Assumes pan coefficient = 1.0 and crop coefficient = 0.90 to represent a mixture of park landscape and agricultural crops.*

[d] *Assumes irrigation efficiency = 80 percent and leaching fraction = 10 percent.*

Figure 6-1 presents the data from Table 6-1 in graphical form. The figure shows that peak irrigation needs occur during the dry summer months, and significantly less irrigation is required during the wet winter months.

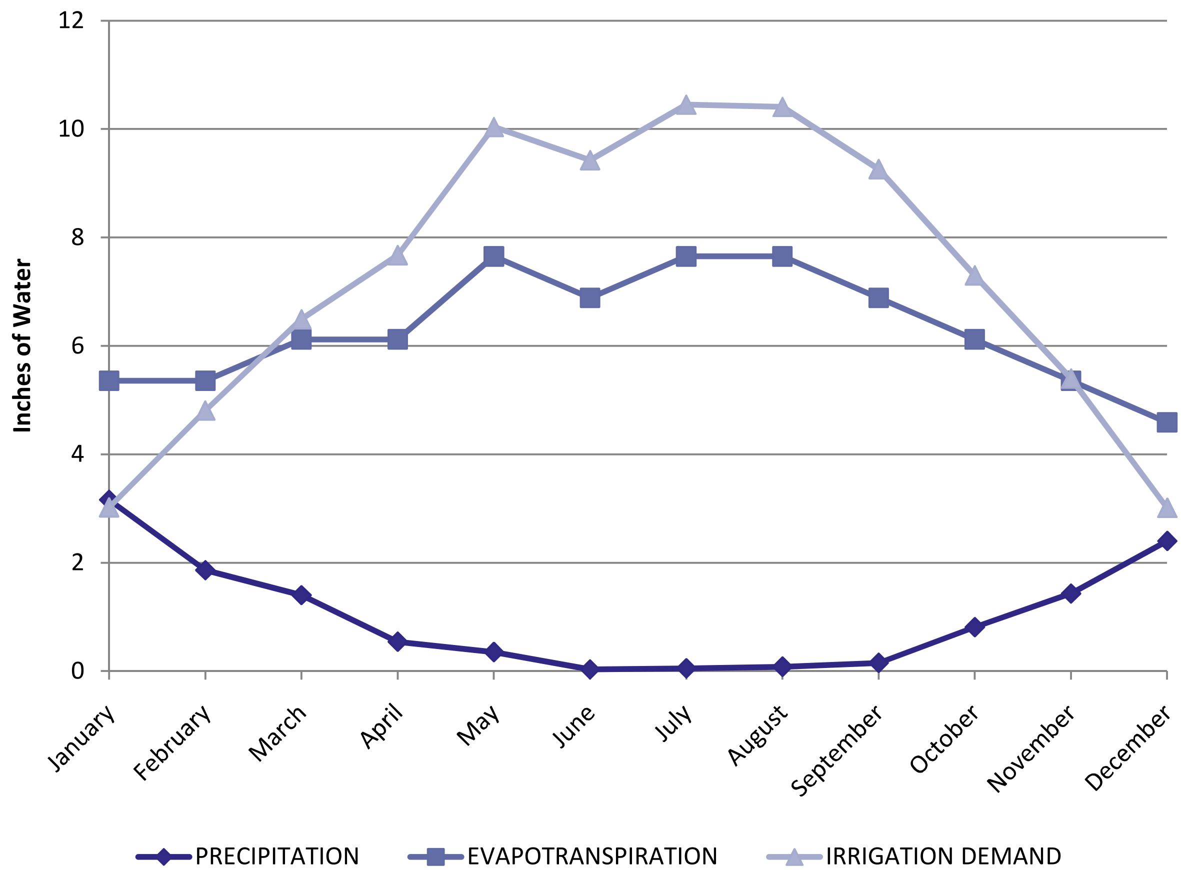

Figure 6-1. Average Year Irrigation Demand

6.1.2 Wet Year Irrigation Needs

Less irrigation water is required during years with above-average precipitation. Statistics are used to evaluate the probability of high precipitation occurring in a given year. For purposes of this water recycling analysis, a wet year will be defined as having a 5 percent probability of occurring during a given year. This can also be called "20-year" annual precipitation, because the probability of occurrence in any given year is one in twenty. Table 6-2 provides an estimate of the 20-year annual precipitation for the site and estimates of the corresponding irrigation needs.

Month	Precipitation [a] (inches)	Pan Evaporation [b] (inches)	Evapotranspiration [c] (inches)	Estimated Irrigation Needs [d]	
				(inches)	(gpd/acre)
January	6.43	5.95	5.36	0	0
February	3.60	5.95	5.36	2.42	2,345
March	2.77	6.80	6.12	4.61	4,037
April	1.26	6.80	6.12	6.68	6,045
May	0.99	8.50	7.65	9.16	8,025
June	0.11	7.65	6.89	9.32	8,435
July	0.13	8.50	7.65	10.3	9,057
August	0.23	8.50	7.65	10.2	8,942
September	0.40	7.65	6.89	8.92	8,070
October	2.16	6.80	6.12	5.45	4,771
November	3.07	5.95	5.36	3.15	2,848
December	5.61	5.10	4.59	0	0
Totals	**26.74**	**84.15**	**75.74**	**70.25**	**62,576**

Table 6-2. Wet Precipitation Year (1 in 20) Irrigation Demand

[a] *Source: NOAA, April 2005. Station 296.1, Olowalu. Period of record 1971-2000.*

[b] *Source: Engott and Vana. 2007.*

[c] *Assumes pan coefficient = 1.0 and crop coefficient = 0.90 to represent a mixture of park landscape and agricultural crops.*

[d] *Assumes irrigation efficiency = 80 percent and leaching fraction = 10 percent.*

Figure 6-2 presents the data from Table 6-2 in graphical form. Note that during the month of January there is no need to apply irrigation water, because the amount of precipitation exceeds the evapotranspiration needs of the vegetation. The implication is that during periods of wet weather there can be little or no demand for recycled water, and the recycled water that is produced during those periods must be disposed of in some manner. The Olowalu Town wastewater management system includes natural treatment systems (described in Section 8) to provide an environmentally sound method for disposing of excess recycled water.

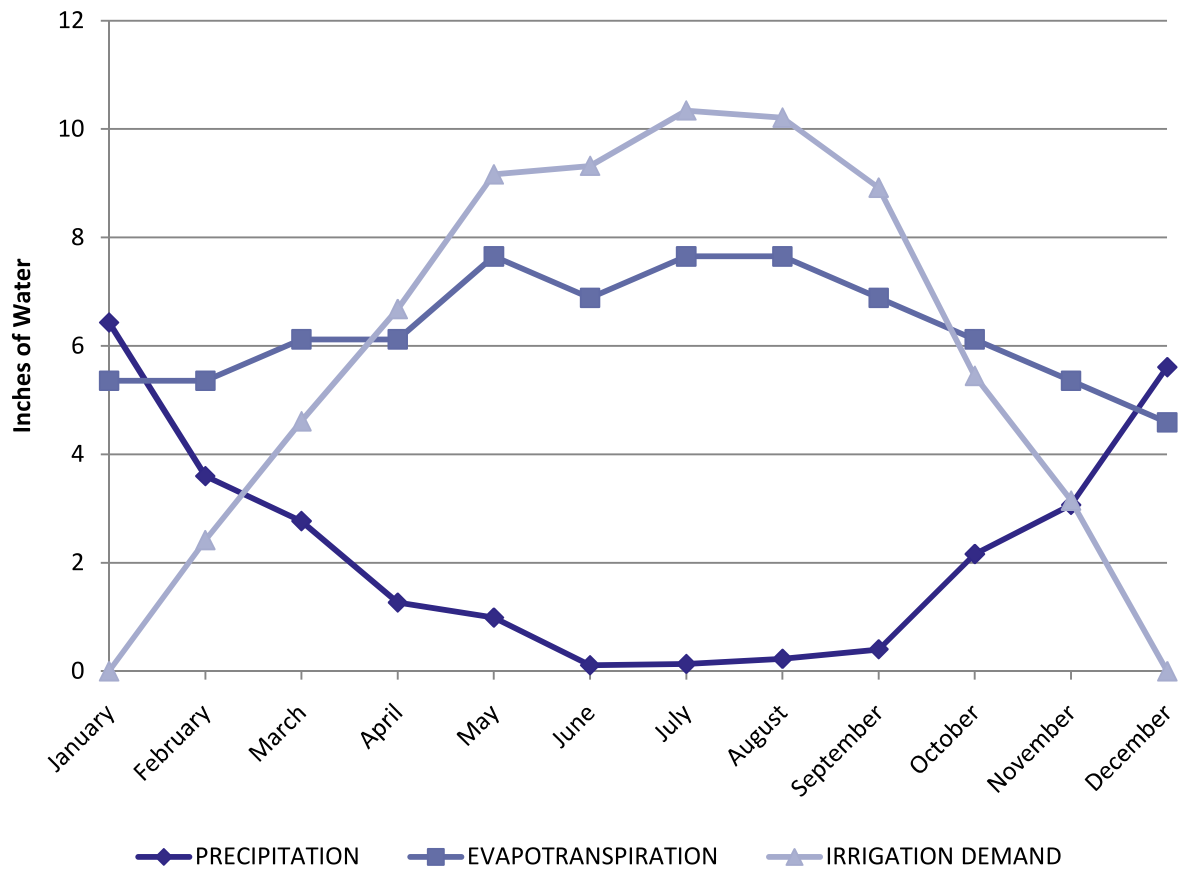

Figure 6-2. Wet Year (1 in 20) Irrigation Needs

6.2 Olowalu Town Irrigated Acreage

Irrigation will be the primary use for the R-1 recycled water at Olowalu Town. Olowalu Town will include ample green areas. Figure 3-2 showed the parcels that have preliminarily identified as users of the R-1 recycled water. The parcels include parks and open space, public areas, agricultural lots, and the highway right-of-way.

Table 6-3 summarizes the gross and net acreage by land use where recycled water will be used. Figure 6-3 provides a graphical presentation of the percentage of anticipated recycled water use by land use designation.

Table 6-3. Olowalu Town Areas Irrigated With Recycled Water

Land Use	Gross Acres	Net Irrigated Acres
Park/Open Space	71	45
Civic/Public/Quasi-Public	19	7
Agricultural	36	27
Highway Right of Way	50	25
TOTALS	176	104

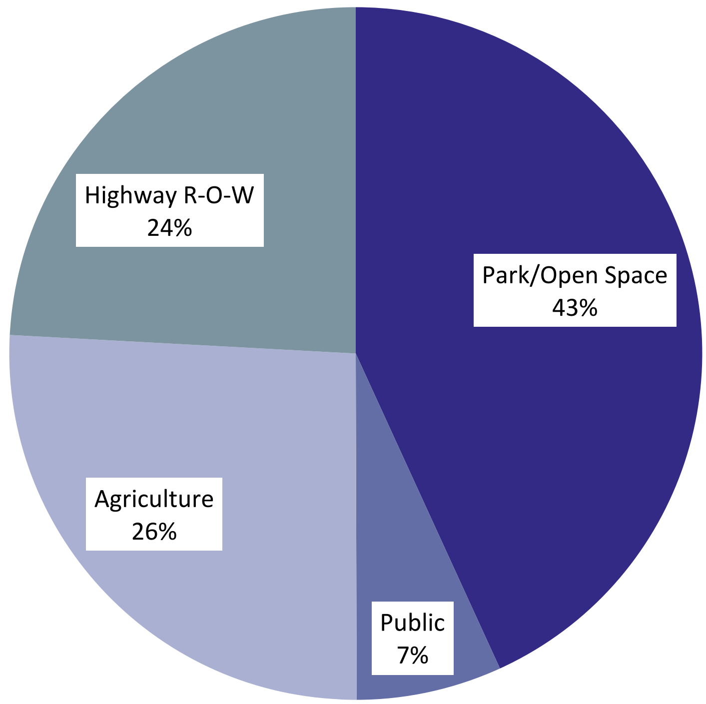

Figure 6-3. Recycled Water Use Areas

6.3 Recycled Water Supply and Demand Analysis

Evaluations were prepared to compare the supply and demand patterns for recycled water at Olowalu Town throughout a year with average precipitation and throughout a wet (1 in 20) year of precipitation to assess the annual needs for supplemental water and volume of excess recycled water that will be expected.

6.3.1 Average Precipitation Year Supply and Demand

The evaluation results for the average precipitation year are presented graphically in Figure 6-4. The horizontal purple line indicates the quantity of recycled water that is expected to be produced throughout the year, while the green line shows the irrigation water demand for a net 104 irrigated acres.

The graph shows that from March through October of an average precipitation year the supply of recycled water is expected to be less than the demand, and the addition of supplemental water will be required to meet the irrigation demand. In the wetter winter months of November through February, there is decreased irrigation demand, and the there may be excess R-1 water will require disposal. The supply and demand analysis for the average precipitation year scenario indicates that over 90 percent of the annual recycled water production will be used, and only 10 percent will require disposal.

During years that are drier than average the volume of excess R-1 water will be less than shown in the figure. Similarly, if the production of R-1 recycled water is less than the design flow rate (525,000 gpd) then there will be less excess R-1 water that requires disposal. The County wastewater standards tend to overestimate wastewater flow in the interest of conservatism, so the latter condition is likely, and therefore greater than 90 percent of the R-1 recycled water will likely be used over the course of an average or dry precipitation year.

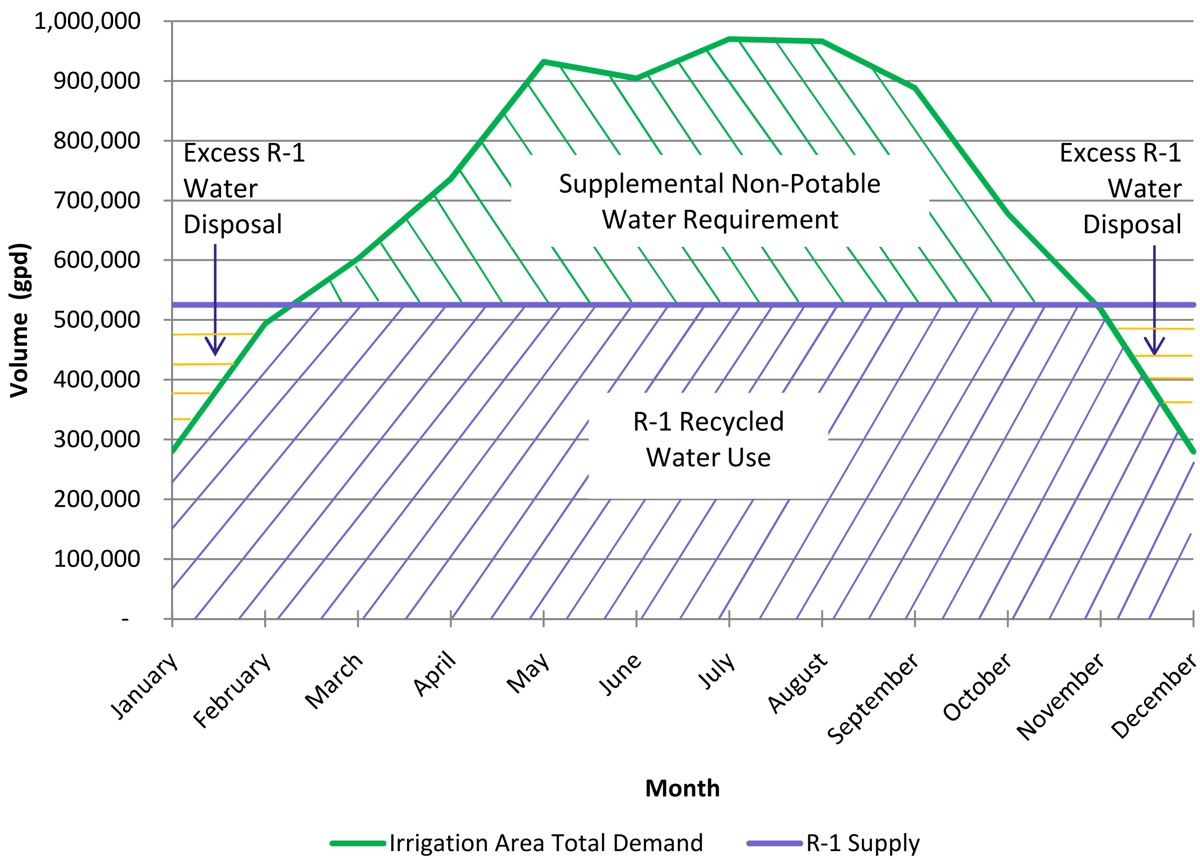

Figure 6-4. Recycled Water Supply and Demand Analysis for Average Precipitation Year

6.3.2 Wet Precipitation Year Supply and Demand

A similar supply and demand analysis was completed for a wet precipitation year. The overall trends are the same as for the average precipitation year; supplemental water is needed during the dry season, and there may be excess R-1 water that will require disposal in the wet season. However, in a wet precipitation year the wet season irrigation demand is lower than during an average precipitation year because the precipitation is greater. This increases the amount of excess R-1 water during the winter months that will require disposal. Supplemental water will continue to be required from April through September, and excess R-1 water disposal occurs in October through March. The supply and demand analysis for the wet precipitation year scenario indicates that approximately 70 percent of the annual recycled water production will be used, and 30 percent will require disposal if R-1 production is equal to 525,000 gpd.

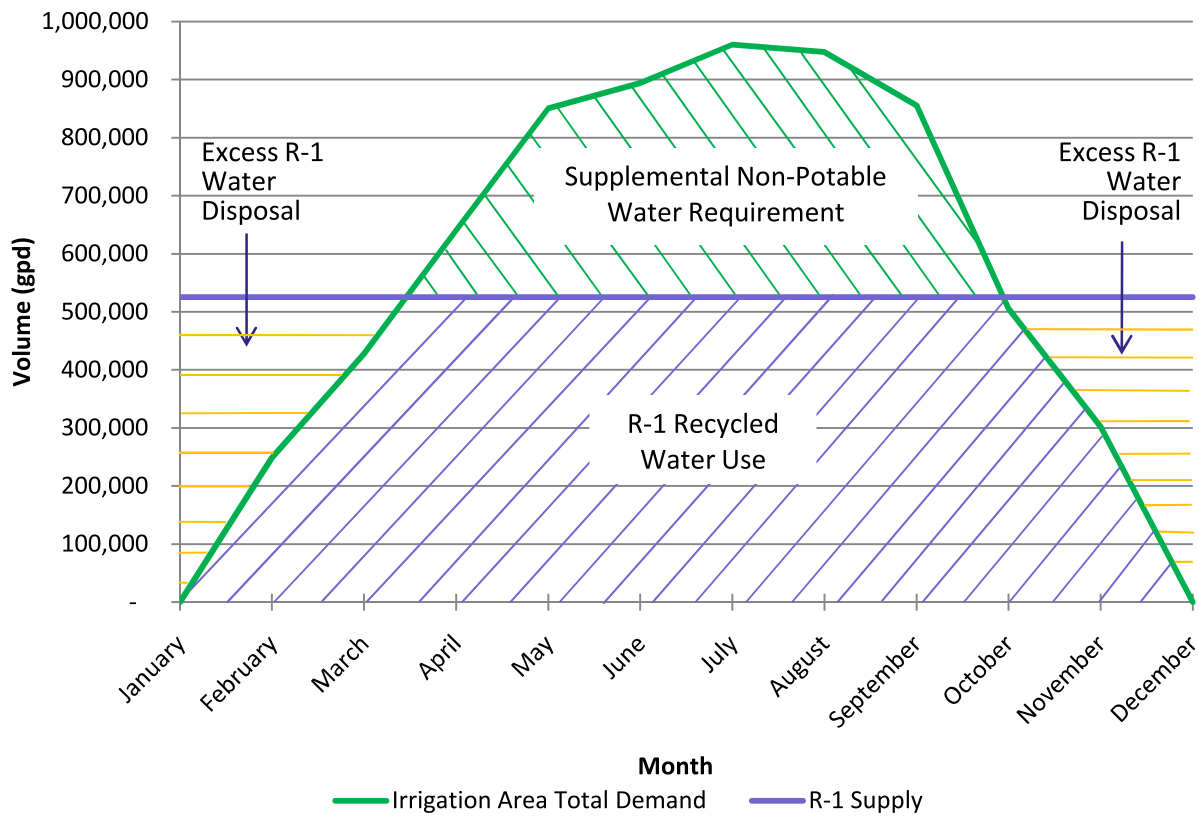

Figure 6-5. Recycled Water Supply and Demand Analysis for Wet Precipitation Year

6.4 Nitrogen Loading Rates

Recycled water typically contains higher nitrogen concentrations than ground or surface water. Nitrogen is a plant nutrient, and recycled water can provide some or all of the nitrogen required for vegetation to grow, reducing or eliminating the need to apply supplemental fertilization. The nutrient uptake by vegetation is a benefit of a water recycling approach for wastewater effluent management; nutrients are put to beneficial use rather than being discharged to the environment.

The amount of nitrogen applied with the recycled water must be balanced with the nutrient uptake of the crop to avoid over-application of nitrogen. As described in Section 4, the Olowalu Town wastewater treatment plant will be designed to reduce the total nitrogen concentration in the R-1 recycled water to 10 mg/L or less. The average precipitation year supply and demand analysis shown in Figure 6-4 indicates an application rate of 1.69 million gallons per acre of R-1 recycled water can be expected during a typical year. The nitrogen loading rate from the recycled water containing 10 mg/L TN would be 141 lbs/acre. Table 6-4 lists some typical crops and their corresponding nitrogen requirements. As shown in the table, the typical crop nitrogen fertilizer requirements exceed the anticipated nitrogen loading rate from the R-1 recycled water application, and so application of supplemental nitrogen fertilizer may be required to obtain optimal growth, but the use of recycled water for irrigation purposes will not result in excess application of nitrogen. As outlined in the next section, recycled water irrigation supervisors will be trained in the proper use of recycled water, including nitrogen management so that excess supplemental nitrogen fertilizer is not applied.

Table 6-4. Nitrogen Fertilizer Requirements of Typical Crops

Crop	Typical Nitrogen Fertilizer Requirements (lbs/acre/year)
Bermuda grass turf	500
Seashore paspalum turf	350
Papaya	350
Pineapple	350
Banana	300
Tomatoes	180
Sweet potatoes	155

Section 7

Olowalu Town Recycled Water Management Program

The following section describes the irrigation management program which shall be implemented at Olowalu Town to comply with the recycled water distribution and use requirements as discussed in Section 5.

7.1 Program Framework

The Olowalu Town recycled water program will be structured to assure the safe use of recycled water in compliance with DOH guidelines. The wastewater utility will designate a recycled water manager who will be responsible for the Olowalu Town recycled water system. In addition, each parcel which uses recycled water will be required to have a designated irrigation manager. Figure 7-1 illustrates the relationships between the DOH, recycled water manager, and irrigation supervisors.

7.2 Recycled Water Manager

The recycled water manager will oversee operation of the recycled water irrigation system at Olowalu Town. He or she will be responsible for ensuring that the DOH guidelines for recycled water distribution and use are adhered to. Key duties will include:

- Monitoring recycled water use
- Training irrigation supervisors
- Inspecting new connections and modifications to the R-1 system
- Reviewing site use plans
- Cross-connection testing
- Reporting program performance to DOH
- Public education
- Records maintenance

7.3 Irrigation Supervisors

Every site where recycled water is used will have a designated irrigation supervisor. It is possible that multiple parcels may be supervised by a single irrigation supervisor (e.g., parks). The irrigation supervisors will be trained in the use of recycled water by the recycled water manager. Operation of the irrigation systems on individual sites will be accomplished by the irrigation supervisors or their employees.

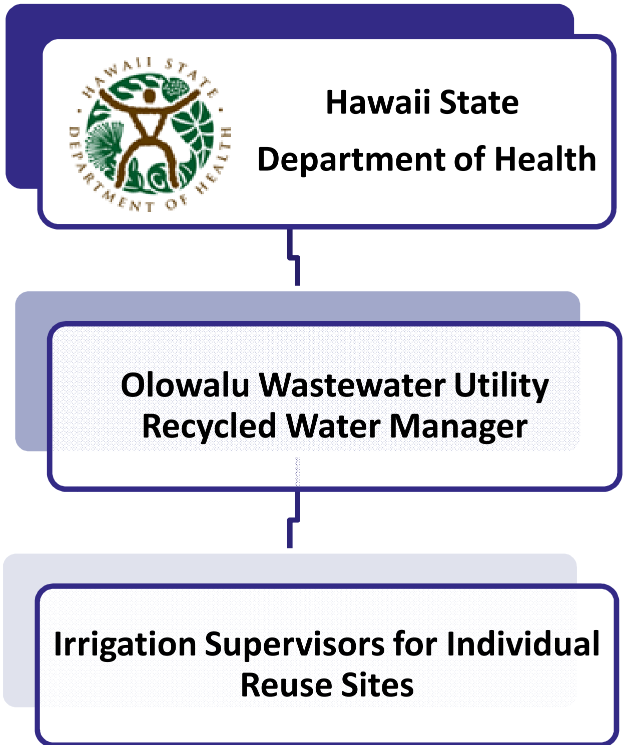

Figure 7-1. Olowalu Town Irrigation Management Program Organization Chart

Section 8

Excess Recycled Water Disposal

The water recycling analysis (Section 6) showed that during the wet season there will be excess R-1 water that will require disposal. This section presents the recycled water disposal components of the Olowalu Town wastewater management system, consisting of a constructed wetland followed by a soil aquifer treatment system. The disposal system will be sized to allow disposal of 100 percent of the peak day wet weather flow from the wastewater treatment plant, in the event of the rare extended wet weather period that reduces recycled water demand to zero.

8.1 Constructed Wetland

Constructed wetlands are engineered wastewater treatment systems that are based on the use of emergent wetland vegetation such as reeds, rushes, and bulrush. The Olowalu Town constructed wetland will be used to further improve the quality of the excess R-1 recycled water prior to disposal.

The type of constructed wetland discussed in this section is the free water surface system. In free water surface (FWS) wetlands, the emergent vegetation is flooded to a depth of 4 to 18 inches, as illustrated in Figure 8-1. The wastewater is treated as it flows through the wetland by naturally-occurring bacteria attached to the submerged vegetation, as well as by physical and chemical processes. Nitrification and denitrification are the responsible processes for nitrogen reduction. Denitrification performance can be excellent due to the presence of carbon from decaying plant litter and anoxic conditions (Crites, et. al., 2006).

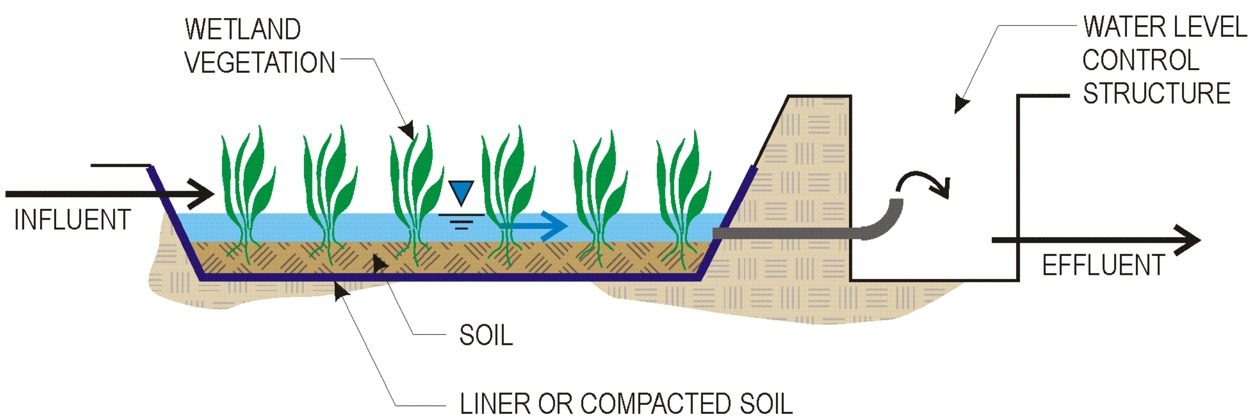

Figure 8-1. Schematic of Free Water Surface Wetland

The amount of treatment that occurs in a FWS wetland is a function of the hydraulic detention time and temperature. Nitrogen reduction via denitrification would be the treatment objective for the Olowalu Town application. The total nitrogen removal rate in a polishing wetland is dependant on the partitioning of the influent nitrogen species; better nitrification in the upstream wastewater treatment process will result in better total nitrogen removal in the wetland. The Olowalu Town wastewater treatment plant will be designed to produce a well-nitrified effluent, so denitrification performance of the wetland will be excellent.

If R-1 water is supplied to the wetland then there would be no need to restrict public access to the water system for public health reasons. FWS wetlands can be designed to provide effluent polishing while also providing habitat for native flora and fauna. Trails or paths can potentially be provided for public access. Figure 8-2 is a photo of a constructed wetland located in the State of Washington that provides polishing treatment and wildlife habitat.

Figure 8-2. A Constructed Wetland for Polishing Treatment and Wildlife Habitat

The wetland for Olowalu Town would have a surface area of approximately 2 acres. The wetland will be sufficient to reduce the nitrogen level of the recycled water from 10 mg/L to 5 mg/L or less prior to flowing to the soil aquifer treatment system. Figure 3-2 showed the preliminary location of the constructed wetland. Table 8-1 lists some native Hawaiian plants that could potentially be used in the Olowalu Town constructed wetland.

Table 8-1. Potential Hawaiian Constructed Wetland Vegetation		
Hawaiian Name	**Common Name**	**Scientific Name**
‘Ae ‘ae	Water hyssop	Bacopa monnieri
‘Aka ‘akai	Softstem bulrush	Schoenoplectus tabernaemontani
Ahu ‘awa	Javanese flatsedge	Cyperus javanicus Houtt.
Kaluha	Alkali bulrush	Schoenoplectus maritimus
Makaloa	Smooth flatsedge	Cyperus laevigatus
Mau‘u ‘aki ‘aki	Tropical fimbry	Fimbristylis cymosa

Source: Pagen, et. al., 2008

8.2 Soil Aquifer Treatment System

Soil aquifer treatment is a natural treatment process whereby wastewater is treated as it infiltrates and percolates through a soil matrix to groundwater. The treatment mechanisms are physical, chemical, and biological. Treatment benefits can include nitrogen and phosphorus removal, heavy metal and trace organic removal, and removal of endocrine disrupting chemicals. The system consists of multiple basins constructed in porous soil. Excess recycled water that has received additional treatment in the constructed wetland would be intermittently dosed to the basins, resulting in saturated soil conditions followed by unsaturated (resting) conditions. The application periods are designed for specific treatment objectives, and can range from 1 day to 12 days depending on the climate, pretreatment, and treatment goals (Crites, et. al., 2006).

The Olowalu Town soil aquifer treatment system will consist of multiple basins at the location that was shown in Figure 3-2. The required total basin area has been preliminarily established at 4.7 acres, but geotechnical evaluations will be required during the design phase to establish the final system size. The basins will be dry for most of the year when recycled water demand exceeds supply. But during the wet winter months (November through February) highly treated excess recycled water from the constructed wetland will be discharged to the soil aquifer treatment system basins for disposal via percolation.

Soil aquifer treatment systems are not injection wells. Injection wells are used to discharge fluids directly into the groundwater aquifer and do not provide the additional treatment benefits as the fluid flows from the surface to the groundwater aquifer. Soil aquifer treatment systems are a form of surface disposal, and additional treatment is provided as the discharged water percolates from the ground surface to the groundwater aquifer.

Section 9

Conclusions

The Olowalu Town wastewater management system will use innovative, efficient, and sustainable technology to minimize adverse impacts upon the natural environment. The wastewater that Olowalu Town residents and businesses will generate will be managed in an environmentally-responsible manner. Olowalu Town's location adjacent to a significant and accessible coral reef system dictates that a conservative, reliable, and appropriate wastewater management system be implemented. The Olowalu Town wastewater management plan has been developed with environmental concerns at the forefront, and effectively and appropriately establishes a system for responsible management of the community's wastewater. Conservative planning assumptions have been used to develop a wastewater management plan that will ensure a high factor of safety for protection of human health and the environment, and will meet or exceed all regulatory requirements.

The proposed Olowalu Town wastewater management system will:

- **Not rely on injection wells for effluent disposal purposes.** The small percentage of recycled water that requires disposal will be discharged to a soil aquifer treatment system after passing through the constructed wetland. The soil aquifer treatment system is a surface disposal system that allows additional treatment benefits as the discharged water percolates to the groundwater aquifer.
- **Provide for a high degree of water recycling to make the best use of water resources.** The wastewater management system will be an important part of the integrated water resources system for the community. All of the Town's wastewater will be treated to the highest DOH water recycling standards to allow reuse for irrigation of parks, schools, public areas, agricultural land, and highway landscaping. In a typical year 90 percent or more of the town's wastewater will be recycled for irrigation purposes.
- **Incorporate nutrient removal technology to protect the environment.** The Olowalu Town wastewater treatment plant will include biological nutrient removal processes to reduce total nitrogen concentrations to 10 mg/L or less. The constructed wetland will further reduce total nitrogen concentrations of excess R-1 recycled water to 5 mg/L or less prior to disposal. These two nutrient removal systems will provide a level of environmental protection that is unsurpassed in Hawaii.
- **Incorporate natural treatment systems where feasible and appropriate.** Excess R-1 recycled water will receive additional treatment in a constructed wetland prior to disposal via the soil aquifer treatment system. Both of these system elements are natural wastewater treatment systems. The constructed wetland will provide wildlife habitat and will be a public amenity.

Section 10

Limitations

This document was prepared solely for Olowalu Town, LLC in accordance with professional standards at the time the services were performed and in accordance with the contract between Olowalu Town, LLC and Brown and Caldwell dated September 30, 2010. This document is governed by the specific scope of work authorized by Olowalu Town, LLC; it is not intended to be relied upon by any other party except for regulatory authorities contemplated by the scope of work. We have relied on information or instructions provided by Olowalu Town, LLC and other parties and, unless otherwise expressly indicated, have made no independent investigation as to the validity, completeness, or accuracy of such information.

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