2004 Hawaii Water Reuse Survey and Report

Final

Prepared for:
Department of Land and Natural Resources
Commission on Water Resources Management

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List of Acronyms

CORP	Central Oahu Regional Park
CSC	Coastal Services Center
CWRM	Commission on Water Resources Management
CWSRF	Clean Water State Revolving Fund
DLNR	Department of Land and Natural Resources
DOH	Department of Health
DWS	Department of Water Supply
EPA	Environmental Protection Agency
EQIP	Environmental Quality Incentives Program
ENV	Department of Environmental Services
GAC	Granular activated carbon
GIS	Geographic Information System
HAR	Hawaii Administrative Rules
HC&S	Hawaii Commercial & Sugar Company
HBWS	Honolulu's Board of Water Supply
IRWD	Irvine Ranch Water District
Mg	Million gallons
Mgd	Million gallons per day
Mg/L	Milligrams per liter
NOAA	National Oceanic and Atmospheric Administration
NRCD	Natural Resources Conservation Service
NPDES	National Pollutant Discharge Elimination System
O&M	Operations and Maintenance
OCWD	The Orange County Water District
PER	Preliminary Engineering Report
R-O	Reverse osmosis
SBR	Sequencing batch reactor
USDA	United States Department of Agriculture
WF-21	Water Factory 21
WRF	Water Recycling Facility
WWRD	Wastewater Reclamation Division
WWRF	Wastewater Reclamation Facility
WWTP	Wastewater Treatment Plant

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Chapter 1: Introduction

Section 1.1: The Role of Water Reuse in Hawaii

The population in the State of Hawaii is increasing as urban development continues on each main island of the Hawaiian chain. On the more populated islands, such as Oahu and Maui, existing water sources are now being stretched to the limits of their sustainable yields. Supplemental sources of water must be developed to meet the demands of Hawaii's population and to ensure that sustainable development can continue. New water sources could come from water that is imported from neighbouring regions; from desalination of sea water; from optimizing operations of existing water systems; from water conservation; and from water reclamation and reuse (1). While reading this report the terms "water reclamation", "recycled water" and "water reuse" will often be used. For clarification purposes, "water reclamation" is the treatment of wastewater to make it usable, "recycled water" is the end product of water reclamation and "water reuse" is the beneficial use of recycled water.

Water reuse should be viewed as a key component of sustainable water resource management. Recycled water can be a drought-proof and reliable supply of water. It can replace potable water that is currently used for non-potable purposes. In some instances, the availability of recycled water has stimulated Hawaii's economic development by attracting business activity. Water reuse also provides a mechanism for nutrients in wastewater to be utilized by vegetation, thereby reducing the need for fertilization in most instances. Finally, water reuse is recognized as an environmentally preferred method of disposing treated wastewater (effluent), when compared to the traditional disposal methods through outfalls and injection wells. While water reuse applications have grown significantly in Hawaii in recent years, recycled water is still an underutilized resource with many opportunities for expansion.

As Hawaii's population increases, wastewater volumes will increase proportionally, creating more recycled water and water reuse opportunities. Integration of water reuse into the overall state-wide water use policy makes good sense and will be critical as water demands increase. State of Hawaii and the Environmental Protection Agency (EPA) regulations require wastewater treatment and encourage its by-product – recycled water – to be available and beneficially reused. In some cases, it may be actually less expensive to develop recycled water distribution systems rather than developing new sources of water and continue to pay effluent disposal costs. While there are significant initial capital costs for communities to develop recycled water distribution systems, the addition of recycled water into their water budgets will secure long-term solutions to sustainable economic growth plans.

Section 1.2: Project Objective

The primary objective of this report is to assist the State of Hawaii Commission on Water Resources Management (CWRM) to understand its role as a possible driving force to the increased utilization of recycled water in Hawaii. This report may be used as a tool by CWRM to implement recycled water into an overall water resources management plan for the State of Hawaii. The report will provide CWRM with a general overview of the current status of water reuse in Hawaii on a statewide basis, as well as provide detailed descriptions of the existing

water reuse projects within each county of Hawaii. Opportunities for future water reuse projects and ideas for future recycled water applications will be examined. Obstacles that restrict the growth and implementation of water reuse will be discussed, along with ideas to overcome those hurdles. The report concludes with a description of federal funding sources that may be used for the development of water reuse projects and a directory of the existing water reuse projects in Hawaii.

It is recommended that this report be updated every five years. Regular updates will allow CWRM to keep informed of the current status of water reuse activity in Hawaii. These updates will also allow CWRM to facilitate its goal of making water reuse a critical component of sustainable water resource management throughout the state of Hawaii.

Chapter 2: Overview of Water Reuse in Hawaii

Section 2.1: Current View and Recent Growth of Water Reuse Activity in Hawaii

Water reuse is well established in Hawaii and there are several successful water reuse projects on all of the populated islands throughout the state. The oldest water reuse project is at Waialua, Oahu where recycled water has been used to irrigate sugar cane and diversified agriculture since 1928. Many of these projects have derived benefits from using recycled water while others have devised innovative solutions to various challenges associated with recycled water use (2). In recent years, a number of new water reuse projects have commenced operation due in large part to the development of comprehensive water reuse programs by the County of Maui's Wastewater Reclamation Division (WWRD) and the City & County of Honolulu's Board of Water Supply (HBWS). Since 1994, the State of Hawaii's Environmental Council has published an annual report that tracks environmental indicators in Hawaii. This report is referred to as the Hawaii Environmental Report Card 2003 and as depicted in **Table 2-1**, it documents the volume of wastewater treated and reused in Hawaii from 1994 to 2002 (3).

Table 2-1: Total Statewide Wastewater Treatment and Reuse – 1994 to 2002

Federal Fiscal Year	Total Wastewater Treated (mgd)	Wastewater Reuse (mgd)	Percentage Reused
1994	151.6	10.5	6.9
1995	150.1	11.1	7.4
1996	150.1	12.3	8.2
1997	150.0	15.6	10.4
1998	150.0	17.0	11.3
1999	150.0	19.5	13.0
2000	150.0	20.0	13.5
2001	150.0	19.9	13.3
2002	150.0	24.0	16.0

The "Total Wastewater Treated" column represents wastewater that is produced and sent for treatment at public and private wastewater treatment facilities. The "Wastewater Reuse" column represents recycled water of all qualities recognized by the Hawaii State Department of Health (DOH).

While the percentage of recycled water used in Hawaii has more than doubled since 1994, recycled water is an underutilized water resource in our state. The increased use of recycled water can contribute to sustainable water resource management in Hawaii, but this will only occur if water reuse programs are supported on both the local and state levels.

Hawaii's water reuse projects are classified into three basic project types by the DOH: (1) golf course, (2) agriculture, and (3) other, which include landscape irrigation, dust control, and other non-irrigation applications. Water reuse has grown significantly in Hawaii since 1996. **Table 2-2**

depicts this growth by comparing the volumes of recycled water utilized for the major categories of water reuse in 1996 to the volumes utilized in 2004.

Table 2-2: Hawaii Water Reuse Projects – 1996 vs. 2004

Project Type	1996 Approximate Volume (mgd)	2004 Approximate Volume (mgd)	% Increase
Golf Course	7.20	11.76	63.3
Agriculture	5.40	6.96	28.9
Other (Landscape, Dust Control, etc.)	1.70	5.28	210.6
Totals	14.30	24.00	67.8

Section 2.2: The State of Hawaii's Guidelines for the Treatment and Use of Recycled Water

The DOH issued the Guidelines for the Treatment and Use of Reclaimed Water in November 1993 and updated the Guidelines in May 2002. The Guidelines are now referred to as the Guidelines for the Treatment and Use of Recycled Water (4) and they identify the requirements for both the purveyors and the users of recycled water. The intent of the DOH is to incorporate the Guidelines into Chapter 11-62 of the Hawaii Administrative Rules (HAR).

Section 2.2.1: Recycled Water Classifications, Definitions and Allowable Uses

The Guidelines define three classes of recycled water. A complete list of the allowable uses of recycled water is summarized in the DOH Guidelines under Chapter III – Uses and Specific Requirements for Recycled Water. **Table 2-3** summarizes the allowable uses and treatment/quality requirements of all recycled water categories defined by the DOH.

Purveyors of recycled water must meet the following treatment and water quality standards for R-1, R-2 and R-3 waters:

R-1 Water is tertiary treated recycled water that has undergone a significant reduction in viral and bacterial pathogens. As defined by the Guidelines, R-1 water is recycled water that is at all times oxidized, then filtered, and then exposed, after the filtration process, to:

A. A disinfection process that, when combined with the filtration process, has been demonstrated to inactivate and/or remove 99.999 percent of the plaque-forming units of F-specific bacteriophage MS2, or polio virus in the wastewater. A virus that is at least resistant to disinfection as polio virus may be used for purposes of demonstration; and

B. A disinfection process that limits the concentration of fecal coliform bacteria to the following criteria:

a. The median density measure in the disinfected effluent does not exceed 2.2 per 100 milliliters utilizing the bacteriological results of the last seven days for which analyses have been completed; and
b. The density does not exceed 23 per 100 milliliters in more than one sample in any 30-day period; and
c. No sample shall exceed 200 per 100 milliliters.

R-1 water can be utilized for spray irrigation without restrictions on use. It is now approved for a number of applications including spray irrigation of golf courses, parks, athletic fields, school yards, residential properties where managed by an irrigation supervisor, road sides/medians and for vegetables and fruits that are eaten raw. The number of projects in Hawaii utilizing R-1 water has increased significantly in recent years.

R-2 Water is disinfected secondary treated recycled water. As defined by the Guidelines, R-2 water means recycled water that has been oxidized, and disinfected to meet the following criteria:

A. Fecal coliform bacteria densities as follows:

a. The median density measured in the disinfected effluent does not exceed 23 per 100 milliliters utilizing the bacteriological results of the last seven days for which analyses have been completed; and
b. The density does not exceed 200 per 100 milliliters in more than one sample in any 30-day period.

When using R-2 water, spray irrigation is limited to evening hours, and a 500-foot buffer zone between the approved use area and adjacent properties is required. Several golf courses in Hawaii are irrigated with R-2 water, although some are exempt from the 500-foot buffer zone requirement because they existed before the DOH established the Guidelines. This exemption is referred to as "The Grandfather Clause." Food crops that are irrigated with R-2 water must either be irrigated via a subsurface irrigation system or, if irrigated with spray irrigation, must undergo extensive commercial, physical or chemical processing determined by DOH to be sufficient to render it free of viable pathogenic agents, before it is suitable for human consumption.

R-3 Water is undisinfected secondary treated recycled water, and there are severe limitations on its use. Currently, the Parker Ranch pasture irrigation project on the Big Island and the Puu O Hoku Ranch constructed wetlands project on Molokai are the only projects in Hawaii that utilize R-3 water.

Reverse osmosis (R-O) treated recycled water is utilized at the Campbell Industrial Park on Oahu. R-O water is wastewater that has undergone secondary treatment and then is purified via R-O. In the case of Campbell Industrial Park, the R-O water that is provided is not disinfected; therefore it is technically classified as R-3 water by the DOH, despite the fact that it is essentially pathogen free water.

Table 2-3: Summary of DOH Guidelines for the Treatment and Use of Recycled Water

Recycled Water Category	Suitable Uses	Treatment/Quality Requirements
R-3	• Surface, drip, subsurface irrigation of: o Feed, fodder and fiber crops, and pasture for animals not producing milk for human consumption. o Non-food bearing tree provided no irrigation with recycled water occurs for a period of 14 days prior to harvesting or allowing access by the general public. o Seed crops that are not eaten by humans. o Orchards and vineyards where the recycled water does not come into contact with the edible portion of the crop. o A food crop, which must undergo extensive commercial, physical or chemical processing, determined by DOH to be sufficient to destroy pathogens, before it is suitable for human consumption. This is allowed no later than 30 days before harvest. • Surface or drip irrigation of ornamental nursery stock and sod farms provided no irrigation with recycled water occurs for a period of 14 days prior to harvesting, retail sale, or allowing access by the general public. • Application within a reclamation facility for the following o Non-spray irrigation of landscape not contacted by the general public; o Polymer dilution water; o Mechanical seal water for gas compressors; o Cooling water for gas compressors and internal combustion engines; o Dilution water for chlorination; o Mechanical seal water and cooling water for sludge pumps; o Heat exchangers: air, water and oil cooling; o Odor and gas absorption; o Centrifuge flushing; and o Flushing grit and sludge pipes; or • Such other uses as approved by DOH	R-3 Water (Undisinfected Secondary Recycled Water) means oxidized wastewater.
R-2	• R-2 water is suitable for the purposes cited under R-3 water. • Subsurface irrigation: o Landscape and turf on parks, elementary school yards. o Residential property where managed by an irrigation supervisor. o Golf Courses o Vineyards and orchards (e.g., banana, papaya). o Food crops that are above ground and not contacted by recycled water. o Pastures for milking and other animals. • Any form of irrigation for: o Fodder crops (e.g., alfalfa) and fiber crops. o Sod not installed by the general public. o Trees grown for timber or firewood, and Christmas trees	R-2 Water (Disinfected Secondary-23 Recycled Water) means recycled water that has been oxidized, an disinfected to meet the following criteria: • Fecal coliform bacteria densities as follows: o The median density measured in the disinfected effluent does not exceed 23 per 100

Recycled Water Category	Suitable Uses	Treatment/Quality Requirements
	whether or not the general public harvests them. o Trees and vines that do not have food crops on them when irrigated. o Seed crops that are not eaten by humans. o Food crops which must undergo extensive commercial, physical or chemical processing determined by DOH to be sufficient to render it free of viable pathogenic agents, before it is suitable for human consumption. o Landscape on cemeteries, and around freeways. o Other landscape vegetation and non-edible plants, allowed only where: ▪ The public would have access and exposure to irrigation water similar to that, which would occur along a freeway or on a cemetery. ▪ Access is controlled so that irrigated area cannot be used as if it were part of a park, school yard or athletic field. o Landscaping of developments under construction, with no access by the public during establishment period, no overspray, and where workers use appropriate protective equipment and clothing. • Surface, drip or subsurface of ornamental plants for commercial use. This is allowed only if the plants are harvested above any portion contacted by recycled water. Subsurface irrigation shall be supplied for the growth of all material used in the production of leis or other flowers used in human apparel; • Use in an industrial process that does not generate mist, does not involve facial contact, and does not involve incorporation into food or drink for humans or contact with anything that will contact food or drink for humans; • Water jetting for consolidation of backfill material around underground pipelines except potable water pipelines; • Dampening soil for compaction at construction sites; landfills, and elsewhere; • Washing aggregate and making concrete; • Dampening brushes and street surfaces during street sweeping; • A source of supply for a landscape impoundment without a decorative fountain; • Flushing sanitary sewers; or • Such other uses as approved by DOH	milliliters utilizing the bacteriological results of the last seven days for which analyses have been completed. o The density does not exceed 200 per 100 milliliters in more than one sample in any 30-day period
R-1	• R-1 water is suitable for the purposes cited under R-2 and R-3 water. • Any form of irrigation for food crops, including all edible root crops, where the recycled water comes into contact with the edible portion of the crop. • Any form of irrigation served by fixed irrigation system supplied by buried piping for turf and landscape irrigation of: o Golf Courses o Parks, playgrounds, school yards, athletic fields o Residential property where managed by an irrigation	R-1 Water (Significant reduction in viral and bacterial pathogens) means recycled water that is at all times oxidized (wastewater in which organic matter has been stabilized, is nonputrescible, and contains dissolved oxygen), then filtered (consistently

Recycled Water Category	Suitable Uses	Treatment/Quality Requirements
	supervisor o Road sides and medians • Any form of irrigation for pasture where milking animals, and other animals graze • Any form of 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 • Drinking water for animals may be accepted if it will not be given to dairy animals, and the applicant demonstrates to the satisfaction of DOH there will be no unreasonable risk of occurrence of adverse effects on the animal related to chemical constituents or radioactivity • Supply for commercial and public laundries for clothing and other lines • Industrial cooling in a system that does not have a cooling tower, evaporative condenser, or other feature that emits vapor or droplets to the open atmosphere or to air to be passed into a building or other enclosure occupied by a person, when all of the following shall occur: o A high efficiency draft reducer is used and the system is maintained to avoid greater rate of generation of drift than that with which a high efficiency drift reducer is associated o A continuous biocide residual, sufficient to prevent bacterial population from exceeding 10,000 per milliliter, is maintained in circulating water o The system is inspected by an operator, capable of determining compliance with this subdivision, at least once per day • Industrial process that does not generate mist or facial contact with recycled water unless personal protective equipment is worn. • Water jetting for consolidation of backfill material around potable pipelines and for compaction of soil backfill above such pipelines. • Flushing toilets and urinals in types of buildings and institutions approved by DOH and where counties have adopted a provision in their plumbing code pertaining to the use of a dual water supply within a building. • A source of supply for a decorative fountain if the recirculating water does not support growth of microorganisms from the surrounding environment that could infect either the respiratory or digestive systems of mammals. • A source of supply for: o A restricted recreation impoundment o Basins at fish hatcheries • Washing of hard surfaces (e.g. parking lots and sidewalks) • Such other uses as approved by DOH.	and reliably produce an effluent that does not exceed 2 ntu at any time), and then exposed, after the filtration process to: • A disinfection process that, when combined with the filtration process, has been demonstrated to inactivate and/or remove 99.999 percent of the plaque-forming units of F-specific bacteriophage MS2, or polio virus in the wastewater. A virus that is at least resistant to disinfection as poliovirus may be used for purposes of demonstration. • A disinfection process that limits the concentration of fecal coliform bacteria to the following criteria: o The median density measure in the disinfected effluent does not exceed 2.2 per 100 milliliters utilizing the bacteriological results of the last seven days for which analyses have been completed o The density does not exceed 23 per 100 milliliters in more than one sample in any 30-day period o No sample shall exceed 200 per 100 milliliters

Section 2.2.2: Requirements for Recycled Water Purveyors and Users

Purveyors of recycled water are required to keep operational records pertaining to the daily volumes and water quality produced by their water reclamation facilities. These records are subject to review by DOH during annual operation and maintenance inspections of each facility.

All projects that use recycled water must first receive DOH approval. The DOH approval process for most new projects requires that each project submit a Basis of Design Report and an Engineering Report to DOH. Construction plans of the project's recycled water transmission and irrigation systems must also be submitted. The full Basis of Design and Engineering Reports may be waived by DOH for smaller reuse projects such as dust control and landscape irrigation areas less than five acres. For smaller projects, a simplified application form may be submitted to DOH in lieu of an engineering report. A final inspection by DOH is also required prior to the commencement of recycled water use. Specific information pertaining to the submittal and approval process for typical water reuse projects is detailed below.

1. Submittals of Engineering Reports and Construction Plans to DOH
    a. Basis of Design Report
        i. Water reclamation facility information
        ii. Approved use area information
        iii. Transmission and distribution system details
        iv. Design application rate
        v. Evaporation losses and precipitation gains
        vi. Maximum daily design percolation rate
        vii. Supplemental water supplies
    b. Engineering Report
        i. Irrigation plan
        ii. Management reuse plan
        iii. Public education plan
        iv. Employee training plan
        v. Vector control plan
        vi. Monitoring system construction report (if project over potable water aquifer)
    c. Construction Plans
        i. Compliance with design standards of the respective County Department of Public Works and Water System Standards
        ii. Identification and description of irrigation system components
        iii. Color coding of pipe and appurtenances

2. Construction Phase Approval
    a. Approval to Construct
        i. Issued by DOH after review of Basis of Design Report, Engineering Report and Construction Plans for conformance w/HAR 11-62 and the Reuse Guidelines
    b. Construction Inspections
        i. Transmission system inspection
        ii. Reuse system inspection

iii. Layout inspection
iv. Operation inspection

3. Operation Phase Approval
    a. Approval to Operate
        i. DOH issues letter after satisfactory completion of construction inspections stating conformance w/HAR 11-62 and the Reuse Guidelines
    b. Performance and Compliance Inspections
        i. DOH conducts periodic O&M inspections on storage impoundments, distribution system and approve reuse areas
        ii. Review of records

Section 2.2.3: County Rules Pertaining to Recycled Water Use

The County of Maui (which encompasses the islands of Maui, Molokai, and Lanai) is the only county in Hawaii thus far to establish its own rules for recycled water use. These rules, which were adopted in June 1997, are referred to as County of Maui Rules for Reclaimed Water Service. The purpose of the Rules is to document requirements for the use of recycled water for irrigation and other purposes within Maui County. The State of Hawaii's Guidelines for the Treatment and Use of Recycled Water, the State of Hawaii's Water System Standards and Chapter 11-62 of the HAR are incorporated into the "Rules".

The Rules include sections on establishing recycled water service, design standards for onsite and offsite recycled water facilities, operational guidelines, monitoring/enforcement provisions and fees/charges.

The County's WWRD provides a copy of the Rules to each property manager or the designated consulting engineering firm of each property that will utilize recycled water. Payment of a connection fee is required upon submittal of the County of Maui's application for recycled water service. A permit for recycled water service is issued after a final inspection of the project is completed.

Chapter 3: County Reuse Activity and Project Descriptions

Section 3.1: County Reuse Activity

The State of Hawaii consists of four counties including the City and County of Honolulu (Oahu), the County of Maui (Maui, Lanai and Molokai), the County of Kauai and the County of Hawaii (the Big Island). Most of the growth of water reuse in Hawaii has occurred on the islands of Maui and Oahu primarily because of the comprehensive water reuse programs developed and implemented by the County of Maui's WWRD and the City & County of HBWS, respectively. **Table 3-1** compares the 1996 reuse activity in each of the four counties in Hawaii to the County reuse activity in 2004.

Table 3-1: County Reuse Activity – 1996 vs. 2004

County	1996 Approximate Volume (mgd)	2004 Approximate Volume (mgd)	% Change
Kauai	3.9	3.0	-23.1
Maui (Maui, Molokai, Lanai)	3.5	5.4	54.3
Hawaii	1.4	1.6	14.3
Honolulu (Oahu)	5.5	14.0	154.5

Kauai is the only county in Hawaii to show a decrease in the volume of recycled water used. This decrease can be partially attributed to Hurricane Iniki that devastated Kauai in 1993 and negatively impacted the island's economy for years. Kauai has also not had any new water reuse projects commence operation since 1996.

Section 3.2: County Government Water Reuse Program Descriptions

This section will provide detailed descriptions of the County of Maui's and the City and County of Honolulu's water reuse programs as both counties have committed significant resources towards the development of their respective programs. To date, the counties of Kauai and Hawaii have not implemented structured water reuse programs; therefore, brief descriptions of their approaches towards water reuse will be provided.

Section 3.2.1: The County of Maui's Water Reuse Program

The County of Maui's WWRD is considered to be a water reuse leader in Hawaii. In 1990, Maui County developed a plan and embarked on a long-range program to reuse millions of gallons of a valuable resource, high quality recycled water, which had been historically disposed into injection wells. To lay the foundation for the County's program several key components were initiated including water reuse feasibility studies, a community-based rate study, creation of a Water Recycling Program Coordinator position, upgrades to the County's Kihei (south Maui) and Lahaina (west Maui) wastewater reclamation facilities to R-1 tertiary treatment capability, passage of an ordinance which mandated the use of recycled water at commercial properties,

adoption of rules for recycled water service, and the creation of a recycled water rate structure which recovers monies spent on distribution system development from both recycled water and sewer users.

The Iao Aquifer has been recently designated by the Commission on Water Resources Management (CWRM). Lack of available water resources in central and south Maui is now an important factor driving the County of Maui's water reuse program.

Program Development

The initial driving factor behind the development of Maui County's water reuse program was a regulatory agency belief that Maui's effluent disposal practices were causing environmental problems. The United States EPA and local environmental groups expressed a concern that injection wells may contribute nutrients that cause algae blooms in coastal waters. In 1995, the EPA placed a limitation on the amount of effluent that could be disposed into the injection wells at the county's Lahaina Wastewater Reclamation Facility (WWRF). This factor played a major role in the passage of the bill, which led to the mandatory recycled water use ordinance on Maui. Increased recycled water use on the island and the results from scientific studies, which indicated that other non-point nutrient sources might be the cause of the periodic algae blooms, have somewhat eased this concern. Nevertheless, effluent disposal will continue to be an important factor driving the County of Maui's water reuse program since most of its wastewater reclamation facilities rely on injection wells. As performance of these injection wells eventually decline, increasing the use of recycled water from the respective facilities rather than drilling additional wells may be required by regulatory agencies.

Potable Water Supply

Water supply is now an important factor driving the County of Maui's water reuse program. The island of Maui has limited supplies of available fresh water. The island's main water source, the Iao aquifer, supplies most of central and arid south Maui with potable water. Much of this water is used for landscape irrigation at parks, schools, condominiums, hotels and single-family residences. Due to increasing development in these areas, the Iao aquifer is showing signs of over pumping. For the past several years, monitoring of the aquifer's wells has indicated that chloride levels are increasing and fresh water levels are decreasing. The State's Commission on Water Resource Management has recently designated the Iao Aquifer as a Ground Water Management Area and soon may be designating the nearby Waihee Aquifer. The designation of water management areas by the Commission is for the purpose of ensuring the long-term sustainability of the resource by establishing administrative control over the withdrawal of ground water in the area to ensure reasonable beneficial use of the water resources in the public interest. The modification of the boundaries or the rescinding of existing water management areas by the Commission may be initiated by the chairperson of the Commission or by petition.

South Maui is one area in Hawaii with several successful water reuse projects due to its arid climate and poor groundwater quality.

Recycled Water Infrastructure

The County of Maui's WWRD reuses recycled water from all five of its facilities. Distribution systems have been developed in the south Maui and west Maui areas **(Figures 3-1 and 3-2)**. The south Maui area has the most complete distribution system at this time and as a result, the most water reuse projects. The south Maui system now provides recycled water to eighteen separate

projects with more scheduled to connect to the distribution system in the near future. Uses include landscape irrigation, agricultural irrigation, fire control, industrial cooling, composting, construction activities and toilet/urinal flushing.

The west Maui distribution is limited due to insufficient recycled water storage but it does service Maui County's largest water reuse project, the Kaanapali Resort. Up to 1.2 mgd is utilized by the resort for golf course and landscape irrigation. Plans are now being developed to expand this system to provide R-1 water to condominiums and hotels in the Kaanapali area. R-1 water is also pumped to Maui Pineapple Company but use has been limited due to above average rainfall since the distribution system was built. Maui Pineapple Company will also phase out pineapple production in west Maui in the year 2006.

In addition to the major distribution systems described above, recycled water is utilized from Maui County's facilities on Lanai, Molokai and in central Maui. On Lanai, wastewater is processed to R-3 quality utilizing stabilization ponds and then the entire plant flow of approximately 0.25 mgd is sent to an auxiliary WWRF owned and operated by the Lanai Company where it is upgraded to R-1 quality and used for irrigation of a golf course. On Molokai, the State Department of Transportation utilizes R-2 water for landscape irrigation along the Maunaloa Highway. Finally in central Maui, R-2 water is used to irrigate coconut trees and native Hawaiian plants at the Kanaha Cultural Park, which is adjacent to the Kahului WWRF.

Program Economics

Since water supply and wastewater disposal were both important factors driving Maui County's water reuse program, both recycled water users and sewer users share the costs associated with recycled water production and delivery. A component of the sewer fees collected from all commercial and residential users of Maui County's sewer system is used to pay for the recycled water program's operation, maintenance and infrastructure costs. Maui County officials believed that sewer users must not only pay the costs associated with wastewater collection and treatment but they must also help bare the costs of effluent disposal whether it is through the use of injection wells or through water reuse. This approach allowed Maui County officials to set the price of recycled water at rates that encourage users to connect to the distribution system. The following user classes with corresponding costs of recycled water were created: Major Agriculture (> 3.0 mgd): $0.10/1000 gallons; Agriculture (including golf courses): $0.20/1000 gallons and All Others: $0.55/1000 gallons. The rates were set at levels slightly below the costs of the water sources typically used by the three recognized user classes. An "avoided cost" category was also created which allows recycled water consumers to pay the same rate for recycled water as they were paying for other non-potable water sources. Connection fees for the south and west Maui areas where major R-1 distribution systems were developed were also established to help pay for the recycled water program.

Public Education and Outreach

Proactive public education has played an important role in the success of the County of Maui's water reuse program. The WWRD's Water Recycling Program Coordinator conducts up to 100 presentations per year on water conservation, wastewater treatment and water reuse to schools, community groups and the general public. Tours of the County's wastewater reclamation

facilities are also provided. In addition, the WWRD issues press releases announcing new projects that are to commence using recycled water and expansions to County recycled water distribution systems. Promotional items such as bumper stickers, magnets, rulers and pamphlets are also utilized. The public has generally supported the concept of reusing wastewater within the community. As a result of its proactive approach to public education, the WWRD has encountered little opposition to its water reuse program.

Section 3.2.2: The City and County of Honolulu's Water Reuse Program

In contrast to the County of Maui, where water reuse has been championed by the municipal wastewater agency, the HBWS has emerged as the lead agency for water reuse in the City and County of Honolulu. The use of recycled water has increased significantly on Oahu since the HBWS developed a comprehensive water reuse program in the late 1990s. The HBWS recognized that recycled water is a valuable resource that will help extend the island of Oahu's potable water supplies.

Program Development

Most water reuse growth on the island has occurred in the arid Ewa district of southwest Oahu where significant development has occurred in recent years. Land where sugar cane was previously grown has now given way to numerous residential, commercial and industrial developments. As a result, the region's water resources have been adversely affected because 1) the recharge of the region's cap rock aquifer has been significantly reduced by the elimination of sugar cane irrigation coupled with the construction of impermeable surfaces and 2) the amount of potable water used in the region has dramatically increased which has placed a strain on Oahu's aquifers. Development of the Ewa area included a number of golf courses that used brackish water from the cap rock aquifer for irrigation, residential subdivisions, which used potable water for irrigation of yards, parks and median strips, and the Campbell Industrial Park that used potable water for industrial processes.

Recycled Water Infrastructure

The City & County of Honolulu was required to build the secondary treatment facilities at the Honouliuli Wastewater Treatment Plant (WWTP) to comply with a 1993 consent order by the Hawaii State DOH. The main objective of the consent order was to establish secondary treatment at the plant and to reuse portions of the treated effluent. Improvements to the facility were completed in 1996 with approximately 2.0 mgd of recycled water being used for in-plant demands. In 1995, the EPA, the DOH and the City entered into a consent decree that required the City to develop a water reuse system that would allow the City to recycle 10 mgd of water by July 2001. The Honouliuli WWTP was selected for implementation of the water reuse requirements because of the increasing demands on the Ewa aquifer, the reduction of recharge due to the cessation of sugar cane cultivation and the close proximity of the facility to potential users of recycled water. The City & County of Honolulu selected U.S. Filter Corporation to oversee construction, own and operate the Honouliuli Water Recycling Facility (WRF). Recycled water distribution systems were built **(Figure 3-3)** to deliver R-1 and R-O water to the potential users. CWRM adopted a policy to champion water reuse in the Ewa plain. It is the policy of CWRM (Commission) to promote the viable and appropriate reuse of recycled water in

so far as it does not compromise beneficial uses of existing water resources. Recognizing that recycled water is a valuable resource in the Ewa plain, direct or indirect reuse will be championed by the Commission. Knowing that R-1 water would ultimately be available in the area, CWRM issued interim water use permits to the planned golf courses and other nonpotable users in the area and conditioned these water use permits on conversion to R-1 water once it became available and acceptable for use.

The Honouliuli Water Reclamation Facility produces both R-1 and R-O recycled water. The Honolulu Board of Water Supply has integrated recycled water into its overall water conservation plan.

The HBWS purchased the Honouliuli WRF in 2000 from U.S. Filter with the intent of integrating water reuse into a plan to conserve water resources through conservation and the development of new water supplies. The Honouliuli WRF receives secondary effluent from the Honouliuli WWTP and produces both R-1 and R-O grades of recycled water. R-1 water is now delivered to five golf courses, three parks and a median strip where it is used for landscape irrigation. R-O water is delivered to the Campbell Industrial Park where it is used for boiler feed water by five companies. Steam from the boilers is used to generate steam for electrical power production. U.S. Filter operates and maintains the Honouliuli WRF on a contractual basis while the HBWS operates and maintains the distribution system.

Program Economics

The HBWS has individual agreements in place with its recycled water customers. Golf courses and other landscape irrigation customers pay $0.25 - $0.40 per thousand gallons for R-1 water. Companies within Campbell Industrial Park pay $4.00 and $5.00 per thousand gallons for R-O

water. The initial rates for the R-1 were set significantly below what it costs the HBWS to produce and deliver the recycled water to the golf courses. Once the agreements expire, the HBWS may need to increase its recycled water rates to recover the costs associated with recycled water production and delivery. The rate increase may place an economic hardship on the golf courses. They may decide to revert back to less expensive cap rock wells for irrigation as long as their utilization is within the allocation limit of their respective permits and provided that the chloride content of the well water does not exceed 1,000 mg/L. If the golf courses do revert back to groundwater sources for irrigation, the HBWS recycled water program could be affected.

Public Education and Outreach

The HBWS has a structured organization in place to manage its water reuse program. The program is staffed with a recycled water program manager and three recycled water program coordinators. As in the case with the County of Maui, proactive public education has been an important component of the Board's water reuse program. The Board has hired a professional public relations firm to develop a strategy and promotional/educational items to gain public acceptance of its program. The program's recycled water coordinators play a key role in the Board's outreach efforts. The coordinators participate in outreach efforts and conduct numerous tours of the Honouliuli WRF and provide presentations to the community on a regular basis.

Section 3.2.3: The County of Kauai's Approach to Water Reuse

The County of Kauai does not have a structured water reuse program. R-2 recycled water from three of its facilities is provided at no cost to nearby projects. For years, effluent from County wastewater reclamation facilities was used to irrigate sugar cane. Transmission systems consisting of ditches and reservoirs were used to transport the effluent to the sugar cane fields. These same transmission systems are still used today to deliver R-2 water to the Kauai Lagoons Resort and to Kikiaola Land Company. The County now has agreements in place with the Kauai Lagoons Resort and Kikiaola Land Company to accept effluent from the Lihue and the Waimea WWRFs, respectively. The Wailua WWRF's effluent is reused at the adjacent Wailua Municipal Golf Course. This is a convenient situation for both the Wailua WWRF and the golf course since the County of Kauai owns both facilities. As these projects are the primary disposal sites for the effluent from the County wastewater facilities, the County has no plans at this time to charge for the recycled water.

Section 3.2.4: The County of Hawaii's Approach to Water Reuse

The County of Hawaii has not developed a water reuse program and currently provides R-2 recycled water to only one project, the Swing Zone Golf Practice Facility in Kona. In this case, the owner of the Swing Zone installed the recycled water distribution system from the County's Kealakehe WWRF to the practice facility at his own expense. The County's Wastewater Division is contemplating developing a distribution system which will provide recycled water from its Kealakehe WWRF to a number of irrigation projects including parks and future golf courses. Lack of available funding however has delayed implementation of these ideas. Technical planning assistance has been provided to the County of Hawaii by the Bureau of Reclamation for the planning and design of a proposed constructed wetlands system that will

utilize recycled water from the Kealakehe WWRF. Federal authorization is being pursued in Congress for funding of this project, along with two other county water reclamation projects (on Maui and Oahu). Federal funding shall be subject to authorization and subsequent Congressional approval for appropriation of funds on a cost-shared basis.

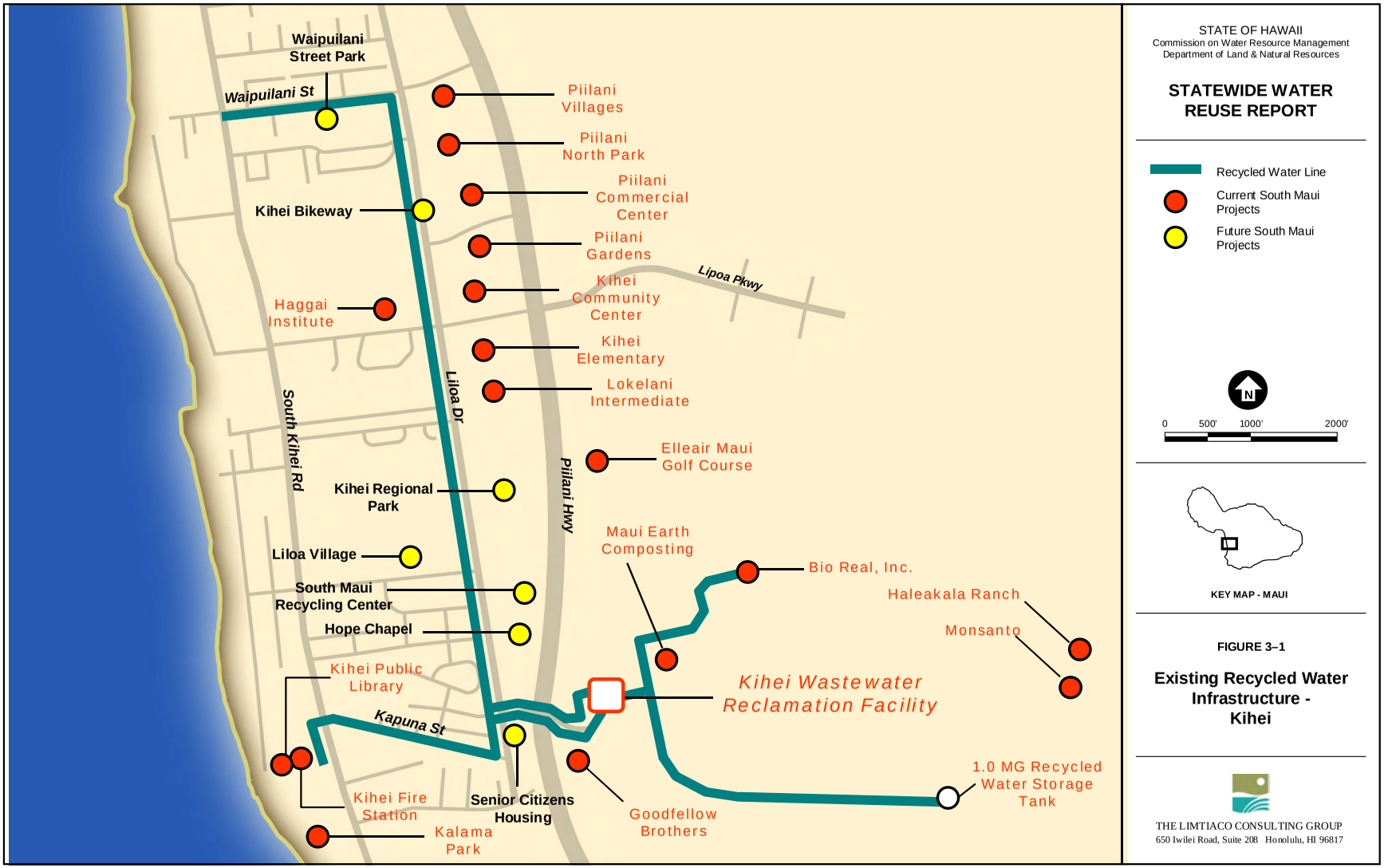

Figure 3-1: Existing Recycled Water Infrastructure – Kihei

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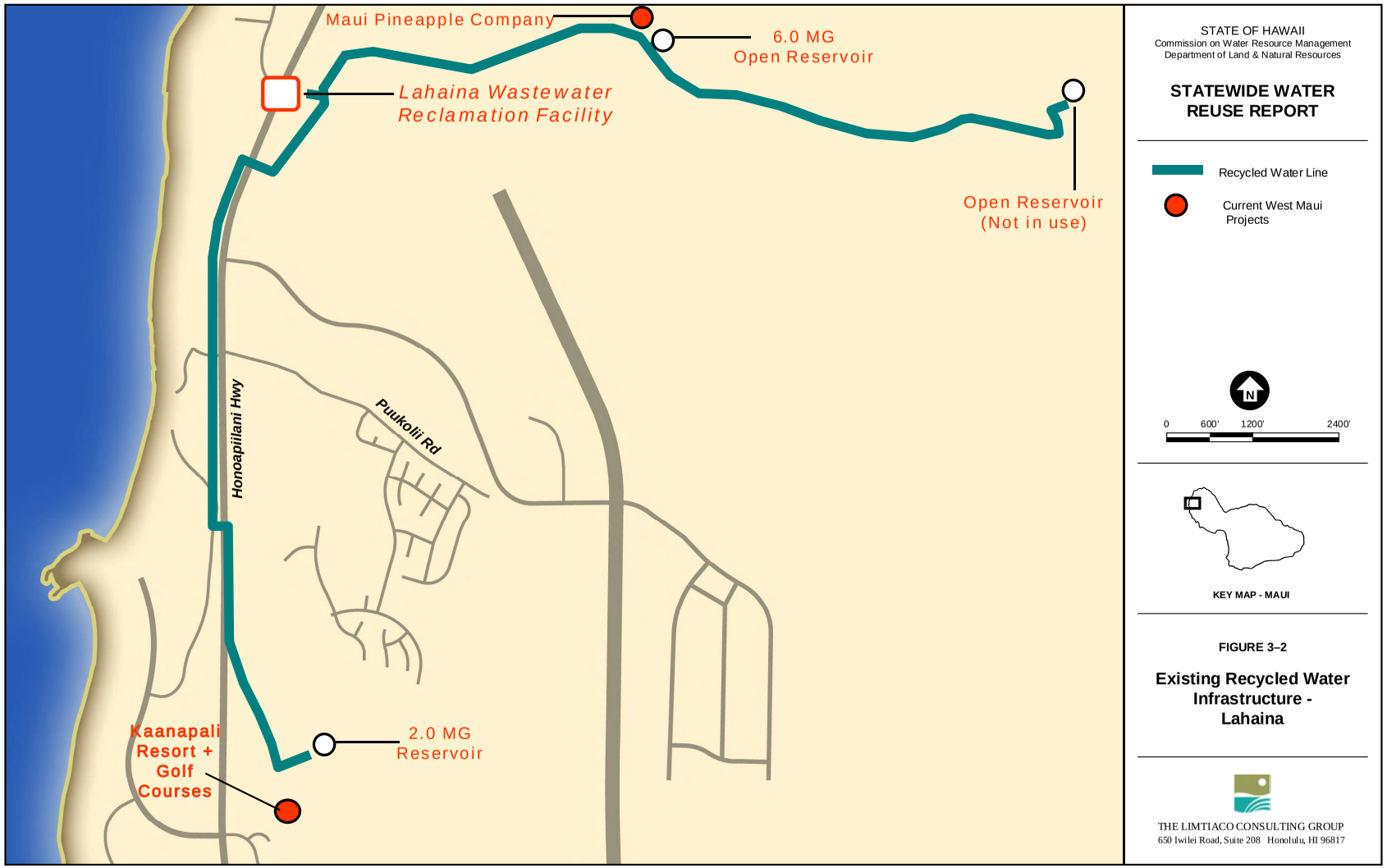

Figure 3-2: Existing Recycled Water Infrastructure – Lahaina

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Figure 3.3: Existing Recycled Water Infrastructure – Leeward Oahu

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Section 3.3: Hawaii Water Reuse Project Descriptions

Prior to surveying Hawaii's water reuse projects, the current contact information and basic data for each project was obtained from the Wastewater Branch of the Hawaii State DOH's Environmental Management Division. Telephone calls were made to project managers to gather detailed information pertaining to their respective projects and to schedule site visitations. The information collected from each project included:

- Project Location
- Wastewater Reclamation Facility Information
- Recycled Water Quality, Volume and Blending Information
- The Year Reuse was Initiated
- Project Type (Golf Course, Agriculture, etc.)
- The Driving Factor for Water Reuse: Water Supply and/or Wastewater Disposal
- Price of Recycled Water
- Benefits and Challenges Associated with Recycled Water Use

Section 3.3.1: Water Reuse in Kauai County

The island of Kauai has abundant surface water resources and there are a number of rivers and streams located throughout the island. Water from these rivers and streams has been diverted through ditch conveyance systems to provide non-potable irrigation water for many golf courses and agricultural projects. As a result, recycled water use at most of Kauai's water reuse projects is considered more of a convenient wastewater effluent disposal option rather than a water supply resource. Most of the projects utilize recycled water for golf course irrigation. The lone exception is at Kikiaola Land Company where R-2 recycled water from the County of Kauai's Waimea WWRF is blended with stream water and used for seed corn irrigation.

Section 3.3.1.1: Kauai County Water Reuse Project Descriptions

Kikiaola Land Company

Kikiaola Land Company leases 450 acres of agricultural land in the Waimea area of southwest Kauai. Recycled water from the County of Kauai's Waimea WWRF is blended in a storage reservoir with water from the Waimea River. River water is conveyed to the reservoir through the Kekaha ditch. From 1973 to 1994, sugar cane was grown in the area. The sugar company's lease expired in 1994 and now, Kikiaola Land Company leases its agricultural land to a seed corn company.

The Waimea WWRF processes 0.3 mgd of R-2 water by using conventional activated sludge and chlorine disinfection. Despite the fact that the facility is at its design capacity and that it does not have effluent filtration capability, the recycled water quality is excellent with total suspended solids in the plant effluent typically less than 1.0 mg/L. All of the facility's effluent is pumped to a storage reservoir where it is blended with river water to approximately a 30% recycled water concentration. This percentage is variable and may increase significantly during times of

decreased rainfall. While some algae is present in the reservoir, it is not considered a major challenge. The County of Kauai does not charge for the recycled water.

The driving factors for water reuse at this project are both water supply and wastewater disposal. The availability of recycled water supplements Kikiaola Land Company's non-potable water supply for it agricultural operations. Waimea is located on the dry, leeward side of Kauai and at times, river water is not available in sufficient quantities to meet the company's demands. Wastewater disposal is also a factor since the Waimea WWRF has no other disposal mechanism in place for its effluent. The facility is at its designed capacity and a back-up injection well is supposed to be drilled in the near future.

A challenge for Kikiaola Land Company is that the lack of County wastewater treatment capacity is stalling their development plans. The company has plans to treat its own wastewater to R-1 quality and use it for landscape irrigation within its future development.

Kauai Lagoons Resort

The Kauai Lagoons Resort is located in southeast Kauai and has irrigated its two golf courses, the Kiele and Lagoons Golf Courses, with recycled water since 1986. Prior to the resort's existence, recycled water was used for sugar cane irrigation and at the Kauai Surf Resort for golf course irrigation. The County of Kauai's Lihue WWRF utilizes primary clarifiers, biotowers followed by activated sludge contact stabilization and chlorine disinfection to process 1.2 mgd of R-2 water. The facility's entire daily flow is pumped to a conveyance ditch that transports the recycled water to a series of two irrigation ponds located at the resort. Recycled water is provided at no cost to the resort.

During the summer months, the Lihue WWRF's daily flow of 1.2 mgd of recycled water is not sufficient to satisfy the irrigation requirements of the two golf courses. Brackish water is blended with the recycled water in the irrigation ponds to meet the resort's irrigation demands. Brackish water is not required to supplement the recycled water during the winter months, as cooler and wetter climatic conditions are present.

The driving factor for water reuse at the Kauai Lagoons Resort is wastewater disposal, but the resort does benefit from a free and consistent supply of water. A long time challenge at this project was that the County of Kauai and the resort had an agreement that required the resort to accept all of the effluent from Lihue WWRF. This was no problem during the summer months when all of the recycled water was utilized for irrigation however during the winter months, the resort had to dispose of excess recycled water into an injection well that it owns and operates. The county addressed this challenge in the summer of 2004 when seven injection wells were drilled at the Lihue WWRF. The wells provide backup effluent disposal capability, which is a Hawaii State DOH requirement for all water reuse projects.

The Kauai Lagoons Resort in southeastern Kauai has utilized recycled water for irrigation of two golf courses since 1986.

Wailua Golf Course

The Wailua Golf Course is located in eastern Kauai and has utilized recycled water from the County of Kauai's Wailua WWRF since 1969. Since it is the only municipal golf course on Kauai, Wailua Golf course is heavily used as greens fees are low and children can play for free. The course was host to the 1996 USGA Amateur Public Links Championship and is considered to be one of the most challenging municipal courses in the nation.

The Wailua WWRF utilizes conventional activated sludge, sand filtration and chlorine disinfection to process 0.65 mgd of wastewater to R-2 quality. Typically, all of the facility's recycled water is pumped to the golf course but during extended rainy periods, plant effluent may be discharged to an ocean outfall. Wailua WWRF operators prefer to pump the effluent to the golf course, as utilization of the outfall requires more monitoring. Recycled water is delivered at no cost to the golf course, as it is the primary disposal option for the Wailua WWRF.

The application of recycled water use at Wailua Golf Course has varied over the years. At times, brackish water is blended with the recycled water and at other times potable water has been used as make-up water. There have been periods of time when recycled water was not used due to problems with the golf course storage reservoir lining. The golf course installed a new liner in the reservoir in the year 2000 and since that time, recycled water has been more consistently utilized. Brackish water is now only used as a supplemental water source during the summer months.

The driving factors for water reuse are both water supply and wastewater disposal. The golf course superintendent prefers to use recycled water and has noticed that the turf grass on the course holds its green color longer than when using brackish water. Fertilization of the course is only required on a quarterly basis when using recycled water as the primary irrigation source as compared to monthly applications when recycled water is not the primary irrigation source. Storage of the recycled water in the reservoir is normally not a problem. However during the rainy winter season, green algae can develop in the reservoir due to the prolonged detention time of recycled water. The algae uses up oxygen in the water and may result in periodic fish kills. Wailua Golf Course is planning to add a diffused aeration system to address this challenge.

Puukea Golf Course

The Puukea Golf Course is located in southeast Kauai and is part of the Puakao Development of Grove Farms Properties, Inc. The golf course has been irrigated with a blend of recycled water and stream water since 1993. Puukea Golf Course is the only project on Kauai that is provided with R-1 water. R-1 water was required at this golf course because of the presence of residences that are in close proximity to the golf course fairways and because the project was conceived after the passage of Hawaii's water reuse guidelines. Wastewater is processed to R-1 recycled water quality at the Lihue-Puhi WWTP (WWTP) using extended aeration activated sludge, chemical coagulant addition, up-flow sand filtration and chlorine disinfection. The entire plant flow of 0.2 mgd is pumped to a large lake on the golf course where it is blended with stream water. There is no charge for the recycled water, as the same company owns both the WWTP and the golf course.

While recycled water can provide up to 20% of the irrigation water used at the Puukea Golf Course, a major function that the golf course provides is that it is a convenient disposal mechanism for the recycled water. The golf course is seeded with a drought tolerant variety of Bermuda grass that only requires occasional irrigation. Due to the large surface area of the golf course lake, water loss due to evaporation significantly affects effluent "disposal" volumes.

Princeville Makai Golf Course

The Princeville Resort is located in northern Kauai. Recycled water has been utilized for the irrigation of the Makai Golf Course, a 27-hole course, since 1971. This is the only project on Kauai where water supply is the main driving factor for water reuse. Potable water was initially used at the golf course but was discontinued due to the high price.

Wastewater is treated to R-2 quality at the Princeville WWRF using activated sludge and chlorine disinfection. The entire flow of 0.675 mgd is pumped to a series of irrigation reservoirs where it is blended with rainwater that has been collected by the resort's storm drain system. As a result, the percentage of recycled water in this blend varies. The golf course pays $3,300 per month or approximately $0.163 per thousand gallons for the recycled water to Princeville Utilities Corporation.

The use of recycled water has been very successful at the Makai Golf Course with no significant problems being reported. The main benefit is that the recycled water is a reliable and inexpensive source of water. The golf course also does provide a convenient disposal option for the resort.

While the nutrients present in the recycled water may benefit the golf course, the superintendent believes that the abundant rainfall in the area hides this benefit. A minor challenge is that during the warm summer months, fish (tilapia) present in the reservoirs occasionally die due to lack of adequate circulation in the reservoirs.

The Princeville Makai Golf Course in northern Kauai blends recycled water with captured rainwater in a series of ponds on the golf course.

Poipu Bay Resort Golf Course

The Poipu Bay Resort is located in southern Kauai and recycled water has been used at the resort's golf course since 1991. Each November, the Poipu Bay Resort Golf Course hosts the Grand Slam of Golf where winners of golf's four major tournaments of the previous season compete against each other.

Wastewater from the resort is treated at the Poipu Bay Resort WWRF to R-2 quality using activated sludge and chlorine disinfection. The facility's entire daily flow of 0.2 mgd is blended with stream water from the Waita Reservoir in a lake on the golf course to a recycled water concentration of 20-40%. This percentage will increase during the wetter winter months and decrease during the dryer summer months. An injection well operated by golf course maintenance personnel is available to dispose of excess recycled water during extended rainy conditions when irrigation is not required. The Poipu Bay Resort absorbs the cost of the recycled water since it owns both the resort and the wastewater reclamation facility.

The driving factor for water reuse at this location is wastewater disposal. The recycled water is considered a reliable source of water but is not necessarily needed due to the abundance of surface water available from the Waita Reservoir. No significant challenges have been associated with the use of recycled water at the Poipu Bay Resort Golf Course.

Kiahuna Golf Club

The Kiahuna Golf Club is located in the Poipu area of southern Kauai. R-2 recycled water has been blended with water from the Waikomo stream and used for irrigation since 1984. The recycled water concentration ranges from 60-80% depending on the time of year. Single-family homes line the fairways of the golf course but since the use of R-2 water was initiated prior to the passage of the DOH's water reuse guidelines in 1993, the 500-foot buffer zone requirement has been waived.

The Poipu Water Reclamation Facility treats 0.5 mgd of wastewater to R-2 quality using the Kaldness Process and chlorine disinfection. The Kaldness Process is a combination of activated sludge and fixed film technology. Small plastic media that are similar in appearance to macaroni are mixed with activated sludge throughout the aeration basin. These media provide a suitable habitat for activated sludge microorganisms to grow and thus increase the capacity of the WWTP. This process was put into operation during the summer of 2004 and was selected because it is considered more cost effective than typical plant expansions, which require the construction of new facilities. Plans are in place to upgrade the Poipu WRF to R-1 capability by the summer of 2005.

Recycled water is provided to the golf course at no charge. The golf course superintendent was unresponsive to our survey thus no benefits or challenges at the golf course were reported. The operators of the Poipu WRF consider the use of recycled water at Kiahuna Golf Club a convenient effluent disposal option.

Section 3.3.2: Water Reuse in Maui County (Maui, Lanai & Molokai)

Most of the water reuse projects in Maui County are provided recycled water by the County of Maui's WWRD. There are also private systems including resorts and housing developments that treat their own wastewater and utilize the recycled water for golf course irrigation. The Pukalani and Makena Golf Clubs on Maui, the Challenge at Manele on Lanai and the Kaluakoi Golf Club on Molokai blend recycled water with other non-potable sources to satisfy their respective irrigation demands.

Section 3.3.2.1: Water Reuse in South Maui

Almost all of the County of Maui's south Maui water reuse projects are supplied with R-1 water from the Kihei WWRF. The facility is designed to produce up to 8.0 mgd of R-1 water. An average of 5.0 mgd is currently produced and up to 40% or 2.0 mgd is reused. Of the 2.0 mgd that is reused, 1.75 mgd is delivered to the various south Maui reuse projects and 0.25 mgd is used for in-plant uses at the Kihei WWRF. The remaining 3.0 mgd that is treated and not reused is disposed of into injection wells located at the Kihei WWRF. The Kihei WWRF utilizes

activated sludge with biological nutrient removal, up flow sand filtration and ultraviolet disinfection to produce R-1 water. The facility has coagulation capability but it is rarely used, as secondary effluent turbidity is typically very low. What recycled water is not reused is disposed of into three injection wells located at the Kihei WWRF.

Section 3.3.2.1.1: South Maui Water Reuse Projects

Elleair Maui Golf Club

The Elleair Maui Golf Club, formerly known as the Silversword Golf Club, is adjacent to the County of Maui's Kihei WWRF and has successfully utilized recycled water since the course was built in 1986. This golf course was built with the intention of using recycled water as its sole source of irrigation water. Currently, an average of 0.5 mgd of R-1 water is used. The golf utilizes pressure from the County's R-1 distribution system to operate its spray irrigation system. Prior to the conversion of the Kihei WWRF to R-1 capability in 1995, R-2 water had been used at the course.

A twenty-year agreement between the County and Elleair Maui Golf Club, which stipulates that the County only be reimbursed for the pumping expenditures it incurs to deliver recycled water to the golf course, is set to expire in July, 2006. At that time, Elleair will be required to pay for R-1 water at a rate of $0.20 per thousand gallons; the rate golf courses are assigned by the County of Maui's recycled water rate structure.

The driving factor for water reuse at Elleair Maui Golf Club is water supply. Benefits include inexpensive, high quality water at sufficient operating pressure and a mild fertilizer value of the recycled water. Since the Kihei WWRF has incorporated biological nutrient removal into its secondary treatment process, the nutrient value of the R-1 water has decreased and the golf course has had to fertilize more frequently. The lower nutrient content of the recycled water has however contributed to less algal build up in water hazards that contain the R-1 water.

Monsanto Seed Corn

Monsanto utilizes genetic engineering to grow disease, insect and pesticide resistant strains of animal feed grade corn at several locations on Maui and on Molokai. A 200 acre farm was developed above the County's Kihei WWRF in 1998 after the County completed the construction of its recycled water core distribution system. An average of 0.22 mgd of R-1 water is used to irrigate the corn. Monsanto is charged $0.20 per thousand gallons for recycled water service by the County of Maui.

An obvious benefit and the driving factor for this project is the availability of a consistent supply of inexpensive water. A challenge for this project is that corn is very susceptible to salinity and the R-1 water from the Kihei WWRF has seen total chlorides in its recycled water increase from 160 to 200 mg/L in recent years. To address this challenge, the County's WWRD will locate the points of salt water intrusion into its south Maui wastewater collection system and effect repairs. Despite the increase in salinity of the R-1 water, this particular farm is one of Monsanto's most productive and produces yields that are superior to yields of farms located both in Hawaii and the mainland United States. Monsanto also utilizes approximately 0.015 mgd of R-1 water at its

office building/bagging facility location. Since potable water is not available, R-1 water is used for landscape irrigation, fire control and toilet/urinal flushing. Monsanto pays $0.55 per thousand gallons for these uses.

The availability of recycled water prompted Monsanto to develop a 200-acre seed corn farm above the County of Maui's Kihei Wastewater Reclamation Facility.

The Monsanto project is a good example of how the availability of high quality recycled water has stimulated sustainable economic development. The company has invested money into Maui, has hired its own employees and contractors, and thus has established a thriving business that has taken advantage of a drought-free source of water. Monsanto has requested that the County extend its R-1 distribution system to north Kihei where it utilizes potable water from the central Maui Aquifers for seed corn irrigation. The County of Maui is currently having a preliminary engineering report (PER) prepared to evaluate the feasibility of expanding its system.

Piilani Reuse System

The County of Maui extended its R-1 recycled water distribution system makai (ocean side) of the Piilani Highway in 1998. A 12 inch pipe line 6100 feet in length now delivers recycled water where it is used for landscape irrigation at the Kihei Community Center, the Haggai Institute, the Kihei and Lokelani Schools, the Piilani Gardens multi-family housing complex, the Piilani Shopping Center, the Piilani Villages subdivision road shoulders and medians, and the Piilani North Park. All these projects except the Haggai Institute pay $0.55 per thousand gallons for recycled water service. The County, exercised the avoided cost clause of its rate structure, and

matched the rate of $0.45 per thousand gallons that the Haggai Institute paid to operate and maintain its brackish water pumping system.

The value of recycled water is exemplified by the projects of the Piilani Reuse System. Brief descriptions of a few of these projects will highlight this point.

Haggai Institute: The Haggai Institute is a leadership training organization that is located at the former site of the Maui Sun Hotel. High salinity brackish water was used to irrigate the property's landscaping. While inexpensive to use, the brackish water resulted in an unhealthy appearance of the landscaping. Potable water was occasionally used to flush accumulated salts from the soils but was expensive and its use was minimized. After the Haggai Institute converted to lower salinity-recycled water, the appearance of the property's landscaping improved dramatically and the volume of irrigation water was actually reduced. The Haggai Institute has expanded its use of R-1 water by using it as a source of water for its fishpond. Management is also considering using the R-1 water in the property's cooling towers. The Haggai Institute uses 0.04 mgd of R-1 water for the purposes cited above.

The Kihei and Lokelani Schools: The Kihei Elementary School and the Lokelani Intermediate School are located side-by-side just makai of the Piilani Highway and are the first and only schools in Hawaii to use recycled water for irrigation. The schools converted their irrigation over to recycled water in 1999 because the supply of potable water is limited. When one school would irrigate their landscaping, the other school would not have enough water pressure to flush its toilets and urinals. As a result, the landscaping was not sufficiently irrigated and the athletic fields at the schools were virtually dust bowls. After recycled water service was commenced the appearance of the landscaping and the turf grass of the athletic fields improved tremendously. The schools are also saving money because the recycled water is less expensive than potable water.

Piilani Shopping Center: The Piilani Shopping Center is a project that is representative of an integrated use of recycled water. The shopping center was built after recycled service was available to the area and thus was designed to utilize R-1 water for irrigation. Because of limited potable water availability, recycled water was also used for the various construction activities at this project including dust control, cement mortar mixing and street cleaning. Over 91,000,000 gallons of R-1 water were used during the construction of the Piilani Shopping Center. A minor challenge has surfaced at the Piilani Shopping Center where recycled water is applied via spray irrigation during evening hours. A grocery store at the shopping center which is open 24 hours per day has reported that vehicles parked in front of the store occasionally get wet with mist during irrigation events. Owners of the vehicles have complained of spotting on their windshields and paint finishes. Spotting occurs due to the presence of dissolved salts present in the recycled water. The irrigation schedule for this area of the parking lot has been rescheduled to early morning hours when business activity at the grocery store is at a minimum.

Over 91,000,000 gallons of recycled water were used during the construction of the Piilani Shopping Center. Recycled water is now used for landscape irrigation.

Fire Control: The main 12-inch pipeline of the Piilani Reuse System passes through an area of Kihei that is prone to brush fires and that had limited fire control capability. To address this issue, the system was designed to include eight fire hydrants that are tapped off of the pipeline. These hydrants have in fact been used to extinguish brush fires in the area. The hydrants are also used as a source of water for dust control at nearby construction projects.

The driving factor for all these projects is water supply. While these projects all use relatively small volumes of recycled water, they collectively save over 0.2 mgd of potable water. The County may extend this system to South Kihei Road where R-1 water could be used for landscape irrigation at condominiums and parks.

Future projects which will utilize recycled water for landscape irrigation from the Piilani distribution system include Hope Chapel; Hale Mahaolu elderly housing complex, Maui County's south Maui recycling center, the Kihei Regional Park, the Kihei Bikeway and green space at two new residential developments.

BioReal, Inc.

BioReal, Inc., a subsidiary of Fuji Chemical Company, utilizes micro algal biotechnology to produce the antioxidant Astaxanthin, which is an ingredient used in the health food industry. BioReal, Inc. was attracted to the south Maui area due to its abundant sunshine and the availability of R-1 water. Since the year 2000, BioReal has used 0.02 mgd of R-1 water from the Kihei WWRF for cooling of the biodomes in which the micro algae is grown. A curtain of

recycled water maintains optimum temperatures for the micro algae. After cooling the biodomes, the R-1 water is collected and directed to piping systems that leads to storage tanks. The R-1 water is cooled in these tanks and then pumped back to the biodomes. Most of the R-1 water used by BioReal is due to evaporative losses from this circulation process. BioReal pays $0.55 per thousand gallons for recycled water service.

The driving factor for this project is water supply and the primary benefit is the availability of ample supplies of R-1 water as potable water in the area is limited. Cost savings are also realized, as the only other water available in the area is potable water. A minor challenge is that algae have developed in the recirculation tanks. Hypochlorite powder is added to the R-1 water recirculation tanks to kill the algae.

BioReal, Inc. utilized recycled water for cooling of microalgae domes. This project is another example of how recycled water has stimulated sustainable economic development.

Maui Earth Compost

Maui Earth Compost is a green waste composting company that has been operating in central Maui for several years. The company expanded its operations to south Maui in 2003 and now leases land that is adjacent to the Kihei WWRF from Haleakala Ranch. Approximately 1,000 gallons per day of R-1 water is used for green waste composting and for a waste paper composting system that utilizes red wiggler worms (Eisenia foetida). The volume of recycled water used is expected to increase when full-scale operations of both the green waste and waste paper composting commence. Maui Earth Compost pays $0.20 per thousand gallons for recycled water service.

While this project uses a small volume of recycled water, it is a good example of how a company can contribute to sustainability on Maui by integrating ecologically sensitive components into its daily operations. A renewable resource (compost) is being produced from previously disposed of materials resulting in landfill diversion. Recycled water is used instead of potable water as the composting water source and is the key component of Maui Earth Compost's operation.

The driving factor for this project is water supply. A minor challenge is that the worm composting spray emitter system has been contaminated with green filamentous algae. It is believed that old PVC pipes that were used may have contained this alga and allowed it to become established in the recycled water delivery system. A new internal transmission system at the composting facility has been brought on line and algae problems have since diminished.

Haleakala Ranch

Haleakala Ranch has intermittently used R-1 from the Kihei WWRF for pasture irrigation and as a source of drinking water for cattle since 1996. Pasture irrigation, though it was successful and resulted in increased growth rates for the cattle, was discontinued in 1997 because the cattle damaged the PVC irrigation system resulting in frequent R-1 water spills. Haleakala Ranch is now irrigating 4500 feet of riparian buffer along Keokea Gulch with R-1 water in an attempt grow vegetative cover that will prevent erosion and sediment runoff into the Kihei coastal waters. A federal 319 (h) non-point source pollution grant was used by Haleakala Ranch to fund the construction of its R-1 water delivery system. Approximately 0.15 mgd of recycled water is applied on a once a week spray irrigation schedule.

The County of Maui charges the Ranch $0.10 per thousand gallons for recycled water service. If the County extends its R-1 water distribution system to the Monsanto North Kihei farms, Haleakala Ranch will be able to significantly increase its use of R-1 water. The Ranch estimates that it could use an average of 1.0 mgd for pasture irrigation and additional sedimentation control projects.

Water supply is the driving factor for this project. The Ranch was able to tap off of Monsanto's seed corn irrigation system to gain access to the R-1 water. The potential benefits include improved coastal water quality due to reduced sedimentation and the creation of a fire break in an area of south Maui that has been prone to brush fires. A challenge for this project is to limit R-1 water application rates to levels that will not cause run off and erosion in Keokea Gulch.

Goodfellow Brothers

Goodfellow Brothers is one of several construction companies on Maui that utilize R-1 from the Kihei WWRF for dust control. Since their south Maui base yard is adjacent to the Kihei WWRF, the company constructed their own recycled water fill station in 1995. The station is tapped into the Kihei WWRF's recycled water utility system and has allowed Goodfellow Brothers to maximize the use of recycled water for dust control at their south Maui construction projects. Goodfellow Brothers pays $0.55 per thousand gallons and has used over 70,000,000 gallons of recycled water since they constructed their standpipe in 1995. Goodfellow Brothers is planning to make improvements to their south Maui base yard and utilize R-1 water for toilet flushing and fire control. Pohaku Masonry has set up a construction base yard adjacent to Goodfellow

Brothers and has installed a tap off of their standpipe. Pohaku Masonry uses up to 1000 gallons per day of R-1 water for dust control and landscape irrigation at their base yard.

The Kihei WWRF has one other R-1 standpipe located at the facility's northwest corner. Several other construction companies utilize this standpipe as a source of non-potable water for dust control. R-1 water for dust control is also periodically drawn by construction companies from fire hydrants that are components of the Piilani reuse system and located on Welakahao Street. All contractors pay the County $0.55 per thousand gallons for the R-1 water.

Water supply is the driving factor for Goodfellow Brothers and other construction companies to use recycled water as the use of potable water for construction activities is not only expensive but a wasteful use of drinking water. A minor challenge is that the operations staff of Goodfellow Brothers sometimes forgets to acquire the State DOH permits that are required for all projects that utilize recycled water. The County of Maui's WWRD works with Goodfellow Brothers to insure that the proper permits are obtained.

The Kalama Park System

R-1 recycled water from the Kihei WWRF is also conveyed to three reuse projects in south Maui through an old 6" PVC pipeline. This system is independent of the County's core recycled water distribution system and has been in place since 1975. Kalama Park, the Kihei Fire Station and the Kihei Public Library all use R-1 water from this pipeline to spray irrigate turf grass and landscaping. In the past, R-2 water was used at the Kalama Park baseball field via spray and subsurface drip irrigation. Restrictions on the use of R-2 water and frequent operational problems with the subsurface drip system required the County's Parks Department to use potable water to irrigate the park until the irrigation system was upgraded in 1998. The entire park encompassing an area of 40 acres is now irrigated with R-1 water. The R-1 delivery system is tapped off of a recycled water storage reservoir at the Kihei WWRF and delivers recycled water to the Kalama Park area at relatively low pressure (45 p.s.i.). This pressure is adequate for the Kihei Fire Station and Kihei Public Library however it is too low to cover the larger irrigated areas of Kalama Park. The Parks Department installed a booster pump station to increase pressure in their irrigation system.

The driving factor for all three projects served by the Kalama Park System is water supply. The main benefit is that the appearance of the turf grass and landscaping at all of the projects has improved due to the availability of a consistent supply of low cost water. These projects all pay a rate of $0.55 per thousand gallons for recycled water service. This cost is much less than the rate paid for potable water thus all the projects are realizing a cost savings directly associated with recycled water utilization. No significant challenges associated with using recycled water have been reported.

Makena South Golf Course

The Makena South Golf Course is the only water reuse project in south Maui that utilizes recycled water from a privately owned wastewater reclamation facility. The Maui Prince Resort owns and operates the Makena WWRF. The facility currently processes 0.06 mgd of R-1 water using activated sludge, traveling bridge dual media sand filtration and ultraviolet disinfection.

The R-1 water is blended with approximately 0.4 mgd of high salinity brackish water in a reservoir on the golf course. The brackish water, which has a chloride concentration of 1500 mg/L, is slightly diluted by the recycled water. This dilution factor will increase in the future as the resort is planning to build a number of single-family residences.

The driving factor for water reuse at the Makena South Golf Course is now wastewater disposal. In the future when more wastewater is produced as the area is developed, recycled water will be viewed as an important source of high quality irrigation water. The R-1 water is delivered to the golf course at no charge.

A challenge for this project is that the Makena WWRF is well under its design capacity of 0.5 mgd. Flows are so low that the wastewater is collected and stored for up to four days before it is treated in a batch process mode. Because of the long detention times of wastewater in the system, the facility has had problems with high effluent turbidity due to excessive algal growth. Expensive coagulants were relied upon to help reduce turbidity levels to meet R-1 standards. To combat this problem and reduce the reliance on coagulants, plant operators installed a shade cloth over the secondary clarifier to reduce sunlight levels. The traveling bridge sand filters are also periodically treated with high doses of sodium hypochlorite to kill algae. These remedies have considerably reduced algae levels at the facility. As development of the Makena area progresses, it is expected that the facility will operate more efficiently with increased wastewater flow.

Section 3.3.2.2: Water Reuse in West Maui

The County of Maui provided R-2 water from its Lahaina WWRF to Pioneer Mill Company in the mid-1980's where it was used for sugar cane irrigation. The R-2 water was pumped to a reservoir at an elevation of 700 foot and blended with stream water. This practice was stopped when Pioneer Mill ceased growing sugar cane in the area in the late 1980's. The County of Maui pursued resuming effluent reuse in the mid-1990's after the EPA limited the volume of effluent that could be disposed of into injection wells at the facility. The EPA suspected that injection wells were linked to periodic algal blooms in the coastal waters of west Maui and strongly encouraged the County to decrease injection well use by increasing effluent reuse. As a result, the County passed it mandatory reuse ordinance, upgraded the Lahaina WWRF to R-1 capability and built a distribution system to deliver R-1 water to the Kaanapali Resort. The County of Maui currently provides R-1 water from the Lahaina WWRF to the Kaanapali Resort and Golf Courses and to Maui Pineapple Company.

The Lahaina WWRF utilizes activated sludge with biological nutrient removal, coagulation capability, up flow sand filtration and ultraviolet disinfection to produce up to 3.0 mgd R-1 water. The facility can treat up to 9.0 mgd however it has only one ultra-violet disinfection channel which limits the facility's R-1 capacity to 3.0 mgd. The County's west Maui water reuse distribution system cannot provide R-1 water to other projects because of its lack of storage capability. Unlike the County's south Maui distribution system that has adequate storage both at the treatment plant and at an offsite location above the facility, the west Maui system has only a small clear well at the Lahaina WWRF. The Kaanapali Resort and Maui Pineapple Company both own and operate reservoirs to which the Lahaina WWRF directly pumps R-1 water. After the reservoirs are full, the R-1 water pumps at the Lahaina WWRF are shut off and the pipelines

are depressurized. As a result, potential R-1 water users in the vicinity of the pipelines are unable to use the R-1 water because there is insufficient pressure in the distribution systems. Please refer to Section 4.1.1.2 that discusses a potential expansion that would address the shortcomings of the west Maui distribution system.

Section 3.3.2.2.1: West Maui Water Reuse Projects

The Kaanapali Resort and Golf Courses

The Kaanapali Resort and Golf Courses have used an average 1.0 mgd of R-1 water since 1997. High salinity brackish water was previously used prior to converting to R-1 water. Recycled water is used to irrigate the lower portions of two golf courses as well as road shoulders along the Honoapiilani Highway and median strips within the resort. The Kaanapali Golf Courses qualified as an "avoided cost" customer in the County of Maui's recycled water structure. Golf course personnel provided documentation to the County that they typically paid $0.16 per thousand gallons to utilize brackish water. As a result, the County matched this rate and sells R-1 water to the Kaanapali Golf Courses for somewhat less than the standard $0.20 per thousand gallons that is specified in the County's recycled water structure.

The Kaanapali Resort utilizes up to one million gallons per day of recycled water to irrigate portions of two golf courses, roadway medians and highway shoulders.

The driving factors for water reuse at this project are both water supply and wastewater disposal. Personnel at the Kaanapali Golf Courses and Resort are pleased with the R-1 water as it has less salinity than the brackish water that was previously used. The appearance of the turf grass on the

golf courses has improved dramatically. Wastewater disposal concerns have also been eased as a significant volume of the Lahaina WWRF's effluent is now being reused and not disposed of into injection wells. The County is challenged by saltwater intrusion into its wastewater collection system in the Lahaina area. The saltwater intrusion has led to moderately high levels of salinity in the R-1 water. Periodic repairs to the collection system have reduced intrusion and the County is planning to rehabilitate the problems areas of the west Maui collection system as part of its capital improvements project in the year 2006. A minor challenge reported by the Kaanapali Golf Course superintendent is that during periods of extended rainfall, the greens that are irrigated with the R-1 water develop a blue-green algae film faster than the greens irrigated with brackish water. Algaecides and frequent aeration are techniques used to combat this challenge.

Maui Pineapple Company

Maui Pineapple Company owns vast agricultural acreage on Maui and grows pineapple at several locations on the island. Their west Maui pineapple plantation uses stream water from the Honolua Ditch system. The amount of water in the Honolua Ditch depends on rainfall and during drought conditions; Maui Pineapple Company does not have enough available water from the ditch to irrigate its pineapple crop. In 2001, Maui Pineapple Company requested to use R-1 water from the Lahaina WWRF as a supplemental source of irrigation water. The company had previously performed pilot tests using the R-1 water from the facility. The tests indicated that a 50% blend of R-1 water with ditch water was suitable for pineapple irrigation. A reservoir the company had just acquired from Pioneer Mill Company was in close proximity to an existing but unused recycled water transmission line that was previously used by the County to fill a reservoir at the 700-foot elevation. At the same time, the County of Maui was required by the EPA to develop a supplemental environmental project to satisfy a condition of a consent decree that required the County to make 0.5 mgd of R-1 water available for reuse. The County proceeded to install a pumping system at the Lahaina WWRF and extend the R-1 water transmission line to Maui Pineapple Company's reservoir in early 2003.

Since the R-1 water was made available, very little has been used by Maui Pineapple Company. Drought conditions subsided and because pineapple requires little water, the increased rainfall was sufficient to irrigate the 300 acres of pineapple served by the reservoir. In addition, Maui Pineapple Company is planning to phase out pineapple production in west Maui by the year 2005. The R-1 water delivery system may be used for some other agricultural operation in the future.

The driving factor for water reuse at this project is primarily wastewater disposal. Maui Pineapple Company only pays $0.02 per thousand gallons since they qualified as an "avoided cost" customer. It costs the County significantly more than this rate to pump recycled water to the reservoir. The County would not have agreed to construct the R-1 water delivery system if it not had been for the EPA consent decree requirement. Water supply is also a factor. The benefit to Maui Pineapple Company and to any future agricultural company that farms this area is that they have a drought proof source of water available. A challenge for any agricultural use of the R-1 water from the Lahaina WWRF is the salinity level of the recycled water. Blending the R-1 water with water from Honolua ditch to reduce chloride levels is an interim solution to this

challenge until the County proceeds with rehabilitation of its collection system to reduce saltwater intrusion.

West Maui Dust Control

An R-1 water fill station has been constructed at the Lahaina WWRF. Contractors have intermittently used the station as source of non-potable water for dust control. Goodfellow Brothers and Kiewit Pacific are two of the primary users of R-1 water for dust control in west Maui. Contractors are charged $0.55 per thousand gallons. The use of R-1 water could be significantly increased if the County's Highway Division would use the R-1 water for dust control and street cleaning.

Section 3.3.2.3: Water Reuse in Central Maui

The County of Maui has not placed a high priority on developing a recycled water distribution system in central Maui. Many of the potential projects that could use recycled water such as parks, a golf course and sugar cane fields in the area are using high quality, inexpensive non-potable water for irrigation. The cost to upgrade the Wailuku-Kahului WWRF to R-1 capability and to construct a recycled water distribution system is estimated to be approximately $15 million. In addition, the County is having a study conducted at this time to determine the feasibility of building a new wastewater reclamation facility further inland away from the tsunami threats and salt air corrosion which plague the existing facility. The County of Maui's position is that it would not make sense to make the capital improvements mentioned above until the study is completed and it decides upon what future course of action to take.

The Wailuku-Kahului WWRF is designed for 7.9 mgd and currently processes 5.5 mgd to R-2 quality using activated sludge with biological nutrient removal, traveling bridge sand filters and chlorine disinfection. Most of the facility's effluent is disposed of onsite into injection wells. Some of the recycled water is used for in-plant uses including cooling, chemical dilution, fire control and landscape irrigation.

Currently there is only one project, the Kanaha Cultural Park, utilizing recycled water from the County's Wailuku-Kahului WWRF. A recycled water fill station has also been constructed at the facility. Construction companies and the State Department of Transportation occasionally utilize R-2 water from the facility for dust control and street cleaning.

Section 3.3.2.3.1: Central Maui Water Reuse Projects

Kanaha Cultural Park

The Kanaha Cultural Park is adjacent to the Wailuku-Kahului WWRF and is a relatively new County park. Residents had used this area as an unauthorized dumpsite for years. In 2001, the Community Work Day Program adopted the site with the intention of cleaning refuse from the area and landscaping it with coconut trees and native Hawaiian plants. Since the park is adjacent to the Wailuku-Kahului WWRF, it made good sense to utilize R-2 water for irrigation. The County extended its in-plant irrigation system to its boundary that is next the park to accommodate the project. Because of the 500-foot buffer zones required with spray irrigation

and the potential for park visitors coming in contact with the R-2 water, a surface drip irrigation system was installed at the park.

The Kanaha Cultural Park utilizes 0.01 mgd of R-2 water and the County Parks Department is charged $0.55 per thousand gallons. While the Parks Department pays for the recycled water, they do not have staff to maintain the park. Volunteers maintain the park and its irrigation system. According to Community Work Day personnel, the park is one of the longest continuous stretches of native Hawaiian plants in the state of Hawaii.

The driving factor for water reuse at this project is water supply. Without the availability of recycled water, the creation of the Kanaha Cultural Park would not have been possible. The obvious benefit is a reliable source of water. A challenge was that vehicles had unrestricted access to the park and frequently would drive over irrigation lines and cause breaks. A fence has been installed to address this challenge.

Pukalani Country Club

The Pukalani Country Club is located in upcountry Maui at an elevation of 1000 feet and it has been using R-2 recycled water to irrigate its golf course since 1978. This project is grand-fathered from the DOH's 500-foot buffer zone requirement when R-2 water is used via spray irrigation. Many of the fairways are bordered by single-family homes.

Wastewater collected from surrounding neighborhoods, the Pukalani Terrace Center and the Kamehameha School campus is treated at the Pukalani WWRF to R-2 quality using activated sludge and chlorine disinfection. The facility's entire R-2 daily flow of 0.23 mgd is blended at the facility with potable quality well water to approximately a 32 percent recycled water blend. The Pukalani Country Club pays the Pukalani WWRF $0.55 per thousand gallons for recycled water service.

Both water supply and wastewater disposal are the driving factors for this project. The well water that is used to supplement the recycled water is pumped from a 1200-foot deep well that is expensive to operate and maintain. Recycled water is less expensive than the well water and its reuse helps lower the overall cost to irrigate the golf course. Thus the main benefit derived by the Pukalani Country Club is the consistent supply of water for the golf course. The golf course also provides a convenient disposal option for the Pukalani Terrace area. A major challenge is that the Pukalani WWRF is an aging facility that is in need of replacement. Plans are in place to replace the existing facility by the year 2007 and possibly incorporate R-1 capability into the new facility. Another challenge is that the area is typically very windy and the R-2 water mist may migrate onto adjacent fairway homes and roadways during night time irrigation events. Golf course maintenance personnel avoid irrigating the course when high wind conditions are present. Despite these challenges, the use of R-2 water at the Pukalani Country Club has had a long history of success.

Haleakala National Park Crater Visitor Center

The Haleakala National Park Visitor Center is located at the summit of Mount Haleakala at an elevation of 10,000 feet. A closed loop water recycling system has been constructed to reuse R-1 water for toilet flushing in the restrooms at the park. R-1 water is produced using a standard

septic system followed by a recirculation sand filter and disinfection with chlorine tabs. The treatment facility has not been not fully approved by DOH yet because it requires a certified WWTP operator to be in direct responsible charge of the treatment plant. Because the system may produce effluent with higher turbidity than conventional R-1 processes, the DOH also requires a third party to monitor the system's effluent quality for two years to verify that it meets the fecal coliform standards for R-1 water. Funding will be required by the federal government to address these issues.

The intent of this project is to blend the R-1 water with captured surface water runoff from the center's parking lot and to pump the blended water to the restrooms for sanitary flushing purposes. The wastewater from the toilets will then be treated to R-1 quality, blended with the captured surface water and used over again. The project has won the Hawaii Chapter of the American Institute of Architects' 2004 Sustainability Design Award as well as the Hawaii Chapter of the American Council of Certified Engineers 2004 Grand Conception Award.

Water supply is the driving factor for water reuse at this project as there is an insufficient supply of surface water required for sanitary purposes. Hauling potable water to the summit for toilet flushing as well as drinking and hand washing purposes is extremely costly for the park. Once the system is approved by the DOH, the park's potable water hauling requirements will be significantly reduced.

Section 3.3.2.4: Water Reuse on Lanai

The island of Lanai has changed its economic base from pineapple cultivation to tourism in recent years. Two resorts, the Lodge at Koele and the Manele Bay Hotel, are located on the island and both recycle their wastewater at their respective golf courses. Water reuse is important on Lanai because the island typically receives below average rainfall and the County of Maui prohibits the use of potable water for golf course irrigation.

The Experience at Koele

The Experience at Koele is a golf course located in central Lanai that opened for public play in 1991. The course was irrigated with potable water but a County ordinance required the course to switch to non-potable water within five years of operation. The Lanai Company constructed the Lanai City Auxiliary Wastewater Treatment Facility in 1994. The facility receives 0.25 mgd of primary treated wastewater from the County of Maui's Lanai WWRF. R-1 water is produced at the auxiliary facility through the use of water hyacinths, chemical coagulant addition, up-flow sand filtration and ultra-violet disinfection. The County of Maui has a fifteen-year agreement with Lanai Resort Partners to provide free primary effluent from its stabilization pond system. While the golf course does not pay for the R-1 water, it pays $250,000 per year for the operation and maintenance of the auxiliary wastewater reclamation facility.

R-1 recycled water is the primary irrigation source for the golf course. Recycled water is also used in the water features at the course. The daily-recycled water volume of 0.25 mgd is a relatively small volume of water to irrigate an eighteen-hole golf course. Golf course maintenance personnel practice extreme water conservation measures to extend the recycled water supply. Rainwater is channelled to the irrigation ponds located on the course. The course

has been planted with drought tolerant Bermuda grass and weather stations are situated throughout the course so that watering only takes place when it is necessary. Soil moisture content is also measured on a regular basis. Because the golf course is located over a potable water aquifer, a ground water monitoring program as required by the DOH's water reuse guidelines has been in place since recycled water use was initiated in 1994.

The Experience at Koele, a world-class golf retreat on the island of Lanai, has used recycled water for irrigation and in its water features since 1994.

Water supply is the obvious driving factor for water reuse at the Experience at Koele and the consistent supply of the recycled water is the main benefit. A mild fertilizer value associated with the use of recycled water is also a benefit. A challenge at this project is that during extended rainy periods, irrigation is stopped and results in stagnant recycled water in the irrigation system piping. Odors develop and are noticeable when irrigation is resumed. The odors typically dissipate after the irrigation system has been flushed. Another challenge is that algae develop in the golf course's water features during the warmer months of the year. Maintenance personnel to address this challenge have successfully used the addition of colorants that block sunlight. Management is also planning to construct a 30 million gallon reservoir to store both recycled water and captured rainwater to address the general shortage of irrigation water for the golf course.

The Challenge at Manele

The Challenge at Manele is a golf course located in southern Lanai and has utilized recycled water blended with brackish water for irrigation since 1995. The Manele WWRF produces up to

0.17 mgd of R-1 water using activated sludge in the sequencing batch reactor mode, chemical coagulant addition and chlorine disinfection. The R-1 water is blended with brackish water to approximately a 40% recycled water concentration. The golf course pays approximately $500,000 per year to help pay for the operation and maintenance of the Manele WWRF.

Both water supply and wastewater disposal are the driving factors for water reuse at the Challenge at Manele. The recycled water helps dilute the salinity of the brackish water and the golf course is the primary wastewater disposal site for the Manele Bay Resort. The recycled water also provides some nutrients and helps reduce the use of traditional fertilizers at the course. The golf course superintendent reported no significant challenges associated with the use of recycled water.

Section 3.3.2.5: Water Reuse on Molokai

The island of Molokai is lightly populated and one of the least visited islands in the Hawaiian chain. The bulk of the wastewater produced is treated at the County of Maui's Kaunakakai WWRF and disposed of via injection wells. A small volume is used for landscape irrigation along the Mauna Loa Highway. The Kaluakoi Resort on the west end of the island also recycles its wastewater for use on its golf course.

Mauna Loa Highway Beautification

Kaunakakai is located in south-central Molokai and is typically very arid receiving less than 15 inches of rainfall per year. The Molokai Chamber of Commerce established the Mauna Loa Highway Beautification Project in 1995 and required a source of water to irrigate native Hawaiian plants that were to be planted along the portion of the highway at the entrance to Kaunakakai. Since potable water was not available, the County of Maui constructed a recycled water delivery system that would both irrigate the landscaping at its Kaunakakai WWRF and the landscaping of the Mauna Loa Highway Beautification Project.

The Kaunakakai WWRF produces up to 0.230 mgd of R-2 water using rotating biological contactors, traveling bridge sand filters, and chlorine disinfection. An average of 0.005 mgd of R-2 water is pumped to the subsurface drip system of the Mauna Loa Highway Beautification Project. While technically under the management of the State Department of Transportation, the project is maintained by the employees of the Kaunakakai WWRF as it fronts the entrance of the County wastewater facility. The Department of Transportation pays $0.55 per thousand gallons for recycled water service.

Water supply is the driving factor for this project. No significant problems have been reported with the operation of the subsurface drip system as a regular flow of R-2 water is maintained and the system is flushed on a regular basis.

The Kaluakoi Resort and Golf Course

The Kaluakoi Resort and Golf Course is owned by Molokai Ranch Company and is located in west Molokai. The golf course has intermittently used R-2 water for irrigation since 1985. The R-2 water is currently blended with backwash water from a surface water treatment plant that the

Molokai Ranch Company owns and operates. The recycled water concentration varies throughout the year and depends on the resort occupancy rate. The R-2 water blend is only used on five fairways on the front nine holes of the course that are not bordered by residences. Potable water is also used as a supplemental irrigation source.

The Kaluakoi WWRF processes 0.04 mgd of R-2 water using activated sludge, gravity sand filters and chlorine disinfection. The facility is in poor shape and has failed to meet R-2 standards in the past. Because sludge accumulated in the golf course ponds, the DOH required the resort to install liners in the ponds to prevent groundwater contamination. A crude sand filter was also constructed and has helped remove solids from the effluent. Molokai Ranch, as part of its 50-year plan, intends to upgrade its wastewater reclamation system to R-1 capability using constructed wetlands.

The driving factor for this project is wastewater disposal. A challenge confronted at this project has been algae accumulation in the golf course ponds. It was noted that the algae became more of a problem after the ponds were lined. Another challenge is that is has been difficult for maintenance personnel to determine fertilizer application rates as part of the course is irrigated with the recycled water blend while the remainder of it is irrigated with potable and backwash water. A final challenge is that more recycled water is available in the winter months of the year when the resort's occupancy rates increase. This is the time of year when irrigation rates are low. During the warmer summer months when irrigation requirements increase, the resort's occupancy rate is lower thus requiring the course to depend more on potable water as its main irrigation source.

Puu O Hoku Ranch

Puu O Hoku Ranch is located in south-central Molokai in Kaunakakai and has recently commenced operation of a constructed wetlands system in the year 2004. The system is relatively small and is designed for only 3,700 gallons per day. Wastewater is collected from the ranch and treated to R-3 quality using septic tanks, effluent screening and the constructed wetland. The R-3 water is used to irrigate trees and shrubs via a subsurface drip irrigation system.

The ranch benefits from this project due to improved wastewater treatment capability and the fact that it is has created a drought-proof supply of water that satisfies much of its irrigation requirements. An initial challenge has been acquiring the appropriate plants for the wetlands system.

Section 3.3.3: Water Reuse in Hawaii County (The Big Island)

Water reuse on the Big Island is mainly taking place at private resort developments where wastewater is treated at resort owned wastewater reclamation facilities and then blended with other water sources and reused for irrigation of the resorts' golf courses. Other projects include the State Department of Transportation's Keahole International Airport where R-1 water is used for irrigation of the airport's landscaping and at Parker Ranch where R-3 water is used for pasture irrigation.

Section 3.3.3.1: Hawaii County Water Reuse Project Descriptions

Waikaloa Beach Resort

The Waikoloa Beach Resort is located in west Hawaii. R-2 recycled water has been blended with brackish water and used to irrigate the resort's two golf courses, the Beach Course and the King's Course, since 1980. The Waikoloa Beach Resort Water Reclamation Plant treats 0.5 mgd to R-2 quality with a series of two facultative lagoons equipped with floating aerators, up-flow sand filtration and chlorine disinfection. The West Hawaii Utilities Company that provides water and wastewater service for the resort, blends the recycled water as it leaves the treatment plant with brackish water that has a total chloride level of 600 mg/L. The blended water with approximately a 20% recycled water concentration is delivered to a lake located between the two golf courses and is sold by the Company to the resort at a rate of $0.30 per thousand gallons.

Water supply and wastewater disposal are both driving factors for water reuse at this location. The main benefit of the recycled water is that it helps dilute the salinity of the brackish water. Minor fertilizer savings are also realized. Algae have been a problem both at the treatment plant and occasionally in the golf course lake. The addition of the up-flow sand filter has helped reduce total suspended solids attributed to algae from approximately 50 to 18 mg/L. Golf course maintenance personnel control algal growth in the lake with a variety of methods including fish (tilapia, grass carp and koi) and by using colorant dyes to restrict sunlight penetration into the lake water. Granular calcium hypochlorite powder has also been used in the past to help control algae. The limited storage in the receiving lake is also a challenge for this project. West Hawaii Utilities Company has plans to drill an injection well in the near future to provide an alternative disposal site for effluent from the resort's wastewater facility.

Mauna Lani Resort

The Mauna Lani Resort is located immediately north of the Waikoloa Resort in west Hawaii. Mauna Lani initiated water reuse in 1984 and blended R-2 water with brackish well water to irrigate its golf courses. Since 1997, Mauna Lani has only utilized its recycled water for the irrigation of nursery trees (coconut palms and plumeria), a sod farm and as a water source for a green waste composting operation. Irrigation of the golf courses with the blended R-2 water was discontinued due to excessive costs associated with chlorine disinfection.

Approximately 0.25 mgd of wastewater is treated to R-2 quality at the Mauna Lani WWRF using two aerated lagoons in series and chlorine disinfection. A unique feature of the Mauna Lani WWRF is that the majority of the power that it utilizes is generated by solar panels. Lagoon systems use much less power than activated sludge systems and west Hawaii is typically very sunny thus the electricity generated by the solar panels usually is enough to completely power the facility. Backup power from Hawaii Electric Light Company is available for use on cloudy days.

The driving factor for water reuse at this location is primarily wastewater disposal although the availability of the recycled water source with a fertilizer value is a plus for the nursery and sod farm operation. No significant challenges associated with the use of recycled water were reported. The resort absorbs the cost of recycled water production.

Mauna Kea Resort

The Mauna Kea Resort has utilized R-2 water blended with good quality brackish water at its golf course since 1996. A daily flow of 0.27 mgd is treated to R-2 quality at the South Kohala Wastewater Corporation's WWRF using activated sludge, cartridge filtration and chlorine disinfection. The facility utilizes influent surge basins, which allow a constant flow of wastewater to be fed to the aeration basins. This process stabilizes plant operations and allows for high quality effluent to be consistently produced. The recycled water and brackish waster are mixed in a blending basin that is located next to the wastewater facility to a 55% recycled water concentration and then pumped to the golf course.

This project commenced operations after the passage of the DOH's water reuse guidelines therefore the use of R-2 water is only used in areas where the 500 foot buffer zone requirement is met. The blended R-2 water is utilized on four fairways of the golf course that do not have residences adjacent to them. The golf course is charged $0.35 per thousand gallons for the recycled water to mainly reimburse South Kohala Wastewater Corporation for electrical costs.

Since an adequate supply of good quality brackish waster is readily available, the driving factor for this project is primarily wastewater disposal. No significant challenges associated with the use of recycled water at this project were reported.

Kona and Alii Country Clubs

The Kona and Alii Country Clubs are located in the Keauhou area of west Hawaii. R-2 recycled water has been used for irrigation and in water features at the golf courses since 1981. Currently, R-2 water is blended with brackish water and used to irrigate the front nine holes of the Kona Country Club course where there are few fairway homes present. Golf course maintenance personnel have the ability to utilize the recycled water throughout both courses if the need arises.

The Heeia WWRF produces 0.5 mgd of R-2 water using activated sludge in the sequencing batch reactor (SBR) mode and chlorine disinfection. Plans are in place to upgrade this facility to R-1 capability by the year 2006. The recycled water is pumped to reservoirs located mauka on the Alii Course and blended to a 60% recycled water concentration with high salinity brackish water. The Heeia WWRF is reimbursed for the electrical costs associated with pumping the R-2 water to the reservoirs. The blended water is then directed to the Kona (makai) course's irrigation system.

The driving factor for water reuse at this project is water supply. Potable water is too expensive to use and brackish water in the area is high in total chlorides (3400 mg/L). A challenge for this project is that the recycled water is also high in salinity with a total chlorides concentration of 2800 mg/L thus the blended water results in salt build up in the courses' soils. During periods of reduced rainfall, the courses' turf has a noticeable yellow appearance due to the high salt content of the irrigation water. This challenge has been addressed by adding gypsum to the courses but this is an expensive remedy that costs approximately $75,000 per year. The main benefit of the recycled water according to the golf course superintendent is that it is "available and wet". No noticeable fertilizer benefit of the recycled water was reported but it is believed that the use of high salinity water for irrigation is hiding this potential benefit.

Most of the water reuse on the Big Island takes place at private resort areas such as the Kona and Alii Country Clubs in the Keauhou district of west Hawaii. These projects typically blend R-2 water with high salinity brackish water.

Sea Mountain Golf Course

Sea Mountain Golf Course is located in southern Hawaii and has used R-2 water blended with potable quality groundwater for irrigation since 1990. Wastewater from a nearby residential condominium and resort area is treated to R-2 quality at the Punaluu Water & Sanitation Company WWRF using activated sludge and chlorine disinfection. The facility treats only 4,000 to 12,000 gallons per day thus the recycled water is highly diluted. Recycled water is provided at no cost to the golf course.

Due to the availability of high quality groundwater in the area, the driving factor for water reuse at this project is wastewater disposal. The golf course superintendent reported no significant benefits or challenges of using recycled water.

Swing Zone, LLC

The Swing Zone is a golf practice facility located in the Kona area of west Hawaii. This is somewhat of a unique project because the owner of Swing Zone installed a recycled water transmission system at his own expense from the County of Hawaii's Kealakehe WWRF to convey 0.06 mgd of R-2 water to the Swing Zone property where it is used to irrigate the facility's turf grass. Since buffer zones are required when using R-2 water via spray irrigation, potable water is still used to irrigate sections of the facility, which are close to roads and adjacent

properties. R-2 water is blended with high salinity brackish water in a 3,000-gallon tank located at the practice facility.

Wastewater is treated to R-2 quality at the Kealakehe WWRF using five aerated facultative lagoons in series and chlorine disinfection. The driving factor for this project is water supply as the high cost of potable water prompted the owner to construct the recycled water transmission system. Recycled water is provided at no cost to the Swing Zone at this time although the County is considering charging $1.00 per thousand gallons at some point in the future. The main benefits at this project include cost savings and dilution of the salinity level of the brackish water. A challenge is that the sprinkler head screens tend to clog with fish parts as mosquito fish are present both in the lagoons at the Kealakehe WWRF and in the storage tank at the Swing Zone.

Keahole International Airport

The Keahole International Airport is located in west Hawaii and is the only project on the Big Island that utilizes R-1 water for irrigation purposes. The State Department of Transportation completed construction of the Keahole International Airport WWRF in 2001. Wastewater is treated to R-1 quality through an activated sludge oxidation ditch system, anthracite mixed media filtration, and ultraviolet filtration. Coagulation capability is also available at the facility but is only used during rare occasions when the secondary effluent is turbid. The daily flow of 0.03 mgd is blended at the treatment plant with an equal volume of potable water in a mixing basin and used to irrigate the airport's landscaping.

The Keahole Airport in west Hawaii is the only project on the Big Island that utilizes R-1 recycled water for landscape irrigation.

The driving factor for this project is primarily wastewater disposal but the high price of potable water in the area makes the availability of high quality recycled water economically attractive. Since the D.O.T. owns both the airport and the treatment plant, the airport does not pay for the recycled water. The project manager considers this project an example of "Environmental stewardship with an economic attachment". No major challenges have been reported.

Parker Ranch

Parker Ranch is located in the Kamuela area of northern Hawaii and is one of two projects in the state of Hawaii that utilizes R-3 water. Since 2003, 0.045 mgd of R-3 water has been used for pasture irrigation. Wastewater is treated at the Waimea Wastewater Company's WWRF using two stabilization ponds in series. A clarification chamber that is situated between the stabilization ponds, utilizes water hyacinths to clarify effluent from the primary pond. The use of water hyacinths was not part of the original design of this facility. The hyacinths were added to the clarification chamber later on by plant operations personnel as a means to improve the effluent quality. This facility is one of only three wastewater treatment facilities in the state that uses water hyacinths as a wastewater treatment method.

After treatment, the R-3 water is pumped from the secondary stabilization pond to two remote 20-acre paddocks of pasture that are located approximately 1000 yards away from the Waimea Wastewater Company WWRF. Each section is irrigated via spray irrigation every other day. A computerized irrigation system located at the treatment facility is used to control delivery of the R-3 water to area.

The driving factor for this project is wastewater disposal. Cattle do not graze in the disposal paddocks because they may damage the spray irrigation system. Aside from being a convenient disposal option, no other benefits were reported. The disposal area was to be developed into a game bird habitat by planting various vegetation and grains. This option has yet to be implemented but may be exercised in the future. A minor challenge is that some algae have developed in the secondary stabilization pond at the wastewater reclamation facility. The algae are controlled through the addition of sodium hypochlorite powder.

Section 3.3.4: Water Reuse in the City & County of Honolulu (Oahu)

Water reuse has been successfully practiced on Oahu for decades. The oldest Hawaiian reuse project is at Waialua Diversified Agriculture where recycled water has been blended with stream water and used for irrigation of sugar cane and diversified agriculture since 1928. Other projects with successful track records include the Marine Corps Base Hawaii Kaneohe Klipper Golf Course, where R-2 water has been used to irrigate the base golf course since 1966, and Hawaii Reserves, Inc., where R-1 water is used to irrigate bananas, papaya, tropical flowers and the athletic fields at the Brigham Young University Hawaii campus since 1995. Most of the growth in water reuse on Oahu has taken place in the Ewa district of southwest Oahu due to the development of a water recycling program by the HBWS.

Section 3.3.4.1: Water Reuse in Southwest Oahu (Ewa)

All of the water reuse projects in the Ewa district of southwest Oahu receive recycled water from the HBWS's Honouliuli WRF. This facility receives secondary effluent from the Honouliuli WWTP that is operated by the City's Department of Environmental Services (ENV). The Honouliuli WRF produces two classes of recycled water, R-1 and R-O. Passing the secondary effluent from the City's Honouliuli WWTP through down-flow sand filters, coagulation and UV disinfection produces the R-1 water. The R-O water is produced by micro filtration and R-O processes. Commencing in 1999, the R-1 water has been used to irrigate golf courses, medians and parks in the area. The R-O water is delivered to the Campbell Industrial Park where it is used for boiler feed water for electrical power production.

Unlike the County of Maui, which depends upon elevated storage to produce consistent pressure in its south Maui recycled water distribution system, the City & County of Honolulu pressurizes its R-1 and R-O systems by running pumps. The systems are designed in a loop fashion to help stabilize system pressure. Despite this design, low pressure in the systems is a problem at times particularly when multiple users draw from the system.

Section 3.3.4.1.1: Southwest Oahu Water Reuse Projects

Campbell Industrial Park

The Campbell Industrial Park is located in the Ewa area of southwest Oahu. Five companies located in the park that previously used potable water for industrial purposes now utilize R-O water from the Honouliuli WRF. R-O recycled water was made available to the park in the year 2000. All of the companies utilize the R-O water to generate electrical power. Since potable water was previously used at these locations, the use of R-O water at Campbell Industrial Park is contributing greatly to the Honolulu Board of Water Supply's integrated water conservation program. Approximately 1.6 mgd of R-O water is provided to these companies. The companies with their respective daily volumes of R-O water use are listed in **Table 3-2** below.

Table 3-2: Daily R-O Water Use at Campbell Industrial Park

Company	Average Daily R-O Use (mgd)
Kalaeloa Partners	0.50
Chevron Refinery	0.40
Tesoro Hawaii Corporation	0.33
AES Hawaii, Inc.	0.30
The Gas Company	0.05
Total	**1.58**

Kalaeloa Partners, the largest consumer of R-O water, utilizes combined cycle technology to generate steam. The steam is combined with exhaust gases from combustion engines to operate a

steam turbine generator that produces electrical energy. Approximately 20% of Oahu's electrical demand is supplied by Kalaeloa Partners. Excess steam is sold to the nearby Tesero oil refinery.

The HBWS charges between $4.00 and $5.00 per thousand gallons of R-O water. The Board has entered into individual agreements for the use of the R-O water with each of the five companies. Since the R-O water is essentially mineral free, all of the companies save money that was spent on chemicals that were required to regenerate their demineralizer units. With potable water, these units needed to be frequently regenerated. Now with R-O water, regeneration time is extended to up to twelve times what it used to be. Despite the fact that the R-O water is more expensive, the companies overall are saving money due to less chemical usage. By saving potable water through the utilization of R-O recycled water, all of the companies have enhanced their standing in the community and have established close working relationships with local environmental groups. The companies have not encountered significant challenges associated with the use of R-O recycled water.

Kalaeloa Partners is one of five companies in the Campbell Industrial Park that utilizes R-O water from the Honouliuli Water Recycling Facility for industrial purposes.

Ewa Area Golf Courses

Commencing in the year 2000, five golf courses located in the Ewa area of southwest Oahu converted their source of irrigation water from brackish ground water to R-1 recycled water from the Honouliuli WRF. The brackish water used by these golf courses was of good quality but the concern was that salinity levels might gradually increase due to the lack of groundwater recharge that previously took place from sugar cane cultivation. Ewa Villages Golf Course, Coral Creek

Golf Course, Hawaii Prince Golf Course, Kapolei Golf Course and West Loch Golf Course all use up to 1.0 mgd each of R-1 water for irrigation. R-1 water is used undiluted and is purchased from the HBWS for rates that range between $0.25 - $0.40 per thousand gallons. The Board has entered into individual agreements with each of the golf courses for the use of the R-1 water. As discussed in Section 3.2.2, the recycled water rates may be significantly increased by the HBWS once these agreements expire. The rate increase may place an economic hardship on the golf courses and they may decide to revert back to less expensive groundwater as their primary irrigation water source. This action could affect the HBWS recycled water program.

The R-1 water is also delivered through the distribution systems of the West Loch and Ewa Villages Golf Courses to parks and median strips that are in close proximity to these respective courses.

Since converting its irrigation system to recycled water in the year 2000, the Hawaii Prince Golf Course has not had to fertilize its fairways due to the nutrients present in the recycled water.

Since converting to R-1 water, all of the golf courses have been able to reduce fertilizer applications. Golf course maintenance personnel state that the R-1 water has a well-balanced nutrient content. Another benefit noticed at the West Loch and Ewa Villages Golf Course was that the snail and clam populations in the golf course ponds was reduced after converting the irrigation source to recycled water. The snails and clams were problematic because they clogged the screens on the sprinkler heads. The superintendents of both courses believe that the higher alkalinity of the recycled water may be responsible for the reduction in the snail and clam populations. A potential challenge faced by some of the Ewa area golf courses is that the

recycled water may be higher in salinity than the brackish water that was previously used. Salts may build up in the soil and interfere with the water uptake of the turf grass. Traditional management techniques such as over irrigation to leach salts from the soil and the addition of gypsum may be required to address this challenge. Algae build up in the West Loch golf course ponds has also been a problem associated with the recycled water. The ponds are shallow in depth and are not aerated. The algae clog the screens of the sprinkler heads and the screens require frequent cleaning. Algaecides have been used but have not been successful in significantly reducing the algae. The golf course superintendent believes that the addition of pond aerators will help reduce the algae, however, West Loch Golf Course is a municipal course and funding for this type of improvement is unavailable at this time.

The driving factor for water reuse at the Ewa area golf courses is both water supply and wastewater disposal. The R-1 water is more expensive than the brackish water that was used but it is considered more of a reliable long-term source of water. The consent decree that required the City to produce and reuse recycled water is also being complied with and has resulted in a significant reduction in the volume of effluent discharged to the ocean.

As noted earlier, it is the policy of the Commission to promote the viable and appropriate reuse of reclaimed water in so far as it does not compromise beneficial uses of existing water resources. Accordingly, Interim Water Use Permits were issued to Ewa area golf courses based on the conditional use of caprock water. These permits recognized the potential availability of reclaimed water in the Ewa Plain, and thus included provisions requiring a change in source of irrigation water from caprock to recycled water when that resource becomes available and acceptable for reuse.

City and County Ewa Area Parks

R-1 recycled water from the Honouliuli WRF is also utilized at City and County parks in the Ewa Area. R-1 water is delivered through the Ewa Villages and West Loch Golf Courses' irrigation systems to the Asing, Ewa Mahiku and West Loch Shoreline Parks. This design has proved to be problematic for park management as algae that have accumulated in the golf course ponds is carried over to the parks' irrigation systems. Sprinkler head screens require frequent cleaning because of the algae accumulation in the irrigation system. Each park is irrigated with approximately 0.1 mgd. A benefit of using recycled water is that the turf grass at the parks grows much better than with the nonpotable brackish water that was previously used due to the nutrient content of the recycled water.

The driving factor for water reuse at the City and County Ewa area parks is both water supply and wastewater disposal. The brackish water that was previously used was of very good quality and met drinking water standards with respect to total chlorides. To use good quality ground water for park irrigation was not considered a good use of this resource. Wastewater disposal is also a driving factor due a consent decree that requires the City and County to increase the use of recycled water in the Ewa district.

Section 3.3.4.2: Water Reuse in North and Central Oahu

Water reuse is practiced at a number of locations on the north shore and in central Oahu including Waialua Diversified Agriculture, Del Monte Pineapple, Waiawa Correctional Facility and at the Turtle Bay Resort's Palmer Golf Course. The bulk of water reuse is practiced at Waialua Diversified Agriculture, using effluent from the City's Wahiawa WWTP and the U.S. Army's Schofield Barracks WWTP, but plans are now being formulated to discontinue reuse in this area by diverting recycled water to other projects in central Oahu including parks and golf courses. In 2004 Aqua Engineers entered into a 50-year agreement with the U.S. Army to own and operate the Schofield Barracks WWTP.

Section 3.3.4.2.1: North and Central Oahu Water Reuse Projects

Waialua Diversified Agriculture

Waialua Diversified Agriculture, formerly known as Waialua Sugar Company is a subsidiary of Dole Food Company and is located in north-central Oahu. Since 1928, effluent from the City & County of Honolulu's Wahiawa WWTP has been discharged to the Wahiawa Reservoir (Lake Wilson). This reservoir serves seven thousand acres of agricultural land and is also fed by mountain stream water. In 1975, the Army's Schofield Barracks WWRF commenced discharging its effluent into a conveyance ditch that parallels Kaukonahua Stream downstream of the Wahiawa Reservoir. The Wahiawa WWTP is an R-2 facility but has all the treatment components of an R-1 facility. An average of 2.0 mgd is treated using activated sludge, up-flow sand filtration and ultraviolet disinfection. The DOH (DOH) does not recognize the Wahiawa WWTP as an R-1 facility because it does not have a backup storage or disposal site for recycled water that fails to meet R-1 standards or exceeds wet weather demands. Additionally, the facility's ultraviolet disinfection system is not designed to meet the National Water Research Institute's requirements that are part of the DOH's 2002 version of the water reuse guidelines. The Schofield Barracks WWTP processes 1.6 mgd to R-2 quality using activated sludge and chlorine disinfection. The flow to the Schofield barracks WWTP has dropped from 2.0 mgd due to recent deployments of troops to the Middle East. The blended water used by Waialua Diversified Agriculture consists of approximately 22% recycled water.

Waialua Diversified Agriculture phased out its sugar operations in 1996 and now grows a variety of crops. Agricultural land is also being leased to small farmers and to an agricultural research station operated by the University of Hawaii. Mango, papaya, seed corn, pineapple and bird of paradise flowers are some of the crops now being raised.

The driving factor for water reuse at this location is wastewater disposal. The Army had a seven-year agreement with Dole Food Company to pay $9,500,000 for seven years of discharge to the Wahiawa Reservoir system. This agreement is about to expire and the Army will be upgrading its wastewater facility to R-1 quality with plans to discontinue discharging to the Wahiawa Reservoir system and utilize the recycled water for golf course and landscape irrigation. The City & County of Honolulu does not pay for discharge to the reservoir. The main benefit of water reuse is that it is now a convenient disposal option. A challenge is that this project is currently supplied with R-2 water. Project managers are limited in the types of crops that can be grown with R-2 water. Another challenge is that nutrients present in the effluent from the Wahiawa

WWTP may have periodically caused excessive aquatic vegetative growth in the Wahiawa Reservoir. The City & County's DES is developing plans to upgrade the Wahiawa WWTP to full R-1 capability, and the HBWS received a $400,000 federal grant to design a distribution system that will deliver R-1 water to the Central Oahu Regional Park (CORP). Please refer to Section 4.1.2 for further discussion on potential future plans for water reuse in central Oahu.

Waialua Diversified Agriculture, a subsidiary of Dole Foods, is the oldest water reuse project in Hawaii. R-2 water has been blended in the Wahiawa Reservoir and used for sugar cane and diversified agricultural irrigation since 1928.

Del Monte Pineapple

Del Monte Company raises pineapple in central Oahu and has utilized R-1 water from the Kunia Water Reclamation Facility since 1999. An average of 0.05 mgd of R-1 water is blended with potable quality well water in a reservoir at Del Monte's farm and applied via a subsurface irrigation system.

The Kunia WRF, a private facility owned by Del Monte, processes R-1 water via trickling filters, up-flow sand filtration and chlorine disinfection. The residential area served by the Kunia WRF is used as employee housing by Del Monte's employees. Del Monte has initiated a groundwater-monitoring program to be in compliance with the DOH's water reuse guidelines because recycled water is used over a potable water aquifer. Recycled water is provided at no cost.

The quality of the R-2 water limits the types of crops that can be grown by Dole Foods.

Wastewater disposal is the driving factor for water reuse at this project. There is an adequate supply of good quality well water and the main benefit is that the irrigation of pineapple provides a convenient disposal option for Del Monte. A challenge for this project is the expenses associated with the groundwater monitoring program.

Waiawa Correctional Facility

The Waiawa Correctional Facility is located in central Oahu and utilizes 0.05 mgd of undiluted R-2 water via a drip irrigation system to irrigate guava, papaya and assorted citrus tree varieties. California grass and Neem trees are also grown. Wastewater is treated to R-2 quality at the Waiawa Correctional Facility WWTP using a pre-aeration basin, water hyacinths, hypochlorite chlorine disinfection and a polishing pond. The R-2 water is pumped to the agricultural fields and applied through a crude drip irrigation system consisting of PVC pipes that have small holes drilled on the bottom sides of the pipes. A conventional drip irrigation system was previously utilized but the drip emitters were prone to plugging.

Wastewater disposal is the driving factor for water reuse at Waiawa Correctional Facility. Water reuse provides a convenient disposal mechanism for the recycled water. Benefits include a free and reliable source of irrigation water and the required agricultural related tasks provide the inmates at the facility with productive work. A challenge at this project is that the water hyacinths at the WWTP need to be periodically thinned out. A suitable method for harvesting the hyacinths has not been developed as of yet.

Turtle Bay Resort

The Turtle Bay Resort is located in northern Oahu and has utilized recycled water for golf course irrigation since 1970. A new facility, the Kuilima WWTP, was built in 1994 and currently treats 0.25 mgd to R-2 quality. The facility uses primary and secondary stabilization ponds equipped with fine bubble diffusers, pressure sand filtration and chlorine disinfection to process the resort's wastewater. The pressure sand filters have not operated very well and as a result, the facility's effluent typically contains a significant amount of fine green algae. The R-2 water is blended with good quality brackish water to a 30-40% recycled water concentration and used to irrigate the Palmer Course at the resort. The resort absorbs the cost of recycled water production thus the golf course is not charged for recycled water service.

The Palmer Course has Seashore Paspalum (Paspalum vaginatum) as its main variety of turf grass. The golf course superintendent noted that a significant benefit associated with recycled water use is that the Seashore Paspalum turf has not required fertilization for over five years due to the nutrients present in the recycled water. A challenge at the Palmer Course is that the fine algae present in the recycled water accumulate within the sandy soil on the greens and cause anaerobic conditions to occur. The greens require frequent aeration to combat this problem. Plant operators at the Kuilima WTP stated that the pressure sand filters at the facility are more suited for drinking water filtration. The resort owners plan to build another hotel at Turtle Bay and upgrade the facility to R-1 capability by 2006 so that the use of recycled water can be maximized.

Section 3.3.4.3: Water Reuse in Eastern Oahu

Recycled water is being used at two locations in eastern Oahu. The Marine Corps Base Hawaii in Kaneohe has successfully irrigated its Kaneohe Klipper Golf Course with R-2 water for many years and Hawaii Reserves, Inc. uses R-1 water for a variety of uses in the Laie area including agricultural and landscape irrigation.

Section 3.3.4.3.1: Eastern Oahu Water Reuse Projects

MCBH Kaneohe Klipper Golf Course

The Kaneohe Klipper Golf Course is located at the Marine Corps Base Hawaii in Kaneohe along the eastern shore of Oahu. This course was the first golf course in Hawaii to use recycled water for irrigation having commenced the use of R-2 water in 1966. The Marine Corps Base Hawaii Water Reclamation Facility treats 1.5 mgd using trickling filters, a polishing pond and chlorine disinfection. The golf course uses 0.5 mgd of the recycled water while 1.0 mgd is discharged to the ocean through the Mokapu outfall that is owned by the City & County of Honolulu. The recycled water is not blended with any supplemental sources of water. The R-2 water is provided at no cost to the golf course.

Potable water is used periodically when the recycled water is not available such as when the water reclamation facility is undergoing maintenance. Golf course personnel have noticed that turf grass at the golf course is much healthier when recycled water is used as the primary irrigation source. The recycled water also is used to irrigate grass and landscaping at common

areas throughout the base but was discontinued due to the DOH limitations associated with spray applications of R-2 water.

A design to upgrade the MCBH Water Reclamation Facility to R-1 capability has been completed however construction has not been funded. The facility does not have enough redundancy, however, a study to incorporate membrane bioreactors into the treatment scheme may soon be funded. The membrane bioreactors would not only add redundancy to the facility but also produce R-1 quality recycled water that could be used to irrigate the golf course and the landscaping throughout the base.

Water supply is the driving factor at the Kaneohe Klipper Golf Course. Potable water is the only other source available and it is expensive to use. Benefits of using recycled water include fertilizer value and cost savings. A challenge is the over spray onto roadways and buildings during irrigation as the Kaneohe Klipper Golf Course is located along Oahu's windward coast. Over spray has been somewhat minimized at the course by wiliwili trees that have been planted along the fairways. The trees block some of the wind blown mist generated during evening irrigation.

Hawaii Reserves, Inc.

Hawaii Reserves, Inc. is located in Laie in northeast Oahu. Hawaii Reserves, Inc. developed its water reuse program as a result of a federal class action suit resulting from unapproved discharges of wastewater effluent to a stream in the area.

The Laie WWRF processes 0.36 mgd of wastewater to R-1 quality via activated sludge, up-flow sand filtration and ultraviolet disinfection. Since 1995, 0.3 mgd of the R-1 water has been reused for a variety of purposes including agricultural and landscape irrigation. A leach field is used to dispose of the R-1 water that is not utilized.

Hawaii Reserves, Inc. has fifty-six acres of agricultural land under production. Bananas, papayas and tropical flowers including hibiscus and plumeria are grown and sold locally. R-1 water is also distributed for landscape irrigation to the nearby Brigham Young University Hawaii campus where it is used to irrigate a baseball field, a rugby field, open space and bananas. R-1 water is also used to irrigate the entrance area of the Polynesian Cultural Center. Hawaii Reserves, Inc. charges $1.00 per thousand gallons for recycled water service. Hawaii Reserves, Inc. intends to turn over its wastewater reclamation facility to the City and County of Honolulu's DES but will continue to operate the recycled water distribution systems as well as the effluent leach fields.

Wastewater disposal is the driving factor for water reuse at this project however the availability of high quality recycled water has allowed Hawaii Reserves, Inc. to both expand its agricultural endeavors as well as provide nonpotable irrigation water at a reasonable cost to the Brigham Young University Hawaii campus and the Polynesian Cultural Center. A challenge at this project is that variable soil percolation rates have resulted in ponding and runoff of recycled water in some areas. Operations personnel at Hawaii Reserves, Inc. are addressing this challenge by converting subsurface irrigation systems to spray irrigation.

Chapter 4: Opportunities for Future Reuse Projects in Hawaii

Section 4.1: Potential Expansions of Existing Recycled Water Distribution Systems

New reuse opportunities will be created by expanding existing recycled water distribution systems. By doing so, the volume of recycled water utilized can be significantly increased thereby improving the economies of scale for reuse program costs. The procurement of funding will determine if and when the existing systems will be expanded.

Section 4.1.1: Potential Expansions of the County of Maui's Systems

The County of Maui has two existing R-1 recycled water distribution systems both of which have the potential to be expanded. The south Maui system is the most complete system as it has recycled water storage both at the Kihei WWRF and offsite at an elevated covered storage tank. The west Maui system does not have adequate storage thus it is limited in the number of projects that it can serve.

Section 4.1.1.1: Potential South Maui System Expansions

The County of Maui is considering expanding its south Maui recycled water distribution system to north Kihei. A PER is being prepared at this time to evaluate the possibility of extending a recycled water pipeline north from the existing elevated 1.0 million gallon storage tank to Monsanto's north Kihei farms. This expansion will require an additional storage tank to be constructed next to the existing tank and the addition of approximately four miles of pipeline. The main reason this expansion is being considered is that Monsanto utilizes potable water from the central Maui aquifer systems to irrigate its seed corn crops at the north Kihei farms. Since up to 1.0 mgd of potable water could be saved, the County of Maui's Department of Water Supply (DWS) is funding the PER. The DWS has indicated that it would contribute funding if the decision is made to construct this expansion. In addition to serving Monsanto's north Kihei farms, the proposed system expansion could also supply R-1 water to Haleakala Ranch and Kaonoulu Ranch since the pipeline would pass through both properties. The R-1 water could be used by the ranches for irrigation of pasture and agricultural crops. Alexander and Baldwin, Inc. have also shown interest in possibly utilizing R-1 water for some form of diversified agriculture. A possible aquaculture facility may also be able to utilize the R-1 water.

A project that will commence in 2005 is the Haleakala Greens Subdivision. R-1 water was required to be used at this project for landscape irrigation as a condition of zoning. Multi-family homes will be built along the fairways of the Elleair Maui Golf Club and the landscaping around the residences will be irrigated with R-1 water from the Kihei WWRF. The developer of the project will install a lateral from the County's 18-inch R-1 water line that is in the area. Since the Maui Research and Technology Park is close by, it also could be provided with recycled water for landscape irrigation. The lateral will be sized so that it can provide recycled water to both projects.

Extending the distribution system to South Kihei Road where recycled water could be used for landscape irrigation at condominiums and county parks could also increase the volume of recycled water utilized in south Maui. Potable and some brackish ground water are currently used at these locations for landscape irrigation. An extension of the Waipulani Street section of the Piilani reuse system to South Kihei Road was actually designed and was to be installed during a road-widening project in 2003. The project was cancelled because the community was not in favor of widening the road. A possible alternative plan of action would be to extend the pipeline across South Kihei Road and then through the County of Maui's Waipulani Park. The park is adjacent to several condominiums and recycled water could be easily supplied to these properties.

Section 4.1.1.2: Potential West Maui System Expansion

The west Maui recycled water distribution system services the County of Maui's largest recycled water customer, the Kaanapali Resort and Golf Courses. The system however is limited in the number of properties it can service because it lacks storage capacity. Elevated storage is desired because it results in a distribution system that is pressurized 24 hours per day. The existing R-1 water pipeline is in close proximity to a number of commercial properties, condominiums, hotels and time-share resort complexes. These properties could potentially utilize R-1 water for landscape irrigation if the County of Maui improves its recycled water distribution system.

The County of Maui's WWRD had the West Maui Reclaimed Water Master Plan prepared by a consultant in 2004. The plan identifies future users of R-1 water in west Maui and proposes a four-phased approach to expand the R-1 water distribution system. Improvements include the installation of offsite elevated storage, additional pipeline, and booster stations. Onsite recycled water storage and additional ultraviolet disinfection at the Lahaina WWRF are also recommended. In addition, a rehabilitation of the Lahaina Front Street gravity sewer is suggested to reduce saltwater intrusion into the collection system and ultimately lower the salinity of the recycled water.

The expansion of the west Maui R-1 system will require a significant capital investment. The West Maui Reclaimed Water Master Plan provides an estimate of over $46 million to complete all four phases of the suggested improvements. Over $27 million is estimated for just the Phase 1 and 2 improvements. While the County of Maui may be successful in receiving partial funding through Congressional appropriations, it will be a challenge for the county to procure the required cost-share funding for expansion of its west Maui distribution system.

Section 4.1.2: Potential Expansions of Oahu Systems

The City and County of Honolulu has water reclamation facilities at two of its eight WWTPs. Both facilities – at Honouliuli in the Ewa district and at Wahiawa in the central Oahu district – are under consideration for expansion. A third facility, the Waianae WWTP on the Leeward Coast, is under consideration for a future water reuse project.

Section 4.1.2.1: Honouliuli Water Reclamation Facility

As described previously in this report, the Honouliuli WRF produces R-1 and R-O water for reuse in the Ewa Plain and Campbell Industrial Park areas. The 12-MGD Honouliuli WRF is in its 5th year of operation, and the HBWS is undergoing planning and design efforts to expand their user base and to improve the reliability of the Honouliuli WRF system. For example, the HBWS is adding distribution lines to serve new users such as the Barbers Point, Ewa International, and the proposed Ocean Pointe golf courses.

A new reservoir that will have a capacity of 6-million gallons (MG) and be located at the site of the existing Barbers Point 215-ft-elevation non-potable reservoirs, is presently in the planning and engineering phase. The proposed reservoir would provide diurnal storage and pressure stability in the western zone of the Ewa water recycling system. This reservoir would also replace the brackish well water that is presently used to irrigate the Ko Olina golf course and resort development.

Further into the future of the HBWS's long-range plans for the Ewa recycling project are a reservoir for storage and pressure stability for the eastern distribution zone, continued expansion of its user base, and expansion of the Honouliuli WRF's treatment capacity.

Section 4.1.2.2: Wahiawa WWTP

The City and County of Honolulu's Wahiawa WWTP completed tertiary treatment upgrades in 2001 to satisfy a 1998 Consent Decree with the State DOH. The upgrades included new up-flow sand filters, ultraviolet disinfection units, and a new, deeper outfall into Lake Wilson (Wahiawa Reservoir). The City has applied for a new NPDES permit, but to date the State DOH has not issued a permit for the discharge.

The HBWS is currently embarking on a project to plan and design a 31,000-foot transmission pipeline and storage facilities for distribution of Wahiawa's effluent to the CORP. Under a 5-year agreement, CORP is being irrigated with groundwater from the Waipio Heights Wells II, which is treated using granular activated carbon (GAC) filtration to remove pesticides residuals. The construction of the Waipio Heights II development is about to begin, compelling CORP to find a new source of irrigation water. Other potential users of Wahiawa's effluent include the Mililani Golf Course, the proposed Waiawa Gentry golf courses, landscaping of the State highway, Mililani parks, and townhouse common areas, and some agricultural and commercial users.

The Wahiawa WWTP, with its tertiary upgrades completed in 2001, does not qualify as an R-1 system for the following reasons:

- Compared to the 1993 DOH Guidelines, the 2002 Guidelines reduced the UV dose requirements, but also required third party testing of the UV system for validation of design parameters, such as lamp output characteristics, instead of relying on EPA models. The third party testing resulted in the derating of the lamp output to such a degree that the Wahiawa UV system did not meet even the lowered dose requirement. In order to meet the new Guidelines, an additional bank of UV lamps is required.

- The discharge into Lake Wilson lacks a backup disposal method. The following are required by the 2002 Guidelines:

    - Either a reject storage tank sized for 1 day's flow for retreatment of effluent of noncompliant water quality, or an alternate disposal method; and

    - Either reservoir storage equivalent to 20 days' flow for wet weather and low-demand periods, or an alternate disposal method.

The HBWS's proposed CORP project requires R-1 certification by DOH to maximize the flexibility in the application and use of the recycled water. Thus, the UV expansion would be required. If the 1-day storage requirement is not implemented, then the DOH would have to approve the discharge of R-2 effluent into Lake Wilson during periods of non-compliance. If the 20-day storage requirement is not implemented, then the DOH would have to approve the discharge of "R-1 quality" R-2 effluent into Lake Wilson during low-demand or wet weather periods.

Other issues may factor into this drive to recycle some of the effluent from the Wahiawa WWTP:

- Kaukonahua Stream and its receiving water, Kaiaka Bay, are subject to Total Maximum Daily Load (TMDL) limits, which have not yet been established by DOH.

- From a regulatory standpoint, based on the 2002 DOH Guidelines, diversified agriculture would benefit from the complete removal of R-2 effluent from Lake Wilson.

- The effluent from the Wahiawa WWTP is a significant contributor of nutrients into Lake Wilson. Public perception that this leads to the infestation of salvinia molesta or other aquatic plants may further the drive to divert effluent from the lake.

- The HBWS is conducting a soil aquifer treatment study to determine the effect, if any, of irrigation using recycled water on the water quality of underlying aquifers.

Section 4.1.2.3: Schofield Barracks WWTP

In 2004, the Schofield Barracks WWTP was turned over from the U.S. Army to Aqua Engineers, a private owner and operator of water and wastewater facilities. Under their agreement, the WWRF will be upgraded with tertiary treatment processes, and 1 MGD of R-1 effluent will be made available to the Army's Kalakaua and Leilehua Golf Courses by 2006. Unless other recycled water users are found, the excess R-1 flow of about 1.6 MGD will probably continue to be discharged in Dole's irrigation ditch, which is downstream of Wilson Dam and parallel to Kaukonahua Stream.

As discussed in Section 3.3.4.2.1, the U.S. Army had previously compensated Dole for the use of the irrigation ditch for R-2 discharge. Depending on the price negotiated between Aqua Engineers and Dole for the disposal of a better quality of effluent, it may be worthwhile for Aqua Engineers to look for new users of the R-1 water. Because of its proximity to the Wahiawa WWTP, the Schofield Barracks WWTP shares a "market" of potential R-1 users. Opportunities

to combine the Schofield Barracks and Wahiawa wastewater systems have been pursued in the past, but have not come to fruition, mainly due to institutional differences between the City and County of Honolulu and the U.S. Army. With the HBWS and Aqua Engineers spearheading a new effort, consolidation of the two systems might be reconsidered.

Section 4.1.3: Potential Expansions of the County of Kauai's Systems

There are no plans in place at this time to expand any of the County of Kauai's recycled water distribution systems. As discussed in Section 4.2.6, Kikiaola Land Company's development plans have been delayed due to the lack of wastewater treatment capacity at the County of Kauai's Waimea WWRF. Kikiaola Land Company has plans to construct its own R-1 wastewater treatment facility and utilize the recycled water for irrigation purposes within its proposed development. Potential uses include irrigation of a new golf course and the common areas within a new residential subdivision.

Section 4.1.4: Potential Expansion of Hawaii (Big Island) System

The County of Hawaii's Wastewater Division is in the planning stages of developing a recycled water distribution system that will utilize recycled water from the Kealakehe WWRF. Phase 1, which will satisfy the requirement of a consent decree for the county to use recycled water, involves the construction of a pipeline that will deliver recycled water to the Honakahau Harbor where it will be used for landscape irrigation. This phase is expected to be completed by June 2005 and could also serve a future development by the Department of Hawaiian Home Lands (DHHL). Phase 2 is in the preliminary design stage and involves the development of a pipeline and reservoir system that could deliver recycled water to a possible future golf course as well as a future development. The Wastewater Division will continue to attempt to obtain federal funding for a constructed wetlands system that will be used to upgrade the Kealakehe WWRF recycled water to a R-1 quality system.

Section 4.2: Potential Project Ideas for Recycled Water Application

This section will discuss potential uses of recycled water application in Hawaii. Some of these applications of recycled water are already taking place in Hawaii but on a very small scale. Any benefits and challenges associated with each suggested potential use will also be discussed.

Section 4.2.1: Constructed Wetlands

The recharge of natural wetlands with recycled water is not allowed by the State of Hawaii's DOH because it is considered an unauthorized discharge to a state waterway. However, wetlands that are constructed with no outlets to waterways such as gulches, streams, rivers or the ocean can be used to provide additional treatment of recycled water. Both natural and constructed wetlands utilize aquatic plants that remove pollutants in water by plant uptake and by microbial action in the roots and stems of the plants. A constructed wetlands system is currently being used on the island of Lanai for the production of R-1 water by the Lanai Company. Stabilization pond effluent from the County of Maui's Lanai WWRF is treated further at an auxiliary facility by

water hyacinths and then upgraded to R-1 quality by traditional methods. The Puu O Hoku Ranch on Molokai has also recently started using a constructed wetlands system to further treat its wastewater.

There are a number of successful projects on the mainland that integrate constructed wetlands into a treatment scheme to reduce nutrient levels and organic carbon in recycled water. The Orange County Water District (OCWD) in Southern California utilizes constructed wetlands to remove these constituents from recycled water prior to recharging groundwater. The City of Goldsboro, North Carolina built a 40-acre constructed wetlands in 2002 consisting of 52,000 wetland plants of 13 different species to "polish" one to four mgd of advanced treated wastewater. The water entering the constructed wetlands had 3 mg/L total nitrogen. The resulting "polished" water had less than 1 mg/L of total nitrogen remaining in it prior to being discharged in the Neuse River (5).

The Lanai Company built a constructed wetlands system that utilizes water hyacinths to improve recycled water quality so that it can be used for irrigation of its golf course.

Constructed wetlands also could provide much-needed habitat for Hawaii's endangered waterfowl such as the Hawaiian Stilt, the Hawaiian Coot and the Hawaiian Duck. During the course of the project survey portion for this report, numerous native Hawaiian waterfowl were observed at virtually all of the wastewater reclamation facilities that utilized aerated lagoon or stabilization pond treatment. The main reason many of these species of Hawaiian waterfowl are endangered is because of loss of habitat due to development and diversion of surface water sources for agriculture. The use of recycled water for constructed wetlands would be a very

suitable use of this resource and help contribute to the recovery of endangered native Hawaiian waterfowl populations.

There are at least four potential sites in Hawaii where constructed wetlands that use recycled water. These potential sites are:

- West Hawaii: The County of Hawaii is already in the planning stages of building a constructed wetland in the vicinity of its Kealakehe WWRF. This project has received technical assistance from the Bureau of Reclamation for the planning and design of the proposed constructed wetlands.

- South Molokai: This proposed site is adjacent to the County of Maui's Kaunakakai WWRF. The site is an abandoned landfill that could be put into productive use by constructing a wetlands system. The main purpose of this project would be to create habitat for endangered Hawaiian waterfowl.

- West Molokai: Molokai Ranch owns The Kaluakoi Resort. The resort's existing R-2 wastewater reclamation facility is in poor condition. As part of its 50-year plan, the Ranch is considering incorporating constructed wetlands as part of a wastewater treatment system to upgrade its recycled water to R-1 quality.

- Central Maui: R-2 water from the County of Maui's Wailuku-Kahului WWRF could be sent to constructed wetlands to remove excess nitrogen from the recycled water. The polished water could then be used for sugar cane irrigation by HC&S (Hawaii Commercial & Sugar Company). The sugar industry has historically resisted using recycled water for irrigation because excess nitrogen results in decreased sugar yields. The use of constructed wetlands as a means of nitrogen removal in recycled water could address this concern.

All four of these projects are suggested because large land areas are available in close proximity to the respective wastewater reclamation facilities and most of the recycled water from these facilities is not utilized.

A challenge associated with constructed wetlands is dealing with major storm flows. Storm events could lead to unplanned discharges from constructed wetlands and negatively impact coastal ocean water quality. Constructed wetlands must be properly designed to deal with occasional heavy storm flows. Additional detention or spreading basins that are normally kept dry should be required as part of the design of all constructed wetlands that are built in Hawaii. Another challenge associated with constructed wetlands is mosquito proliferation. Mosquitoes are typically controlled at these sites by introducing fish that eat mosquito larvae, the addition of larvicides and in extreme instances by aerial fogging with insecticides.

Section 4.2.2: Groundwater Recharge

The use of highly treated recycled water to recharge groundwater in Hawaii could become an important water resources management tool to combat depleted groundwater supplies associated with increased development. Groundwater recharge with recycled water is an allowable use per

the State of Hawaii's Guidelines for the Treatment and Use of Recycled Water but the DOH must evaluate the feasibility of proposed projects on a case-by-case basis.

There are two common methods of recharging groundwater with recycled water: direct injection and surface spreading. Direct injection involves pumping recycled water into coastal aquifers to provide hydraulic barriers to seawater intrusion into freshwater aquifers. The Orange County Water District (OCWD) Water Factory 21 (WF-21) project is a good example of this practice. WF-21 utilizes disinfected tertiary effluent that is treated further by either GAC or R-O and other processes to produce recycled water that has extremely low levels of nitrogen, organic carbon, and other trace organic constituents. The recycled water is blended with dilution water (i.e., desalted seawater or deep well water) and then injected into a series of closely spaced barrier wells that extend to various levels into the coastal aquifer. The recycled water blend serves both to prevent seawater intrusion into the inland freshwater aquifer and to augment freshwater supplies. Strict monitoring of the WF-21's product water is required to insure that it meet local standards pertaining to nitrogen, boron, total organic carbon, trace organics, microbial and other constituents (6).

The second method involves surface spreading of recycled water in large infiltration basins where the recycled water percolates though the soil into the groundwater table over time. This method is the simplest, oldest, and most widely applied method of artificial groundwater recharge. It is considered more favorable than direct injection because it allows efficient use of space and requires only simple maintenance (7). Los Angeles County and the OCWD both practice surface spreading groundwater recharge. In the OCWD's case, Santa Ana River water that is made up of a high percentage of recycled water from effluent discharges from cities along the river is treated through a constructed wetlands system prior to groundwater recharge. This arrangement is necessary to remove nitrate-nitrogen from the river water since high nitrate levels in drinking water can cause methemoglobinemia or "blue baby syndrome," which is a serious threat to infants under 6 months of age. The constructed wetlands remove up to 88% of the nitrate-nitrogen in the river water and also reduce organic carbon compounds. The OCWD utilizes approximately 1,000 acres of surface water percolation facilities along the Santa Ana River for groundwater recharge (8).

An emerging concern associated with recharging potable supplies of groundwater with recycled water is that recycled water may contain pathogens or trace amounts of toxic chemicals. Extreme caution is warranted because of the difficulty in restoring a groundwater basin once it is contaminated. Regulatory agencies throughout the nation are proceeding with extreme caution when permitting water reuse applications that affect potable water supplies. Specific trace organic compounds are of particular concern. Full-scale advanced wastewater treatment is required including chemical clarification, filtration, air stripping, activated carbon adsorption, microfiltration, nanofiltration, R-O, and advanced oxidation using hydrogen peroxide and ultraviolet irradiation (7). Due to this concern and the required advanced treatment requirements, it may not be feasible to utilize recycled water to recharge potable aquifers in Hawaii. Recharge of non-potable aquifers with recycled water may be considered.

In Hawaii, a potential location for groundwater recharge using recycled water could be in the Ewa district of southwest Oahu. Groundwater recharge has significantly decreased since cultivation of sugar cane was discontinued. At the time of this writing, groundwater recharge via

an onsite trench using R-1 water from the Honouliuli WRF is being considered by the City and County of Honolulu's ENV. This practice would allow ENV to comply with consent decree requirement to reuse 2.0 mgd of R-1 water for in-plant uses at the Honouliuli WWTF. Only 0.7 mgd of the 2.0 mgd received by the facility is currently used. The balance of R-1 (approximately 1.3 mgd) is disposed of via the City's sewer outfall system.

In efforts to more effectively utilize the portion of R-1 water currently being disposed of through the outfall, ENV has approached CWRM with a proposal to jointly study the beneficial effects of recharging the Ewa Caprock Aquifer using recycled water. The proposed study entails recharging the underlying aquifer with up to 2.0 mgd of R-1 water via an onset trench.

The objective of the study would be to monitor changes to the caprock resource (e.g. "freshening" effects) resulting from indirect reuse of recycled water. Baseline data would be collected and existing monitoring wells would be utilized to collect ground water data to assess water quality including but not limited to, changes in chloride levels, lag time and spatial extent of any changes to the hydrologic conditions of the caprock non-potable resource (9). CWRM has recommended authorizing the Chairperson of the Department of Land and Natural Resources (DLNR) to enter into a Memorandum of Understanding with ENV to jointly undertake the proposed study and to consult with DOH prior to the study's implementation.

Other potential methods of recharging groundwater in the area could include directly injecting R-O water from the Honouliuli WRF into the Ewa Caprock Aquifer or sending R-1 water from the facility to constructed wetlands for nutrient removal prior to recharging groundwater recharge via spreding basins or seepage trenches.

Section 4.2.3: In-Stream Flow Restoration

The use of recycled water to augment or restore stream flows is currently not allowed by the Hawaii DOH because it is considered an unauthorized discharge to a state waterway per Chapter 11-54 of the HAR. The Hawaii DOH would need to remove this regulatory obstacle before recycled water could be used as a source of water to restore stream flows. Stream augmentation is differentiated from a surface water discharge in that augmentation seeks to accomplish a beneficial end, whereas discharge is primarily for disposal. Augmentation may be necessary in locations where a significant volume of water is drawn for potable or other uses, significantly reducing the downstream volume of water in the river or stream. The discharge of recycled water to streams and rivers is common on the U.S. mainland. The San Antonio River in Texas is dependant on tertiary treated recycled water to insure a continuous flow during the warm summer months of the year. Without recycled water, the scenic River Walk in San Antonio would not be popular tourist attraction that it is today. In Japan, tertiary recycled water is used to augment streams in urban areas and for creating ornamental streams and lakes (10). If the Hawaii DOH allowed highly treated recycled water to be discharged to streams and the recycled water met stream water quality standards, existing stream conditions could be improved and aquatic life could be sustained or enhanced. Both nutrient removal and high-level disinfection of the recycled water would be required prior to discharge. In addition, dechlorination may be required to protect aquatic wildlife where chlorine is used at the primary wastewater disinfectant (11).

Locations in Hawaii that could utilize recycled water for stream flow augmentation or restoration would be higher elevation communities that are in relatively close proximity to streams.

Augmenting stream flows with recycled water is not currently allowed by the Hawaii DOH as it is considered an unauthorized discharge to a state water way. Many states on the U.S. mainland rely on recycled water to replenish depleted streams.

Section 4.2.4: Recharge of Natural Wetlands

As in the case of in-stream flow restoration, recharge of natural wetlands is not allowed by the DOH, as it is considered an unauthorized discharge to a state waterway. If the DOH eventually allows this type of use for recycled water, nutrient removal and dechlorination of the recycled water would be required prior to discharge.

A proposed location for recharging natural wetlands is the Kanaha Pond in central Maui that is adjacent to the Wailuku-Kahului WWRF. During periods of dry weather, high salinity brackish water is pumped to the pond to replace evaporative losses. The Wailuku-Kahului WWRF has recently incorporated nutrient removal capability into its activated sludge process though the addition of anoxic zones. Since the water in Kahaha Pond already contains a high level of algae, utilization of reduced-nutrient recycled water from the facility should not degrade water quality. The salinity level of Kanaha Pond may decrease since the salinity of the recycled water from the Wailuku-Kahului WWRF is considerably lower than the brackish water that is currently used to recharge the wetland.

Section 4.2.5: Recreational Uses

The use of R-1 water is approved by the DOH as a source of supply for restricted recreational impoundments and basins for fish hatcheries. Restricted recreational impoundments are water features that have no direct access by the general public. An example of a restricted recreational impoundment that utilizes recycled water is a water hazard at a golf course. An exception to this scenario is the Wahiawa Reservoir in central Oahu. The reservoir is currently used for unrestricted recreational purposes such as boating and fishing despite the fact that it receives R-2 water from the City & County of Honolulu's Wahiawa WWTP. The WWTP actually produces "R-1 quality" water, but it is not certified as R-1 by the DOH because the facility lacks the required one-day and twenty-day backup storage/disposal capabilities. The DOH Wastewater Branch is not in favor of recreational uses of R-2 water and would like the discharge of R-2 water to the Wahiawa Reservoir to be discontinued.

Tertiary treated recycled water (R-1 quality) is utilized for unrestricted recreational use in other states such as California and Texas. Unrestricted recreational uses involve body contact with the recycled water and include boating, fishing, swimming and skiing. The recycled water used for unrestricted recreational applications should be aesthetically enjoyable, clear and not have objectionable odor. It also should be pathogen free, not contain any toxic substances or heavy metals and have a pH of 6.5 to 8.3 to avoid irritation to the eyes. Nitrogen and phosphorous should also be controlled as these nutrients can cause unacceptable levels of algal growth (12).

Hawaii has the potential to use recycled water for unrestricted recreational applications but the DOH must first revise the "Guidelines" prior to such uses being allowed. The DOH also must revise its stance on not allowing recycled water to be discharged to state waterways. The use of R-1 water as a source of water for lakes that are used for boating and fishing such as the Wahiawa Reservoir (Lake Wilson) on Oahu would appear to be the most likely application in Hawaii.

The use of R-1 water as a water supply for fish hatcheries is also allowed by the Hawaii DOH water reuse guidelines. R-1 water could be used at aquaculture facilities that are near R-1 water distribution systems. A proposed aquaculture facility is being considered on Maui that would be located near a proposed R-1 water line in the south Maui area.

Section 4.2.6: Irrigation

The use of recycled water for landscape and agricultural irrigation has tremendous potential for growth in Hawaii. The Hawaii DOH supports the use of recycled water for these applications and the water reuse guidelines essentially are geared towards irrigation projects. For landscape irrigation, the use of R-1 water is preferable because it provides the user with tremendous flexibility since there are no restrictions on the time that the recycled water may be applied via spray irrigation. There are also no buffer zones associated with spray irrigation of R-1 water. R-1 water is also preferable for agricultural irrigation since it is allowed by the DOH Guidelines for direct spray application of fruit and vegetables that are eaten raw. Conversely, the use of R-2 water limits the types of crops that can be grown and the methods of irrigation.

The potential expansions of existing recycled water distribution systems cited in Chapter 4.1 could provide recycled water to several projects for landscape irrigation. In addition to those locations, there are other areas in Hawaii that could be provided with R-1 recycled water for irrigation purposes. In some cases, the wastewater reclamation facilities in these areas would need to be upgraded to R-1 capability and distribution systems would need to be constructed. These potential areas include:

- Central Maui: The County of Maui's Wailuku-Kahului WWRF is an R-2 facility that currently treats approximately 5.5 mgd. Most of the R-2 water is discharged to injection wells for disposal. The facility could be upgraded to R-1 capability and a distribution system could be built to deliver R-1 water where it could be used for landscape irrigation at County parks, Maui Community College, the Dunes at Maui Lani golf course and highway medians. Many of these areas are currently irrigated with good quality brackish water thus supplying R-1 water for irrigation of these projects will not result in any potable water savings. The County is also having a study conducted at this time to evaluate the feasibility of building a new plant further inland. The improvements mentioned above to the existing facility will not be made if the County decides to abandon the existing facility and build a new plant. If a new plant is built further inland, it will be an R-1 facility and a distribution system to deliver recycled water to the projects mentioned above would be considered.

  Another possible use of recycled water from the Wailuku-Kahului WWRF would be sugar cane irrigation. The facility would not need to be upgraded to R-1 capability but as discussed in Section 4.2.1; the recycled water would need to undergo additional nutrient removal. Excess nitrogen would decrease sugar yields. A constructed wetlands system would be a potential means of nutrient removal.

- West Hawaii: The County of Hawaii's Kealakehe WWRF is an R-2 facility that utilizes stabilization ponds. Most of the recycled water from the facility is disposed of into infiltration ponds. While meeting R-2 standards, the effluent does contain fine algae that result in higher levels of total suspended solids. In order to utilize the facility's recycled water for landscape irrigation, an upgrade to R-1 capability would be required. A distribution system could be built to deliver recycled water for irrigation of county parks, landscaping at Honokahau Harbor and two future golf courses.

- Southwest Kauai: Kikiaola Land Company's currently leases its agricultural land to a seed corn company that uses diluted R-2 water from the County of Kauai's Waimea WWRF for irrigation. Kikiaola Land Company's development plans have been delayed because the Waimea WWRF is at its design capacity of 0.3 mgd. Kikiaola Land Company plans to phase out agriculture in the area. The company has developed plans to build a golf course, expand the Waimea Plantation Cottages complex, and build a mix of affordable apartment-style housing and market value single-family homes. Kikiaola Land Company recently purchased a membrane bioreactor package plant and is planning to treat its own wastewater to R-1 quality and reuse the recycled water for irrigation within its development. The company hopes to start this project by the year 2007.

- West Maui: The County of Maui has an R-1 water distribution system that delivers recycled water to 200 acres of agricultural land owned by Maui Pineapple Company. Maui Pineapple Company is planning to phase out pineapple production in west Maui by the year 2006. The land could be put into some other form of agricultural activity and utilize the R-1 water from the County's Lahaina WWRF. Maui Pineapple Company in partnership with Pacific Biodiesel is currently raising test plots of various bio-fuel crops in west Maui. Pacific Biodiesel has facilities on Maui and Oahu that produce biodiesel from used vegetable oils. Bio-fuel crops would enable the company to increase its bio-fuel production. Potential bio-fuel crops could include canola, safflower, or corn from which oils could be used for bio-fuel production. Large-scale production of bio-fuel crops and the subsequent increased production of bio-fuel would contribute to more energy sustainability in Hawaii by reducing dependence on imported oil.

Section 4.2.7: Construction Uses

A significant volume of potable water could be saved in Hawaii if recycled water was used for construction activities instead of potable water. Dust control is the most common construction use for recycled water and the DOH allows both R-1 and R-2 recycled water to be used for this purpose. Other uses include cement mixing, street cleaning and backfilling.

Maui County is the only county in Hawaii to consistently use recycled water for dust control.

The County of Maui's WWRD provides millions of gallons of recycled water each year to contractors for control of dust at construction sites. All three of Maui County's wastewater reclamation facilities on Maui are equipped with recycled water fill stations. Recycled water is

also drawn from fire hydrants that are components of the County's Piilani reuse system. The County's WWRD has helped DOH develop a short application form to facilitate permitting for construction projects. The County of Maui's Water Department is now limiting the number of potable water construction meters that it issues. Contractors are directed to the WWRD so that recycled water service may be obtained. While it is not always feasible to use recycled water because it is not available in all areas of Maui, its use for construction activities is being maximized.

Other counties in Hawaii could construct recycled water fill stations at their respective wastewater reclamation facilities. To maximize the use of recycled water for construction activities, the local water departments and contractor associations should be notified of the availability of these fill stations. Additional incentives for contractors could include simplified permitting procedures and pricing the recycled water at rates that are less expensive than potable water rates.

Section 4.2.8: Industrial Uses

The use of recycled water for industrial purposes is not a new concept and there are several successful projects on the U.S. mainland that use recycled water for a number of industrial applications. These applications include cooling systems, cooling towers, cooling ponds, boiler feed water, pulp and paper production, textile manufacturing, carpet dyeing and petroleum and coal production (13).

There are currently two locations in Hawaii where recycled water is provided to companies for industrial purposes. These locations are at the Campbell Industrial Park in southwest Oahu where R-O recycled water is fed to boilers to produce steam that is used for electrical power production and in south Maui where R-1 water is used for cooling of biodomes at an algae farm. These two projects are models of sustainable business activity for future industrial projects to follow. Beneficial products are being produced with little impact on potable water resources. In addition to these locations, most of the wastewater reclamation facilities throughout Hawaii use the recycled water from their own facilities for industrial applications. These applications included chemical dilution, pump mechanical seal lubrication, cooling, foam control and wash down activities.

There is potential to expand the use of recycled water for industrial purposes in Hawaii. Besides the industrial uses cited above, highly treated recycled water could be used in cooling towers. The Hawaii DOH Guidelines allow R-1 water to be used in cooling towers as long as it contains a continuous biocide residual. The R-1 water would have to be chemically softened so it would not produce scale on cooling system components. The recycled water might also be corrosive due to its total dissolved solids concentration. Corrosion inhibitors would need to be added to the recycled water. Biological growth and fouling are also concerns when using recycled water in cooling towers. A continuous feed of a biocide, i.e. chlorine, would restrict biological growth while chemical softening would prevent fouling from occurring (12). Commercial properties in Hawaii that are in close proximity to R-1 recycled water lines may consider utilizing R-1 water in their cooling towers.

Composting with recycled water is currently taking place on Maui by Maui Earth Compost Company and on the Big Island by the Mauna Lani Resort.

Section 4.2.9: Composting

Composting of waste materials such as green waste, biosolids and waste paper not only produce valuable soil amendments but also aids in landfill diversion. Composting does require water and typically non-potable water is used. In Hawaii, there are two projects that utilize recycled water for composting. Both projects are small but could be used as models for Hawaii to manage much of its solid waste in a sustainable manner. The Mauna Lani Resort in west Hawaii has a small green waste composting operation. Green waste from the resort is composted in static piles using R-2 water from the resort's wastewater reclamation facility. On Maui, the Maui Earth Compost Company situated its south Maui operation adjacent to the County of Maui's Kihei WWRF so that it could have easy access to the facility's R-1 water. Green waste is composted in windrows and typically blended with soil, sand or seaweed. Waste paper is composted using red composting worms that produce castings that are an excellent organic fertilizer.

Larger-scale versions of these projects could significantly increase landfill diversion in Hawaii. Market opportunities for compost in Hawaii exist as the state currently imports much of its fertilizer and compost products from the U.S. mainland. Large land areas with available recycled or some other non-potable water would be required. A potential location for this type of project could be at Haleakala Ranch in south Maui. Ranch representatives have expressed an interest in possibly leasing land that is next to the County of Maui's R-1 water distribution system for a large-scale composting operation.

Section 4.2.10: Toilet and Urinal Flushing

The use of recycled water for flushing toilets and urinals represents an excellent opportunity to displace a significant volume of potable water in Hawaii. The Irvine Ranch Water District (IRWD) in Southern California pioneered this innovative use of recycled water. In 1991, IRWD became the first water district in the nation to obtain health department permits for the interior use of recycled water from a community system. Recycled water is currently used for toilet flushing in IRWD's facilities as well as in several high-rise office buildings constructed with dual piping systems. Potable water demands in these buildings have dropped by as much as 75 percent due to the recycled water use (14).

The Hawaii water reuse guidelines allow R-1 water to be used for toilet and urinal flushing in counties that have language in their respective plumbing codes pertaining to dual water supplies within buildings. Currently, there are two projects, both on Maui, where R-1 water is used for toilet and urinal flushing. The Monsanto office building and bagging facility in south Maui utilizes R-1 water from the County of Maui's Kihei WWRF. Also on Maui, the Haleakala Crater visitor center will soon blend R-1 water from its own package WWTP with surface water runoff and use the blended water to flush toilets and urinals in the visitor center's rest rooms. Potable water to both of these areas is not available thus necessitating the use of R-1 water for toilet and urinal flushing. Other areas in Hawaii that have no or limited potable water availability could also make use of R-1 water for toilet and urinal flushing, if it is readily available.

As in the case of the IRWD, recycled water could be used for sanitary flushing purposes in office buildings in Hawaii. New office buildings could be designed with dual distribution systems to easily accommodate the recycled water supply. Existing office buildings could also be retrofitted with dual plumbing systems if the required retrofit could be accomplished in a cost effective manner.

Chapter 5: Removing Obstacles & Facilitating Implementation of Water Reuse Activities

Water reuse may face a number of different obstacles that may delay or even cancel the implementation of projects and activities. This chapter will identify these obstacles and make recommendations on how to overcome them. In addition, strategies that will help facilitate water reuse activities in Hawaii will also be discussed.

Section 5.1: Mandatory Use Ordinances

Ordinances that require commercial properties to utilize recycled water for irrigation or other purposes have been used in several states to establish a strong customer base and maximize recycled water usage. Mandatory use ordinances are established because of a shortage of potable water resources or due to environmental problems associated with effluent disposal. Several cities in the mainland U.S. have ordinances as part of their water reuse programs. Thus far, the County of Maui is the only county in Hawaii to have a mandatory use ordinance in place. The Hawaii DOH Wastewater Branch attempted to establish such an ordinance in 2001 but it was not approved by the legislature.

The County of Maui's mandatory use ordinance was passed in 1996 primarily as a means to reduce the use of injection wells for effluent disposal. A secondary reason was to proactively supplement the limited potable water supplies within Maui County. The EPA limited the volume of effluent that could be discharged to the Lahaina WWRF's injection wells to 6.7 mgd because it believed that nitrogen in the effluent was causing periodic seaweed blooms in the coastal waters of west Maui. This action was of concern to Maui County because it would effectively stop development in west Maui. The ordinance was seen as a mechanism to reduce the use of the injection wells by increasing the volume of recycled water utilized. Despite the obvious need for the ordinance, an extensive educational effort was required to pass the bill for the ordinance. Some of the large landowners of Maui County were opposed to the ordinance and lobbied County Council members to not approve it. In the end, the bill was passed and the ordinance was established with certain conditions.

The County of Maui's ordinance was initially applicable only in regions where R-1 water was available meaning in west Maui and in south Maui. It has since been revised to include central Maui where R-2 water is available. The ordinance requires commercial properties that are within 100 feet of the County's recycled water distribution system to connect to the system within one year of the system's availability and use the recycled water for irrigation.

The ordinance was effective in convincing the Kaanapali Resort and Golf Courses to convert its irrigation system from brackish water to R-1 water in 1998. Kaanapali Resort is the County's largest recycled water customer using up to 1.0 mgd. The resort's conversion to recycled water service accomplished the County's goal of reducing the use of the Lahaina WWRF's injection wells for effluent disposal. The ordinance also has helped to establish a broad customer base in south Maui where numerous commercial properties have connected to the County's recycled water distribution system.

Other counties in Hawaii could follow Maui's lead and pass a mandatory reuse ordinance to accelerate development of their respective water reuse programs. The State of Hawaii's DOH could also attempt to pass a mandatory reuse ordinance. This broader approach would allow the DOH to meets it goal of increasing the volume of recycled water reused in Hawaii. In either case, an educational effort should be undertaken at an early stage to convince lawmakers and the general public of the many benefits that such an ordinance can provide.

At a minimum, any proposed mandatory use ordinance should contain sections on connection requirements, cross-connection control measures, an inspection policy and penalties for violation, system reliability, water quality requirements and fees/rates for recycled water service.

Section 5.2: Encouraging Demand for Recycled Water

Creating a sound customer base for recycled water is always a challenge during the early stages of a municipality's water reuse program. Public information and outreach programs that identify why water reuse is necessary are important, especially during the early stages of the program. Whether it is to supplement existing water supplies or to mitigate a wastewater effluent disposal issue, the reason for recycling wastewater must be firmly established within the community. To gain support for a water reuse program, recycled water purveyors must involve the public and managers of potential water reuse projects in the development of a water reuse policy as early as possible. In this way, they will feel that they are contributing to sustainable water resource management within their respective communities. A sense of environmental stewardship will be created within the community through a proactive public involvement effort.

Perhaps an equally if not a more important tactic to encourage demand for recycled water is for municipalities to include economic incentives into their recycled water rate structures. The County of Maui created a number of economic incentives to be included into its recycled water rate structure to "kick start" its water reuse program. These incentives included a two-year waiver of connection fees, a mechanism to recover irrigation system retrofit costs, setting usage rates slightly lower than the water sources typically used by various user classes and establishing an avoided cost category that allows the recycled water rate to match what was previously spent on other non-potable water sources (15). The fact is that if potential water reuse project managers can save money at their projects when using recycled water, then they will most likely have little or no objection to converting to recycled water from other water sources. Please refer to Section 5.3, which will further examine the economics of recycled water.

A third approach to encourage demand for recycled water is to require that recycled water be used for irrigation purposes as a condition of zoning for future commercial properties. This concept would be feasible for planned developments at commercial properties that are in close proximity to existing recycled water distribution systems. Building permits would only be issued if the developments were designed to utilize recycled water for irrigation purposes.

Section 5.3: Understanding the Economics of Recycled Water

An important component of implementation of water reuse programs is the determination of how to pay for recycled water reuse projects. Water reuse projects in general and in particular, the

development of recycled water distribution systems is expensive to construct and operate. The revenues earned from selling recycled water are often insufficient to pay for the full capital and operating costs associated with the production and delivery of the recycled water. This fact is true especially if the recycled water purveyor sets the recycled water rate comparable to the user's existing water rate. To set recycled water rates at levels that will allow the purveyor to recover the full capital and operating costs of the recycled water system will most likely result in recycled rates that are significantly higher than the rates that the users pay for their alternative water sources. Thus, there would be no economic incentive for a user to convert to recycled water.

Spreading the cost of financing water reuse projects is preferred rather than laying the entire financial burden on the recycled water user. There are four main potential sources of funds for water reuse projects:

- Recycled water users
- Potable water users
- Sewer users
- Government grants

Recycled water users can be charged through recycled water rates (dollars per thousand gallons of recycled water used) or through direct up-front payment of a portion of the project costs. These up-front payments can be termed assessment fees, capacity fees, connection fees, impact fees, or system development fees, but they all basically represent a "joint venture" between the recycled water purveyor and the user to pay for all or a portion of the capital costs of the project.

Potable water users may appropriately be charged a portion of recycled water project costs if they benefit from the implementation of the recycled water program, e.g., if reduced chances of potable water rationing result from water reuse. Similarly, sewer users may be charged for water reuse projects if they receive benefits from reuse. Because future injection wells or outfall discharges of effluent in Hawaii may be limited in the future by regulatory agencies, water reuse becomes an acceptable alternate disposal method, and it is appropriate for sewer users to pay for a portion of water reuse projects.

Government grants currently represent an unlikely source of funds due to limited state and federal budgets, but recycled water purveyors in Hawaii should be vigilant in the search for potential sources of government grants from various state and federal agencies. (Note that government loans are not considered sources of funds because they must be repaid. They do, however, represent a low-cost method of obtaining construction funding and are desirable for that reason.) (16). Please refer to Chapter 6, which discusses potential funding sources for water reuse projects.

The County of Maui created a community based committee to help them develop its recycled water rate structure. The committee consisted of representatives from the large landowners on Maui, the Maui Chamber of Commerce, the Maui Hotel Association, the Maui Realtor Association, members from the County of Maui's WWRD and Department of Finance and the County's consultant. The committee decided upon a "composite" rate structure for its water reuse program that identified three main user classes: Major Agriculture ($0.10 per thousand

gallons), Agriculture-including golf courses ($0.20 per thousand gallons) and All Other ($0.55 per thousand gallons). The recycled water rates were set to levels that were somewhat less expensive than the conventional alternative water sources used by the three user classes. Connection fees were set for south and west Maui where significant recycled water distribution systems were constructed. Meter fees were also developed. Because effluent disposal was an important factor driving Maui's water reuse program, sewer user rates were also slightly increased.

Maui's approach has allowed recycled water to become an attractive non-potable water source because it is less expensive than conventional alternative water sources. At the same time, sewer users help pay for the water reuse program because it is believed that they must be held responsible for not only the collection and treatment of wastewater they produce but for its ultimate disposal, whether it be through injection wells or though water reuse (15).

It is recommended that recycled water purveyors in Hawaii attempt to recover the capital and operations cost of their respective water reuse programs by having recycled water users, sewer users and potable water users all contribute through their bimonthly user fees.

Section 5.4: Lack of Cooperation Between Municipal Agencies

Water reuse provides both water supply and wastewater disposal benefits. A common issue encountered in the early stages of municipal water reuse programs is the determination of which agency; the water supplier or the wastewater services provider, will champion and administer the program. Recycled water is the link between water and wastewater thus even if one agency (water or wastewater) does take the lead in running the municipality's water reuse program; the other agency should support the program in some capacity.

Section 5.4.1: The County of Maui's Situation

The County of Maui's water reuse program is administered by the WWRD. The program was developed and distribution systems were constructed without any assistance, financial or otherwise, from the County's DWS. Despite the fact that the use of recycled water has resulted in significant potable water savings on Maui, the DWS has historically shown little interest in the concept of water reuse as a means of extending potable water supplies. This attitude may be changing as the DWS has recently funded a Preliminary Engineering Report (PER) to evaluate a potential expansion of the south Maui R-1 distribution system that would result in direct potable water savings. The true test of the DWS' commitment towards water reuse in Maui County will come when it is time to actually fund the potential expansion of the south Maui system. At the very least, the funding of the PER is a positive first step towards interagency cooperation within Maui County's municipal government.

Another challenge on Maui is that the WWRD is now a water purveyor. While the WWRD is experienced in the operation and maintenance of WWTPs and pumping stations, it has little experience in operating and maintaining water distribution systems. The WWRD's Water Recycling Program Coordinator has hired contractors to perform critical maintenance on the County's recycled water distribution system as an interim measure and has recommended that as

the WWRD expands its recycled water distribution systems, the water reuse program be adequately staffed with qualified operations and maintenance personnel.

Section 5.4.2: The City & County of Honolulu's Situation

The City & County of Honolulu's water reuse program is administered by the HBWS. The HBWS is an experienced water purveyor thus it was well prepared to take over the operation and maintenance of the R-1 and R-O recycled water distribution systems in southwest Oahu when the HBWS assumed control of the systems in 1999. The HBWS is planning to expand the southwest Oahu system and develop a recycled water distribution system in central Oahu. The City's ENV, the wastewater service provider, has a stake in these plans since wastewater disposal concerns will be eased if the recycled water distribution systems are constructed and put into use. A case in point is the water reuse development plans for central Oahu (Section 4.1.2.2). Water reuse at the CORP will benefit the ENV because effluent from the Wahiawa WWTP can be diverted from the Wahiawa Reservoir. However, before water reuse can take place at the CORP, the ENV must upgrade its Waihiawa WWTP to R-1 capability. Thus interagency cooperation between the HBWS and ENV must take place.

An area of concern of the HBWS's water reuse program as discussed in Section 3.3.2 is how to recover costs associated with recycled water production and delivery. Infrastructure costs in particular are expensive to recover and may require the HBWS to price its recycled water at rates than will be unattractive to existing and future users. A potential solution to this situation would be for the ENV to subsidize the HBWS water reuse program by adding a water reuse component to its sewer rate structure. This approach was utilized by the County of Maui and has resulted in competitive recycled water rates that are set at levels slightly lower than conventional irrigation water sources. This concept will require cooperation by the ENV with the HBWS. The ENV may be hesitant to add a water reuse component to its sewer rate structure because the department has a number of ongoing and future improvement projects that need to be financed and any increase in sewer user fees may need to be reserved for these improvements.

Section 5.5: Regulatory (State) Issues

There are at least two state regulatory issues in Hawaii that are preventing recycled water from being used for potentially high volume applications. Both of the issues are DOH related. The issues are: 1) The DOH Wastewater Branch will not allow R-1 water to be used for single-family lot irrigation and 2) Chapter 11-54 of the HAR prohibits the use of recycled water for restoring natural wetlands or stream flows.

Section 5.5.1: DOH Refusal to Allow R-1 Water for Single-Family Lot Irrigation

Irrigation of single-family lots requires vast volumes of potable water in Hawaii and on the leeward sides of the islands may use up to 65% of a residence's total water consumption. The City of St. Petersburg, Florida is recognized as a pioneer in urban water reuse and now operates one of the largest urban reuse systems in the world. Close to 37 mgd of tertiary treated recycled

water is provided to over 10,000 customers for irrigation of lawns at single-family residences. The continued expansion of the St. Petersburg's recycled water system has significantly contributed to reducing potable water demands (17). The DOH Guidelines state that R-1 water may be used for "any form of irrigation served by fixed irrigation system supplied by buried piping for turf and landscape irrigation of a residential property where managed by an irrigation supervisor" (4). The DOH has approved the use of R-1 water for multi-family residential settings in Hawaii. A request by MEDO, LLC in June 2004 to irrigate single-family lots in the Liloa Subdivision in Kihei, Maui was denied by DOH despite the fact that a detailed proposal was prepared. The proposal was to create a single-family residential community that has a single landscaping administrator for all parks, common areas, and residential landscaping. All lot owners would be required to utilize the same landscaping contractor to perform all installations, repairs, inspections and maintenance of their irrigation systems. By covenant of the Liloa Village Homeowner's Association, homeowners would not be allowed to control the operation or perform any maintenance of their own irrigation systems.

The proposal essentially met the requirement of the DOH Guidelines that a residential property may be irrigated with R-1 water if managed by an irrigation supervisor. Yet it was denied by DOH on the grounds that the Guidelines do not allow use of recycled water on privately owned single-family residential properties and that the Guidelines do not address specific requirements for dual-plumbed recycled water facilities. The DOH also did not feel it could adequately protect public health with such a project. MEDO, LLC is considering appealing the denial.

In communicating with DOH regarding this issue, it was learned that they do not feel comfortable with the concept of irrigating single-family lots with recycled water because they lack sufficient manpower to adequately monitor for conditions such as cross connections to the potable water system and overspray of recycled water. These concerns could be addressed by requiring the homeowner's association to provide the DOH with periodic cross connection inspection reports by a licensed plumber and requiring the development's single-family lots to be designed and built with subsurface drip irrigation systems. Retrofitting existing single-family lots with dual distribution systems to accommodate R-1 water would probably not be cost effective however; future single-family developments could be designed with such systems.

Section 5.5.2: DOH Regulations Pertaining to Discharge of Recycled Water to State Waters

The use of recycled water is commonly used on the U.S. mainland and in foreign countries for recharging natural wetlands and for in-stream flow restoration. The federal Bureau of Reclamation encourages the use of recycled water for these purposes. In Hawaii, this type of application of recycled water is not permitted as it is considered an unauthorized discharge to a state waterway. Chapter 11-54-04 Basic water quality criteria applicable to all waters (a) states that all waters shall be free of substances attributable to domestic, industrial, or other controllable sources of pollutants, including substances or conditions or combinations thereof in concentrations which produce undesirable aquatic life (18). When contacted to clarify this issue, a representative from the DOH Clean Water Branch stated that the main concern with using recycled water for recharging natural wetlands or restoring stream flows is that nutrients in the recycled water could result in excessive algal growth in the receiving waters.

This concern could be addressed by requiring that before recycled water was to be used for recharging natural wetlands or restoring stream flows, it be put through a nutrient removal process. Activated sludge facilities are now being designed with anoxic zones that are effective in significantly reducing both nitrogen and phosphorous concentrations in wastewater. The County of Maui has added anoxic zone biological nutrient removal at all three of its Maui island facilities to lower the nutrient content of the effluent from the facilities. This action was taken to address the concern that injection well disposal of effluent may be contributing to algal blooms in Maui's coastal waters. Effluent total nitrogen concentrations at the three facilities have been lowered from 20 mg/L to a range of 5 to 7 mg/L. Phosphorous levels have also been significantly lowered. Dialogue would need to be initiated with the DOH Clean Water Branch to determine if they would consider amending HAR Chapter 11-54-04 to allow nutrient reduced recycled water to be discharged to natural wetlands or streams. Maximum recycled water nitrogen and phosphorous levels could be established by DOH. As part of this dialogue, it could be argued that in many cases, utilization of recycled water for these purposes could actually improve the water quality of the natural wetlands and streams.

Section 5.6: Local Plumbing Codes

As discussed in Section 4.2.10, the DOH Guidelines allow R-1 water to be used for toilet and urinal flushing in counties in Hawaii that have language in their respective plumbing codes pertaining to dual water supplies within buildings. To facilitate the use of R-1 water for toilet and flushing in Hawaii, it is recommended that all counties in Hawaii be encouraged to incorporate Appendix "J" of the 1997 version or later of the Uniform Plumbing Code into their respective county plumbing codes. Appendix "J" has the specific language pertaining to dual water supplies within buildings that is required by the DOH Guidelines.

Designing future office and commercial buildings with dual water supplies for the purpose of flushing toilets and urinals with R-1 recycled water represents an excellent opportunity to displace large volumes of potable water. Failure to update Hawaii's plumbing codes as recommended above could result in DOH denial of projects that desire to utilize recycled water for this purpose.

Section 5.7: Public Acceptance

The importance of implementing a proactive public education program prior to beginning a water reuse project or program has been recognized for some time. Sound and proactive communication and education programs are essential for water reuse projects and programs to succeed. Failure to educate the public early on may delay or even stop the implementation of water reuse projects and programs.

The County of Maui's WWRD and the HBWS have the two most progressive water reuse programs in Hawaii. Both agencies realized that public acceptance was critical for their water reuse programs to succeed and have committed substantial time and resources towards proactive public education and community involvement. Both agencies target five main groups in their educational outreach programs. These groups include politicians, schools, the general public, community organizations and new/potential recycled water users. For all the groups that are

reached by these programs, two key concepts are emphasized. Initially, the need for recycling wastewater is established. The main reason for implementing water recycling programs is to supplement limited fresh water supplies. The public needs to be made aware that recycled water can be an important component of the community's overall water supply. Secondly, a basic understanding of how wastewater is treated and made safe for recycling is provided. The community may have concerns regarding the safety of using recycled water for landscape irrigation, especially in locations such as parks, schoolyards, shopping centers, hotels and condominiums. By providing the community with a basic understanding of how recycled water is produced with an emphasis on disinfection, monitoring and quality assurance, it is believed that the community will feel more comfortable with the idea of using recycled water.

Proactive public education is an essential element for all water reuse programs. The City and County of Honolulu's Board of Water Supply and the County of Maui's Wastewater Reclamation Division have both established successful educational outreach programs.

The County of Maui's WWRD was the first municipality in Hawaii to develop a comprehensive water reuse program. As mentioned above, its educational outreach program reaches a number of target groups within the community. A detailed explanation of what is presented to each group is described below.

- Politicians: During the early stages of Maui's water reuse program, a significant amount of time was spent educating Maui County Council members about recycled water use. During the mid-1990's, the County's Department of Public Works was attempting to pass its mandatory recycled water use ordinance and its recycled water rate structure. Council members needed to be thoroughly educated about the benefits and safety aspects of

recycled water use. Presentations were given at council meetings and were later used to educate their constituents. In addition, testimonials from local and national water reuse experts were given during these council meetings. Educational literature was also provided to each council member prior to the council meetings so that they could be prepared to ask questions during the meetings. Occasional program updates are now provided by the Director of Public Works to keep council members "in the loop". This point is considered important because County Council support will be required to authorize funding for future expansions of Maui's recycled water distribution systems.

- Schools: Educating young people is great way to gain prolonged support for not only the idea of recycling water but for also developing behavior which will enhance sustainability within the community. At the beginning of each school year, a standard letter is sent to all public and private schools in Maui County notifying them of the environmental education program offered by the County's WWRD. The program is offered to grades ranging from kindergarten to the college level. Specific components of the program include classroom presentations on water conservation/wastewater reclamation and reuse, a microbiology lab session that identifies activated sludge organisms, wastewater reclamation facility tours, career day speaker appearances, and assistance with school science projects. Facility tours are offered to grades five and above and are typically accompanied with desktop demonstrations utilizing actual samples from the various units of the wastewater treatment process. Slide shows (both 35mm and Power Point) have been developed and are utilized in the classroom along with a corresponding question and answer sheet. Videos (The Water Environment Association's H_2O TV series) and poster boards are also used. Educational booklets on water conservation and wastewater reclamation along with promotional items such as rulers, stickers, magnets and water conservation kits are distributed.

- General Public: Presentations and wastewater reclamation facility tours are offered to the general public through the County of Maui's web site and the WWRD's Wastewater System's Information Pamphlet. A video entitled "Water Recycling in Hawaii" which was produced by the Hawaii Water Environment Association is occasionally broadcast on the local community cable access television station, Akaku and is available for loan upon request. In addition, press releases announcing expansions to the County's recycled water distribution system are published in the local newspaper, The Maui News.

- Community Organizations: Presentations about Maui's water recycling program are delivered to community groups such as Rotary Clubs, Lions Clubs, the Maui Chamber of Commerce, the Maui Hotel Association, community associations, senior citizen groups, and engineering and landscape architecture groups. Organizations such as these have regular meetings and Maui County has welcomed these speaking engagements and utilizes them to provide the most current information about its water-recycling program. The program received benefit from these presentations, as the County was able to engage and identify program change agents and champions. The Kihei Community Association in particular has been an excellent forum to proactively inform the community about the County's water recycling plans. Kihei is located in arid south Maui and is the area where the County has constructed its most complete recycled water distribution system. As a

result, there are several successful water reuse projects currently in operation. Community support has been vital to the success of these projects.

- New and Potential Recycled Water Users: Educational presentations focusing on the production, safety, and proper management of recycled water are delivered to owners, managers and employees of new and potential water reuse projects. An emphasis is placed on how water quality is maintained including continuous turbidity monitoring, automatic diversion of substandard recycled water, and 7 days/week fecal coliform monitoring. Best management practices when utilizing recycled water are also discussed. Examples of successful local and national water reuse projects are cited. Facility tours are offered and educational pamphlets along with promotional items are distributed.

The educational outreach program described above may be used as a template for other municipalities in Hawaii to follow during the development of their respective water reuse programs. It is recommended that all recycled water purveyors regardless if they are a municipality or a private development implement proactive, sincere and open communication with the public to gain the support that is required for all water reuse projects and programs to succeed.

Chapter 6: Federal Agency Reuse Programs

This chapter will provide information about federal agency programs that could provide funding for the design and construction of water reuse projects in Hawaii. Section 6.1 provides information about federal programs that contribute larger sums of monies that could assist recycled water purveyors with the development of major recycled water distribution systems that convey recycled water to multiple water reuse projects. Section 6.2 provides information about federal programs that contribute smaller sums of monies that could be used for the development of individual water reuse projects.

Section 6.1: Federal Funding Sources Recommended for Recycled Water Distribution System Construction

Section 6.1.1: Clean Water State Revolving Fund

The Clean Water State Revolving Fund (CWSRF) program works like a bank. Federal and state contributions are used to capitalize or set up the program. These assets, in turn, are used to make low or no-interest loans for important water quality projects. Funds are repaid to the CWSRF over terms as long as twenty years. Repaid funds are then recycled to fund other water quality projects. These CWSRF resources can help augment the financial resources currently available to fund a number of different types of water conservation and reuse projects including plumbing fixture retrofits, use of efficient landscape equipment, recycling of gray water, and reuse of wastewater.

Nationally, the CWSRF has in excess of $27 billion in assets. Currently, the CWSRF is funding approximately $3 billion in water quality projects each year. The Clean Water Act of 1987 authorized the CWSRF to fund point source, nonpoint source, and estuary projects. Water conservation and reuse activities/projects may be considered point source if they are developed as a component of a wastewater treatment works. Projects that receive CWSRF funds are typically publicly owned however some water conservation and reuse projects may be classified under the nonpoint source category if they are part of a larger polluted runoff abatement activity. The necessary first step in obtaining CWSRF funding is to get the activity/project in a state's Intended Use Plan. The State of Hawaii DOH coordinates the CWSRF program.

Each state must approve a source of loan repayment as part of the application process. The source of the payment need not come from the project itself. Possible repayment sources include developer fees, recreational fees, storm water management fees, wastewater user charges, recycled water user charges and donations or dues made to nonprofit groups and associations (19).

Section 6.1.2: Bureau of Reclamation, Title XVI

The Reclamation Wastewater and Groundwater Study and Facilities Act of 1992 (Title XVI of Public Law 102-575) authorized the Bureau of Reclamation's water reclamation and reuse program. Also know as Title XVI, the act directs the Secretary of the Interior to undertake a

program to investigate and identify opportunities for water reclamation and reuse. Over the years, the act has authorized the Bureau to participate in the construction of a number of water reuse projects and feasibility studies in the western U.S. Title XVI also provides a program for Federal participation (through cost sharing) of specific water reuse projects up to certain specified amounts. Construction funds can be provided only for projects specifically authorized by Congress pursuant to Title XVI. Typically, the Bureau makes a funding recommendation on construction of an authorized project in the President's annual budget request to Congress. To receive Federal funding under Title XVI, projects must have a feasibility report completed by the Bureau or the non-Federal project sponsor; the Secretary of Interior must determine that the non-Federal project sponsor is financially capable of funding its share of the project's costs; and the Secretary must approve a cost-sharing agreement with the non-Federal project sponsor which commits the non-Federal project sponsor to funding its proportionate share of the project's construction costs on an annual basis.

The Bureau of Reclamation is authorized to fund up to 25 percent of the total project cost with a maximum contribution of $20 million per project. For demonstration projects, the Federal contribution is limited to a maximum of $20 million per project. A maximum Federal share of up to 50 percent of the total demonstration project may be made if the Secretary determines that the project is not feasible without such Federal contribution.

The project sponsor is required to provide at least 75 percent of the total planning, design and construction costs. Certain kinds of in-kind contributions are allowed. In addition, the sponsor must pay all operation and maintenance costs for the project. For demonstration projects, the sponsor is required to provide at least 75 percent of the cost, unless the demonstration project is not feasible without a greater Federal contribution, in which case the sponsor is required to pay at least 50 percent.

Proposed projects for Title XVI funding must specify uses of water for municipal and industrial water supply, irrigation supply, groundwater recharge, fish and wildlife enhancement, or outdoor recreation. Funds can be used for water quality improvement features where improvement of the water is needed to allow for reuse (20).

Section 6.1.3: USDA Water and Wastes Disposal Systems for Rural Communities

This United States Department of Agriculture (USDA) Rural Utilities Service Program provides monies to provide basic human amenities, alleviate health hazards, and promote the orderly growth of the rural areas of the nation by meeting the need for new and improved rural water and waste disposal facilities. Funds may be used for the installation, repair, improvement, or expansion of a rural water facility including costs of distribution lines and well pumping facilities. Funds also support the installation, repair, improvement, or expansion of a rural waste disposal facility, including the collection and treatment of sanitary waste stream, storm water, and solid wastes.

The Consolidated Farm and Rural Development Act, Section 306, Public Law 92-419, 7 U.S.C. 1926 authorized funding of this program. For fiscal year 2004, the program made available $900

million in direct loans, $75 million in guaranteed loans and $600 million in grants. Matching funding is not required. Eligible organizations include community/watershed groups, nonprofit groups, conservation districts, local government (including counties and other political subdivisions of a state), tribal agencies and other authorities, associations, cooperatives and Indian tribes that are Federally recognized.

More information can be found at www.usda.gov/rus/water/programs.htm. or call (202) 690-2670 (21).

Section 6.1.4: Public Works and Development Facilities Program

This program provides assistance to help distressed communities attract new industry, encourage business expansion, diversity local economies, and generate long-term, private sector jobs. Among the types of projects funded are water and sewer facilities, primarily serving industry and commerce; access roads to industrial parks or sites; port improvements; business incubator facilities; technology infrastructure; sustainable development activities; export programs; brown fields redevelopment; aquaculture facilities; and other infrastructure projects. Specific activities may include demolition, renovation, and construction of public facilities; provision of water or sewer infrastructure; or the development of storm water control mechanisms (e.g., a retention pond) as part of an industrial park or other eligible project.

The Economic Development Administration Reform Act (Public Law 105-393), which replaces and amends the Public Works and Economic Development Act of 1965 authorized funding for this program. For fiscal year 2004, funding levels were set at $232 million. Matching funding is not required. Eligible organizations include community/watershed groups, non-profit groups, educational institutions, private landowners, conservation districts, water and wastewater utilities, local governments, state/territorial agencies and tribal agencies. All proposed projects must be consistent with an approved regional Comprehensive Economic Development Strategy.

For more information, contact the U.S. Department of Commerce, Economic Development Administration at (202) 482-5268 or www.cfda.gov (Search on program 11.300) (21).

Section 6.1.5: Community Block Development Program

The Department of Housing and Urban Development sponsors this program, intended to develop viable communities by providing decent housing and a suitable living environment by expanding economic opportunities primarily for persons of low and moderate income. Recipients may initiate activities directed toward neighborhood revitalization, economic development, and provision of improved community facilities and services. Specific activities may include public services, acquisition of real property, relocation and demolition, rehabilitation of structures, and provision of public facilities and improvements, such as new or improved water and sewer facilities.

The Housing and Community Development Act of 1974, Title 1 authorized funding for this program. The fiscal year 2004 funding level was set at $4.3 million. Matching funding is not required. Eligible organizations include community/watershed groups, non-profit groups,

educational institutions, private landowners, water and wastewater utilities, local governments, and state/territorial agencies.

For more information, contact the Department of Housing and Urban Development at (202) 708-3587 or www.hud.gov/offices/cpd/communitydevelopment/programs (21).

Section 6.2: Federal Funding Sources Recommended for Individual Water Reuse Projects

Section 6.2.1: USDA Environmental Quality Incentives Program

The United States Department of Agriculture (USDA) Natural Resources Conservation Service's Environmental Quality Incentives Program (EQIP) was established to provide a voluntary conservation program for farmers and ranchers to address significant natural resource needs and objectives. Nationally, it provides technical, financial, and educational assistance. Sixty percent of it is targeted to livestock-related natural resource concerns and the rest to more general conservation priorities. EQIP is available primarily where there are significant natural resource concerns and objectives.

The Food, Agriculture, Conservation, and Trade Act of 1996 authorized funding for this program. For fiscal year 2004, $832 million was funded with the median funding for projects at $8,200. Matching amounts of 25 to 50 percent are required. Eligible organizations include businesses, community/watershed groups, non-profit groups, educational institutions, private landowners, water and wastewater utilities, state/territorial agencies and tribal agencies.

For more information, contact the U.S. Department of Agriculture's Natural Resources Conservation Service at (202) 720-1840 or http://aspe.os.dhhs.gov/cfda/p10912.htm (21).

Section 6.2.2: Natural Resources Conservation Service: Conservation on Private Lands

The National Fish and Wildlife Foundation is working to expand and strengthen its partnership with the Natural Resources Conservation Service (NRCS) to support innovative and effective conservation and stewardship of our country's private lands. The goal of the partnership is to support high quality projects that engage private landowners, primarily farmers and ranchers, in the conservation and enhancement of wildlife and natural resources on their lands. Successful projects will address conservation practices in ongoing agriculture, ranching, and forestry operations (at the watershed or landscape scale); offer value for fish and wildlife; include partnerships; and have a strong "on-the-ground" component.

The funding level for fiscal year 2004 was not available but for fiscal year 2003 it was set at $3 million. All projects should include matching funding from project partners at a minimum ratio of 1:1 although leverage ratios of 2:1 are preferred. Private landowners are the main group eligible for this funding. Other eligible organizations include non-profit groups, educational

institutions, conservation districts, local governments, state/territorial agencies and federal agencies.

For more information, call (202) 857-0166 or www.nfwf.org/programs/grant_apply.htm (21).

Section 6.2.3: Coral Reef Conservation Fund

The National Fish and Wildlife Foundation's Coral Reef Conservation Fund supports projects that build public-private partnerships to reduce and prevent degradation of coral reefs and associated reef habitats (e.g. sea grass beds, mangroves etc.). Projects may address causes of coral reef degradation wherever they occur, from inland areas to coastal watersheds to the reefs and surrounding marine environment. Requested project emphasis will vary. For updated information, project managers should check the internet web link listed below.

The Coral Reef Conservation Act of 2000 authorized funding for this program. The funding level for fiscal year 2004 was not available but for fiscal year 2003 it was set at $900,000. All projects should include matching funding from project partners at a minimum ratio of 1:1 although leverage ratios of 2:1 are preferred.

For more information, call (202) 857-0166 or www.nfwf.org/programs/grant_apply.htm (21).

Section 6.2.4: Coastal Services Center Cooperative Agreements

The National Oceanic and Atmospheric Administration (NOAA) guides the conservation and management of coastal resources through a variety of mechanisms, including collaboration with the coastal resource management programs of the nation's states and territories. The mission of the NOAA Coastal Services Center (CSC) is to support the environmental, social, and economic well being of the coast by linking people, information, and technology. The vision of the NOAA CSC is for the center to be the most useful government organization to those who manage and care for our nation's coasts. In fiscal year 2004, CSC will support activities in the following areas: landscape characterization and restoration, GIS integration and development, coastal remote sensing, information resources, Pacific Services Center, and integrated ocean observing systems.

Funding for this program was authorized by 16 U.S.C. 1456C, 15 U.S.C. 1540, 33 U.S.C. 1442, 33 U.S.C. 883 (a-e). Funding for fiscal year 2004 was set at $3 million. Eligible organizations include businesses, community/watershed groups, non-profit groups, educational institutions, conservation districts, water and wastewater utilities, local governments, state/territorial agencies and tribal agencies.

For more information, call (843) 740-1222 or www.csc.noaa.gov (21).

Section 6.2.5: Clean Water Act Section 319(h): Non-point Source Management Program

Congress amended the Clean Water Act (CWA) in 1987 to establish the section 319 Non-point Source Management Program because it recognized the need for greater federal leadership to help focus State and local non-point source efforts. Under section 319, states, territories, and Indian tribes receive grant monies that support a wide variety of activities including technical assistance, financial assistance, education, training, technology transfer, demonstration projects, and monitoring to assess the success of specific non-point source implementation projects.

This program is EPA sponsored and administered by the State of Hawaii DOH Clean Water Branch, Hawaii's designated non-point source agency. The federal share of the project must not exceed 60 percent of the total project cost. The non-federal share must be at least 40 percent of the total project cost.

The Hawaii Water Environment Association utilized this source of funding in the year 2000 to administer a statewide educational outreach program to gain support for water reuse projects in Hawaii. The educational video "Water Recycling in Hawaii" was produced as part of this program. Haleakala Ranch on Maui also utilized this program for the development of its sedimentation control project utilizing R-1 recycled water in the year 2003.

For more information, call the DOH Clean Water Branch at (808) 586-4309 or http://www.epa.gov/owow/nps/cwact.html (22).

Chapter 7: References

The following references were utilized during the preparation of this report. In addition to the references cited below, information was obtained during interviews, telephone conversations and e-mail correspondences with recycled water purveyors, water reuse project managers, various city and county water and wastewater officials and State of Hawaii DOH officials.

(1) Levine, A.D.; Asano, T.; (2004), Recovering Sustainable Water from Wastewater. *Environmental Science & Technology, June 2004*.

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(9) State of Hawaii, Department of Land and Natural Resources, Commission on Water Resource Management; (2004), Staff Submittal, *Ewa Caprock Reuse Recharge Study*, November 16, 2004.

(10) US EPA Office of Technology Transfer and Regulatory Support. EPA/625/R-92/004; (1992), *Guidelines for Water Reuse*, pp. 90 – 93.

(11) Asano, T., Ed. (1998), *Wastewater Reclamation and Reuse*. CRC Press: Boca Raton, FL., p. 644.

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(14) Irvine Ranch Water District Website, www.irwd.com.

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(16) Brown and Caldwell. (1995), *County of Maui - Rate and Fee Alternatives for Reclaimed Water Service*, pp. 1-1 to1-3.

(17) City of St. Petersburg Website, www.stpete.org/wwwrecla.htm.

(18) Hawaii Administrative Rules, Chapter 11-54-04(5).

(19) US EPA Office of Water. EPA 832-F-99-050; (1999), *Funding Water Conservation and Reuse with the Clean Water State Revolving Fund*.

(20) U.S. Department of the Interior, Bureau of Reclamation. (1998), *Guidelines for Preparing, Reviewing, and Processing Water Reclamation and Reuse Project Proposals Under Title XVI of Public Law 102-575, as Amended*.
(21) US EPA Watershed Academy website. *Catalog of Federal Funding Sources for Watershed Protection*, www.cfpub.epa.gov/fedfund.
(22) US EPA Polluted Runoff (Non-point Source Pollution) website: http://www.epa.gov/owow/nps/cwact.html.

APPENDIX A:

State of Hawaii Water Reuse Project Directory
(December 2004)

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STATE OF HAWAII WATER REUSE PROJECT DIRECTORY (December 2004) *Note: Recycled water used for in-plant uses at Hawaii's wastewater reclamation facilities not included.

REUSE PROJECT	PROJECT TYPE	CONTACT	TEL. # (808)	RECYCLED WATER PRICE	VOLUME (MGD)	QUALITY	APPLICATION	PURVEYOR
County of Kauai								
Kauai Lagoons Resort	Golf Course	Victor Nemeth/Fred Wong	241-6050	Free	1.2	R-2	Blend w/brackish/undiluted	County of Kauai-Lihue WWRF
Wailua Golf Course	Golf Course	Ed Okamoto	241-6666	Free	0.65	R-2	Blend w/brackish/undiluted	County of Kauai-Wailua WWRF
Kikiaola Land Company	Agriculture	Roland Sagum	338-1900	Free	0.3	R-2	Blend w/stream water	County of Kauai-Waimea WWRF
Princeville Makai G.C.	Golf Course	Yoshi Harata	826-3741	$0.16/1000 gallons	0.65	R-2	Blend w/rain water	Princeville Utilities Company
Puakea Golf Course	Golf Course	Dan Urwiler	245-8740	Free	0.2	R-1	Blend w/stream water	Grove Farm Development-Lihue-Puhi WWRF
Kiahuna Golf Club	Golf Course	Robert Medeiros	742-9595	Free	0.25	R-2	Blend w/stream water	Poipu WRF
Poipu Bay Resort G.C.	Golf Course	Charles Rebb	742-1013	Free	0.2	R-2	Blend w/stream water	Hyatt WWTP
City & County of Honolulu								
M.C.B.H. Klipper G.C.	Golf Course	Jeff Larson	257-6920	Free	0.5	R-2	Undiluted	Marine Core Base Hawaii WWRF
Hawaii Reserves/BYU	Agriculture/Landscape	Jeff Tyau	293-6432	Free, will be charging $1.00/1000 gallons	0.3	R-1	Undiluted	Hawaii Reserves Inc.-Laie WWRF
Turtle Bay Resort - Palmer Course	Golf Course	Mike Honma	293-5225	Free	0.16	R-2	Blend w/potable well water	Kuilima WWRF(Resort)
Waialua Div. Agriculture	Agriculture	Yoshi Tanabe	621-3220	Free, Army pays $9 mil./7 yrs.	3.6	R-2	Blend w/stream water	C & C Honolulu-Wahiawa WWRF, Army-Schofield Barracks
Oahu Flowers	Agriculture (Bird of Paradise)	Dave Kein	626-4045	$0.30/1000 gallons	0.7 (2x/mo.)	R-2	Blend w/stream water	C & C Honolulu-Wahiawa WWRF, Army-Schofield Barracks
Pioneer Hybrid International	Agriculture (Seed Corn)	Richard McCormick	637-0100	$0.30/1000 gallons	0.475	R-2	Blend w/stream water	C & C Honolulu-Wahiawa WWRF, Army-Schofield Barracks
Kahuku Farms	Agriculture (Mango)	Melvin Matsuda	223-2251	$0.30/1000 gallons	0.03	R-2	Blend w/stream water	C & C Honolulu-Wahiawa WWRF, Army-Schofield Barracks
Univ. of Hawaii Research	Agriculture	Susan Migita	637-4735	$0.30/1000 gallons	0.03	R-2	Blend w/stream water	C & C Honolulu-Wahiawa WWRF, Army-Schofield Barracks
Del Monte	Agriculture (Pineapple)	Ed Gonzalez	571-1137	Free	0.05	R-1	Blend w/well water	Kunia Water Reclamation Facililty
Waiawa Correctional Facility	Agriculture/Landscape	Archie Yu	587-1333	Free	0.035	R-2	Undilluted	Waiawa Correctional Facility WWRF
Ewa Villages Golf Course	Golf Course	Heide Madrigal	681-0033	$1.20/1000 gallons	0.7	R-1	Undilluted	Honoululi WWRF/US Filter
Fort Weaver Road Medials	Landscape	Heide Madrigal	681-0033	$1.20/1000 gallons	0.125	R-1	Undiluted	Honoululi WWRF/US Filter
Coral Creek Golf Course	Golf Course	Ron Huffman	440-1111	$1.20/1000 gallons	1	R-1	Undiluted	Honoululi WWRF/US Filter
Hawaii Prince Golf Course	Golf Course	Gerald Yoza	944-4567	$1.20/1000 gallons	1	R-1	Undiluted	Honoululi WWRF/US Filter
Kapolei Golf Course	Golf Course	Nobuo Nakamura	674-2227, 2173	$1.20/1000 gallons	1	R-1	Undiluted	Honoululi WWRF/US Filter
West Loch Golf Course	Golf Course	Tony Balada	675-6075	$1.20/1000 gallons	0.9	R-1	Undiluted	Honoululi WWRF/US Filter
West Loch Shoreline Park	Landscape	Tony Balada	675-6075	$1.20/1000 gallons	0.152	R-1	Undiluted	Honoululi WWRF/US Filter
Ewa Mahiku District Park	Landscape	Wayne Lee	733-7382	$1.20/1000 gallons	Unknown	R-1	Undiluted	Honoululi WWRF/US Filter
Asing Park	Landscape	Wayne Lee	733-7382	$1.20/1000 gallons	Unknown	R-1	Undiluted	Honoululi WWRF/US Filter
AES Hawaii Inc.	Industrial	Doc Savidge	682-3410	$4 - 5/1000gal	0.3	R-O	Undilluted	Honoululi WWRF/US Filter
Kalaeloa Cogeneration	Industrial	Ruedi Tobler	682-5288	$4 - 5/1000gal	0.5	R-O	Undiluted	Honoululi WWRF/US Filter
Tesoro Hawaii Corp.	Industrial	Robert Walker	479-0541	$4 - 5/1000gal	0.33	R-O	Undiluted	Honoululi WWRF/US Filter
The Gas Company	Industrial	Michael Kita	673-4811	$4 - 5/1000gal	0.05	R-O	Undiluted	Honoululi WWRF/US Filter
Chevron Refinery	Industrial			$4 - 5/1000gal	0.4	R-O	Undiluted	Honoululi WWRF/US Filter
County of Hawaii								
Waikoloa Beach Resort/G.C.	Golf Course	John Palos/Stephen Green	886-6232/936-4240	$0.30/1000 gallons	0.5	R-2	Blend w/brackish water	Waikaloa Beach Resort WRF
Mauna Lani Resort/G.C.	Nursery/Sod Farm/Composting	Norman Ah Hee	896-0906	Free	0.25	R-2	Undilluted	Mauna Lani WWRF
Kona & Alii Country Clubs	Golf Course	Mike Yukon	322-9915	Pumping Costs	0.5	R-2	Blend w/brackish water	Heeia WWRF
Sea Mountain Golf Course	Golf Course	Rodney Anbres	928-6233	Free	0.012	R-2	Blended w/potable well water	Punalu'u Water & Sewer
Mauna Kea G.C.	Golf Course	Alan Nakamoto	882-5486	$0.35/1000 gallons	0.27	R-2	Blended w/brackish water	South Kohala WW Corp.
Swing Zone Driving Range	Driving Range/Practice Facility	Larry Walker	329-6909	Free	0.06	R-2	Undilluted	Kealakehe WWRF
Parker Ranch	Pasture	Buzz Paxton	885-2319	Free	0.045	R-3	Undiluted	Waimea Wastewater Company WRF
Keahole Airport	Landscape	John Santangalo	938-2552	Free	0.03	R-1	Blend w/potable water	Keahole International Airport WWRF

STATE OF HAWAII WATER REUSE PROJECT DIRECTORY (December 2004) *Note: Recycled water used for in-plant uses at Hawaii's wastewater reclamation facilities not included.

REUSE PROJECT	PROJECT TYPE	CONTACT	TEL. # (808)	RECYCLED WATER PRICE	VOLUME (MGD)	QUALITY	APPLICATION	PURVEYOR
County of Maui								
Experience at Koele	Golf Course	Les Jeremiah	565-4172	Free (15 yr. agreement w/Cof M)	0.25	R-1	Undiluted & blend w/rain water	C of M/Lanai Water Company
Challenge at Manele	Golf Course	Earl Mamuad	565-2980	Free	0.16	R-1	Blend w/brackish water	Manele Bay Resort WWRF
Elleair Maui Golf Club	Golf Course	David Burnett	879-3091	Pumping Costs ($0.035/1000 gal)	0.9	R-1	Undiluted	County of Maui-Kihei WWRF
Monsanto-Seed Corn	Agriculture, Landscape, Toilet Flushing	Dan Clegg	879-4074	$0.20 & $0.55/1000 gallons	0.25	R-1	Undiluted	County of Maui-Kihei WWRF
Kalama Park	Landscape	Ray Catiel	875-4108	$0.55/1000 gallons	0.2	R-1	Undiluted	County of Maui-Kihei WWRF
Kihei Community Center	Landscape	Ray Catiel	875-4108	$0.55/1000 gallons	0.3	R-1	Undiluted	County of Maui-Kihei WWRF
Piilani North Park	Landscape	Ray Catiel	875-4108	$0.55/1000 gallons	0.025	R-1	Undiluted	County of Maui-Kihei WWRF
Kihei Fire Station	Landscape	Jeff Schaefer	879-2741	$0.55/1000 gallons	0.006	R-1	Undiluted	County of Maui-Kihei WWRF
Kihei Library	Landscape	Janet Fehr	875-6833	$0.55/1000 gallons	0.01	R-1	Undiluted	County of Maui-Kihei WWRF
Goodfellow Brothers Const.	Dust Control	Ray Skelton	242-1875	$0.55/1000 gallons	0.02	R-1	Undiluted	County of Maui-Kihei WWRF
Kaanapali Resort/G.C.	Golf Course/Landscape	Tim Canute	661-0991	$0.16/1000 gallons	1	R-1	Undiluted	County of Maui-Lahaina WWRF
Mauna Loa Hwy.-Kaunakakai	Landscape	Martin Kahae	553-1701	$0.55/1000 gallons	0.005	R-2	Undiluted	County of Maui-Kaunakakai WWRF
Pukalani Country Club	Golf Course	Patrick Watanabe	572-0779	$0.55/1000 gallons	0.23	R-2	Blend w/potable well water	Pukalani WWRF
Haggai Institute	Landscape/Fish Pond	Fred Danielson	877-5197	$0.45/1000 gallons	0.02	R-1	Undiluted	County of Maui-Kihei WWRF
Piilani Shopping Center	Landscape	Graham Park	874-8900	$0.55/1000 gallons	0.03	R-1	Undiluted	County of Maui-Kihei WWRF
BioReal, Inc.	Cooling of Algae Domes	Toshiuki Yamagishi	875-0202	$0.55/1000 gallons	0.02	R-1	Undiluted	County of Maui-Kihei WWRF
Kanaha Cultural Park	Landscape	Pat Rocco	270-7232	$0.55/1000 gallons	0.005	R-2	Undiluted	County of Maui-Kahului WWRF
Kihei Elementary School	Landscape	Lynette Ducosin	244-1905	$0.55/1000 gallons	0.03	R-1	Undiluted	County of Maui-Kihei WWRF
Lokelani Intermediate School	Landscape	Vernan Kalanikau	244-3522	$0.55/1000 gallons	0.03	R-1	Undiluted	County of Maui-Kihei WWRF
Piilani Gardens	Landscape	Lora Velenzuela	874-1800	$0.55/1000 gallons	0.02	R-1	Undiluted	County of Maui-Kihei WWRF
Piilani Villages	Landscape	Cindy Mendes	244-7684	$0.55/1000 gallons	0.015	R-1	Undiluted	County of Maui-Kihei WWRF
Pohaku Masonry	Dust Control/Landscape	Bill Hicks	283-4156	$0.55/1000 gallons	0.001	R-1	Undiluted	County of Maui-Kihei WWRF
Haleakala Ranch	Sedimentation Control/Pasture Irrigation	Richard Sylva	250-1706	$0.20/1000 gallons	0.01	R-1	Undiluted	County of Maui-Kihei WWRF
Maui Pineapple Company	Agriculture (Pineapple)	Marlon Domingo	870-8697	$0.02/1000 gallons	0.01	R-1	Blended w/stream water	County of Maui-Lahaina WWRF
Maui Earth Composting	Green Waste Composting/Vermiculture	Tim Gunter/Robert Belle	877-0403	$0.20/1000 gallons	0.0001	R-1	Undiluted	County of Maui-Kihei WWRF
Kaluakoi Resort & Golf Course	Golf Course	James Millar	660-2887	Free	0.04	R-2	Blend w/potable backwash water	Kaluakoi WWRF
Makena South Golf Course	Golf Course	Dan Homna	874-1111	Free	0.07	R-1	Blend w/brackish water	Makena WWRF
Puu O Hoku Ranch	Landscape	Ron Crites	(530) 747-0650	Free	0.0037	R-3	Constructed Wetland	Puu O Hoku Ranch Constructed Wetland
Haleakala Crater Visitor Center	Toilet and urinal flushing	Frank Baublits	572-4420	Free	0.0001	R-1	Blend with captured rain water	Haleakala National Park WWRF

APPENDIX B:

Acknowledgements

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Appendix B: Acknowledgments

During the development of this report, several representatives of local government agencies, wastewater reclamation facilities and water reuse projects were contacted to provide information about their respective programs, facilities and projects. The Limtiaco Consulting Group is grateful to these individuals as the information they provided allowed the report to provide CWRM with an accurate view of the current state of water reuse in Hawaii. The individuals who contributed information for the report along with their respective affiliations are listed below.

- **State of Hawaii**
  - Department of Health, Environmental Management Division, Wastewater Branch
    - Tomas See, Engineering Supervisor VI
  - Department of Land & Natural Resources, Commission on Water Resource Management
    - Dean Nakano, Planning Manager
    - Lenore Nakama, Hydrologist

- **Kauai County**
  - County of Kauai, Wastewater Division
    - Melvin Matsumura, Division Chief
    - Craig Shimatsu, Head Operator (Wailua WWRF, Lihue WWRF)
  - Kikiaola Land Company
    - Roland Sagun, Planning and Development Coordinator
  - Kauai Lagoons Resort
    - Victor Nemeth, Superintendent
  - Wailua Golf Course
    - Ed Okamoto, Superintendent
  - Puukea Golf Course
    - Dan Urwiler, Head Superintendent
    - Calvin Speegle, Aqua Engineers-Lihue-Puhi WWRF Head Operator
  - Princeville Makai Golf Course
    - Yoshi Harata, Golf Course Superintendent
    - Larry Dill, Princeville Utilities Manager
    - Val Inarod, Princeville WWRF Head Operator
  - Poipu Bay Resort Golf Course/Poipu WWRF
    - Charles Rebb, Golf Course Superintendent
    - Matthew Lewis, Aqua Engineers-Poipu Bay Resort WWRF Head Operator
  - Kiahuna Golf Club
    - Brad Snyder, General Manager
    - Hugh Strom, Aqua Engineers Manager (Poipu WRF)

- **Maui County**
  - County of Maui Wastewater Reclamation Division
    - Clarence Solomon-Kihei WWRF Supervisor
    - John Kostrick-Lahaina WWRF Supervisor
    - Nick Estabilo-Wailuku-Kahului WWRF Supervisor
    - John Souza-Kaunakakai WWRF Supervisor
    - Manual Silva-Lanai WWRF
  - Elleair Maui Golf Club
    - Oswaldo Cardenas-Hernandez, Golf Course Superintendent (former)
  - Monsanto Seed Corn
    - Paul Koehler, Maui Manager
    - Dan Clegg, Operations Manager
    - Mark O'Conner, Operations Manager
  - Haggai Institute
    - Fred Danielson, Manager
    - Mark Menzies, Maintenance Manager
  - Kihei and Lokelani Schools
    - Vernon Kalanikau, Maintenance Manager
  - BioReal, Inc.
    - Toshiuki Yamagishi, Facilities Manager
  - Maui Earth Compost
    - Tim Gunter, President
    - Robert Belle, Worm Farmer
  - Haleakala Ranch
    - Scott Meidell, Land & Resource Manager
    - Richard Sylva, Land Steward
  - Goodfellow Brothers
    - Ray Skelton, Superintendent
    - Donna Speed, Kihei Base Yard Manager
  - County of Maui Parks Department
    - Ray Katiel, South Maui District Supervisor
  - Makena South Golf Course/Makena WWRF
    - Lance Sakugawa, Assistant Golf Course Superintendent
    - Tom Johnson, Makena WWRF Supervisor
  - Kaanapali Resort and Golf Courses
    - Tim Canute, Golf Course Superintendent
  - Maui Pineapple Company
    - Marlon Domingo, West Maui Supervisor
  - Kanaha Cultural Park
    - Pat Rocco, Central Maui District Supervisor
  - Pukalani Country Club/Pukalani WWRF
    - Patrick Watanabe, Golf Course Superintendent
    - Hugh Strom, Aqua Engineers Manager (Pukalani WWRF)
  - Haleakala National Park Visitor Center

        - Westley Chun, Engineering Solutions, Inc. (design engineer)
    - The Experience at Koele
        - Les Jeremiah, Golf Course Superintendent
        - Bruce Mitsunaga, Aqua Engineers-Lanai Auxiliary WWRF Head Operator
    - The Challenge at Manele
        - Earl Mamuad, Golf Course Superintendent
        - Erwin Ozoa, Aqua Engineers-Manele WWRF Head Operator
    - Kaluakoi Resort and Golf Course
        - James Millar, Operations Manager
    - Puu O Hoku Ranch
        - Ron Crites, Brown and Caldwell (design engineer)

- **Hawaii County**
    - County of Hawaii, Wastewater Division
        - Peter Boucher, Wastewater Division Chief
        - Mark Norman, Kealakehe WWRF Head Operator
    - Waikaloa Beach Resort & Golf Courses
        - Bob Spetich, West Hawaii Utilities, Utilities General Manager
        - Stephen Green, West Hawaii Utilities, Chief Field Engineer
        - John Palos, Golf Course Superintendent
    - Mauna Lani Resort
        - Norman Ah Hee, Maintenance Supervisor
        - George Oliva, Mauna Lani STP Supervisor
    - Mauna Kea Resort & Golf Course
        - Alan Nakamoto, Golf Course Superintendent
        - Ricky Antonio, South Kohala Wastewater Corporation WWRF Supervisor
    - Kona and Alii Country Clubs
        - Mike Yukon, General Manager & Head Superintendent
        - Jon Kawamura, Aqua Engineers-Heeia WWRF Supervisor
    - Sea Mountain Golf Course
        - Rodney Anbres, Golf Course Superintendent
        - Hugh Strom, Aqua Engineers-Punaluu Water & Sanitation Company WWRF
    - Swing Zone, LLC
        - Larry Walker, President
    - Keahole International Airport
        - John Santangalo, Island Utilities Services, Vice President
    - Parker Ranch
        - Robby Pagliai, Island Utilities Services, Field Technician

- **City and County of Honolulu (Oahu)**
    - City and County of Honolulu, Board of Water Supply
        - Joe Meyers, Water Recycling Program Manager

        - Clayton Brown, Recycled Water Coordinator
    - Veolia Water
        - Ken Windram, Project Manager
    - City and County of Honolulu, Department of Environmental Services
        - Ross Tanimoto, Environmental Quality, Supervisor
        - Zachary Asato, Wastewater Treatment & Disposal, Regional Supervisor
        - Berwin Nyuha, Wastewater Treatment & Disposal, Plant Superintendent
    - AES Hawaii, Inc.
        - Doc Savidge, Manager
    - Kalaeloa Partners
        - Ruedi Tobler, Manager
    - Tesoro Hawaii Corporation
        - Robert Walker, Manager
    - The Gas Company
        - Mike Kita, Manager
    - Ewa Villages Golf Course
        - Heide Madrigal, Golf Course Superintendent
    - Coral Creek Golf Course
        - Ron Huffman, Golf Course Superintendent
    - Hawaii Prince Golf Course
        - Gerald Yoza, Golf Course Superintendent
    - Kapolei Golf Course
        - Nobuo Nakamura, Golf Course Superintendent
    - West Loch Golf Course
        - Tony Balada, Golf Course Superintendent
    - Wailua Diversified Agriculture
        - Yoshi Tanabe, Manager
        - Susan Migita, University of Hawaii Research Station Manager
        - Hugh Strom, Aqua Engineers-Schofield Barracks WWRF
    - Del Monte
        - Ed Gonzalez, Kunia WWRF Head Operator
    - Waiawa Correctional Facility
        - Archie Yu, State of Hawaii, Department of Accounting and General Services, Engineer
    - Turtle Bay Resort
        - Mike Honma, Golf Course Superintendent
        - Hugh Strom-Aqua Engineers-Kuilima Wastewater Treatment Plant
    - MCBH Kaneohe Klipper Golf Course
        - Jeff Larson, Facilities Manager
        - Clint Tolbert, Golf Course Superintendent
    - Hawaii Reserves, Inc.
        - Jeff Tyau, Project Manager