ENERGY EVALUATION

Department of Water Supply - Operations
County of Hawai'i

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Hilo, Hawai'i 96720

May 2015

PROCESS ENERGY SERVICES, LLC
WATER ♦ WASTEWATER ♦ INDUSTRIAL

Hawaii Energy
YOUR CONSERVATION & EFFICIENCY PROGRAM

ENERGY EVALUATION

for the

HAWAII COUNTY DEPARTMENT OF WATER SUPPLY

May 2015

Rev 1: July 2015

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While the recommendations in this report have been reviewed for technical accuracy, Process Energy Services is not liable if the projected savings are not achieved. The recommendations are based on an analysis of conditions observed at the time of the evaluation, information provided by facility staff and estimated costs for equipment and labor based on similar projects. Actual savings and project costs will depend on many factors, including varying process flows and loads, recommendations implemented, seasonal variations, and proper equipment operation. Before implementation of the measures presented in this report, Process Energy Services recommends a more detailed analysis to verify savings and project costs.

SECTION 1. EXECUTIVE SUMMARY

This report details energy saving recommendations identified by Process Energy Services for the County of Hawaii Department of Water Supply (DWS) high-energy use pump stations.

The evaluation targeted energy cost saving measures that included pump system efficiency improvements, application of variable frequency drives, alternative operating strategies, application of utility rate schedule riders, power factor correction and other system improvements to reduce energy costs.

In addition, we have also included recommendations for the department's energy management program to continue the process of operating the system at a high level of efficiency.

The objectives of the report included the following:

- Provide an overview of each system to determine how the pump systems are currently being operated and how new capital improvements will impact system energy use.
- Assemble energy, flow and equipment operational information based on the data collected to develop a baseline of pump system energy use.
- Summarize previously identified energy projects.
- Identify and develop new potential cost saving projects.
- Package the improvements as an interactive group of cost effective projects.

As cost savings projects were developed, each measure was prioritized based on ease of implementation, cost effectiveness and ability for each project to support subsequent measures. The projects have been categorized as energy conservation measures (ECMs), for projects that require a capital investment, operational measures (OMs) for projects that have fast paybacks (under one year), and energy supply measures (ESMs) for improvements that may reduce energy costs without reducing energy consumption (i.e. demand savings, rate schedule changes). We have also included energy management practices (EMPs) for recommendations that will help formalize the DWS energy management program and future energy management measures (FEMs) that can be considered as part of future system upgrades.

The report organization includes an Executive Summary to provide an overview of the recommended project savings and costs. Section 2 provides an overview of the DWS systems, Section 3 provides background information on the factors that effect DWS energy use, and Sections 4 through 12 contain an energy related overview of each water system. Section 13 includes a review of each proposed measure and Section 14 discusses project implementation and financing options.

1.1 Project Summary

The Project Evaluation Economic Summary shown in Table 1.1 provides an overview of our estimates for total project costs and annual savings. A more detailed summary of the qualified measures and their associated savings is presented in Table 1.2.

Table 1.1: Water System Energy Costs & Project Summary

Water System 2014 Annual Electric Energy Costs

Puna	$ 1,110,576
South Hilo	$ 2,717,888
North Hilo	$ 110,366
Hamakua	$ 744,081
North Kohala	$ 521,537
South Kohala	$ 5,695,309
North Kona	$ 9,581,196
South Kona	$ 1,608,993
Kau	$ 253,142
Total	**$ 22,343,058**

Projected Annual Cost and Savings Summary

	Calculated Savings	Percent of Costs
Electric Cost Savings	$ 2,241,294	10%

Project Costs/Payback

Estimated Cost of Projects	$5,192,501
Hawaii Energy (hawaiienergy.com)	$TBD
Adjusted Simple Payback	2.3 years

In addition to the energy cost savings, reducing facility energy use will also provide environmental benefits that include reducing greenhouse gas emissions (GHG) that include CO_2, N_2O and CH_4. The information in this evaluation can be used by the DWS to develop a GHG inventory plan in accordance with the EPA's Climate Leadership Program.

Reduced Energy & Power Plant Emissions

Carbon Dioxide (1.82 lbs/kWh)	10,254,997	lbs/year
Sulfur Oxides (0.0050 lbs/kWh)	28,173	lbs/year
Nitrous Oxides (0.0055 lbs/kWh)	30,990	lbs/year

Based on 5,634,614 kWh savings, emission unit source: U.S. EPA eGrid 2007 and U.S. EPA Office of Air Quality Planning & Standards for Hawaii *(www.epa.gov/cleanenergy/energy-resources/egrid/faq.html)*.

Table 1.2: Recommended Cost Saving Projects

No	Cost Saving Measures	Annual Energy Savings (kWh)	Annual Demand Savings (kW)	First Year Annual Savings ($)	Initial Cost ($)	Adjusted Simple Payback (yrs)
	ENERGY MANAGEMENT PRACTICES					
EMP 1	Assign Staff as a Part Time Energy Management Analyst	--	--	--	--	--
EMP 2	Formalize Energy Management Program	--	--	--	--	--
EMP 3	Hire Additional Water Service Investigator	--	--	--	--	--
EMP 4	Surface Water/Spring Cost/Savings Study	--	--	--	$200,000	--
	Total for EMPs	--	--	--	**$200,000**	--
	ENERGY SUPPLY MEASURES					
ESM 1	Power Factor Correction Capacitors	--	--	$100,922	$232,484	2.3
ESM 2	Reduce Two Pump Operation	--	879	$141,195	--	--
ESM 3	Optimize Existing Rider M Accounts	--	--	$23,804	--	--
ESM 4	Pursue Additional Rider M Agreements	--	--	$301,458	$129,896	< 1
ESM 5	VFDs for Back up Wells	--	1223	$179,289	$1,540,630	8.6
	Total for ESMs		**2102**	**$746,668**	**$1,903,010**	**2.5**
	OPERATIONAL MEASURES					
OM 1	Investigate Maukaloa Spring Flow Reduction	176,800	0	$60,112	$40,000	< 1
OM 2	Optimize use of Waimea WTP Flow	3,097,483	0	$829,385	$116,667	<1
OM 3	Optimize use of Hakalau Iki Spring	23,783	0	$9,782	$0	--
OM 4	Use Most Efficient Pumps	105,432	42	$40,962	$0	--
	Total for OMs	**3,403,498**	**42**	**$940,241**	**156,667**	**< 1**
	ENERGY CONSERVATION MEASURES					
ECM 1	Purchase Additional Leak Detection Loggers	290,950	0	$110,561	$670,276	6.1
ECM 2	Pump Efficiency Improvements	1,210,810	1160	$171,540	$1,480,213	8.6
ECM 3	Replace Cla-Valves with Ball Valves	106,227	35	$37,821	$212,917	5.3
ECM 4	Remove Flow Meter Strainers	52,649	13	$19,161	$102,084	5.3
ECM 5	Downsize Halekii Well	570,480	153	$206,946	$437,501	2.1
ECM 6	Replace Halekii VFD	--	--	$8,356	$29,833	3.6
	Total for ECMs	**2,231,116**	**1,361**	**$554,385**	**$2,932,824**	**5.3**
	TOTAL	**5,634,614**	**3,505**	**$2,241,294**	**$5,192,501**	**2.3**
	FUTURE ENERGY MEASURES					
FEM 1	Consider Larger Storage Tanks for New Sites	--	--	--	--	--
FEM 2	Investigate Additional Hydro Generation Projects	--	--	--	--	--
FEM 3	Evaluate Savings/Costs for Combining Piihonua #3 Accounts	--	--	--	--	--

1.2 Hawaii Energy

Hawaii Energy is the ratepayer-funded energy conservation and efficiency program administered by Leidos Engineering, LLC under contract with the Hawaii Public Utilities Commission serving the islands of Hawaii, Lanai, Maui, Molokai and Oahu.

Hawaii Energy provided 100% of the funding for this report and has initially contributed $130,000 for the purchase of additional leak detection loggers (included as ECM #1) based on preliminary data assembled by Process Energy Services and the Department of Water Supply before the draft report was completed.

1.3 Funding Options

An important consideration for the DWS is to be able to fund the identified energy projects in a timely manner in order to make a significant impact on reducing operating costs. In the past, several funding options for energy projects were considered by the DWS. These funding options included:

- Redefine the power cost charge (PCC) to provide a fund for energy projects
- Performance contracting/municipal leases

A summary of these approaches are provided below:

<u>Redefine PCC</u>

Redefining the DWS Rate Power Cost Charge (PCC) has been considered in the past to help create a fund that could be used for energy projects. It may be possible to do this with a rate schedule wording change as shown below.

Current Definition:	Power cost charge is the actual power cost/water consumed.
Proposed Definition:	Total DWS electric utility service cost/water service volume

If an additional $0.07/kgal (approximately one million in annual funding based on 2014 pumpage) were allocated to this energy account, this would provide an ideal low cost approach to make progress on the projects identified.

Performance Contracting

As discussed in Section 14, performance contracting is an ideal approach to have one firm perform the energy project design, construction, arranging financing (typically done with a municipal lease) and guarantee the energy savings. Several performance contracts have been successfully performed by the County of Hawaii resulting in millions of dollars in energy savings.

The benefits of this option are that the design and construction management for the identified energy projects would help leverage DWS staff time. A performance contractor would also be able to identify additional energy projects that were not found as part of the recent pumping/process evaluation. This would include lighting and HVAC improvements.

Recommendation

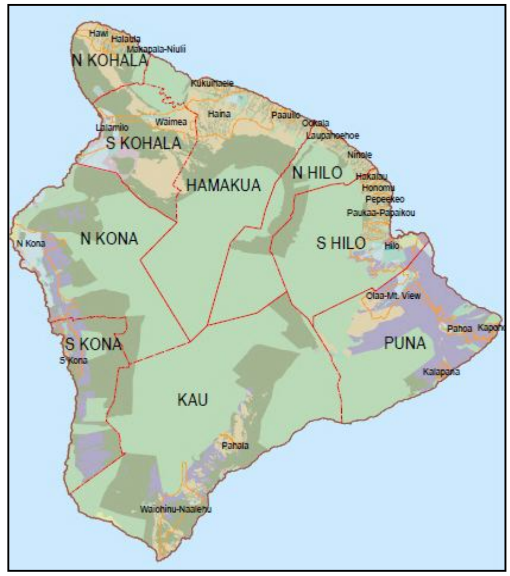
We recommend investigating all three methods for project funding. Based on annual projected savings of 2.2 million and an estimated project cost of 5.2 million, the energy projects would provide a return on investment of over 300% (based on 10 year equipment life).

We recommend the following steps to begin this process:

- Pursue project development by developing a sample RFP for the performance contracting approach.
- With Corporation Counsel assistance, investigate an adjustment to the PCC to have this option available for funding energy projects once approved by the Water Board.

SECTION 2. DWS WATER SYSTEMS

The Department of Water Supply (DWS) provides domestic water service through its 25 water systems throughout the island. The individual water systems are not interconnected except in the districts of South Hilo and Kona. The Department strives to provide dependable, high quality, potable water at a reasonable cost and has concentrated its efforts towards providing uninterrupted water service.



The DWS water service area can be described by the four water operations districts used by the DWS Operations Division. These four districts are: Hilo-Puna (District I), Hamakua and Kohala (District II), Kona (District III), and Kau (District IV). Each water system can be further divided into operational areas as shown in Table 2.1.

Table 2.1: Water System Operational Areas

District	System
Puna	Kalapana Kapoho Olaa-Mt View Pahoa
South Hilo	Hilo Hakalau Honomu Paukaa-Papaikou Pepeekeo
North Hilo	Laupahoehoe Ninole Ookala
Hamakua	Haina Kukuihaele Paauilo

District	System
North Kohala	Halaula Hawi Makapala-Niuli
South Kohala	Lalamilo Waimea
North Kona	
South Kona	
Kau	Pahala Waiohinu-Naalehu Hawaiian Ocean View

SECTION 3. ENERGY MANAGEMENT STRATEGIES

3.1 Energy Program

An effective energy management program provides a systematic approach to reducing facility energy use and costs. An energy management program is more than just developing energy improvement projects. A successful program is structured to provide an on-going process that can be used to continually evaluate new projects, track savings and encourage efforts within the organization to improve efficiency.

An effective energy program includes the following key components:

- Assign Energy Management Analyst Responsibilities to Existing Staff
- Establishing an Energy Policy
- Selecting an Energy Management Team
- Developing a facility energy use baseline to track energy use/flow data.

The EPA 2008 Energy Management Guidebook for Water and Wastewater Utilities (*www.epa.gov/waterinfrastructure/pdfs/guidebook_si_energymanagement.pdf)* presents a management system approach for water and wastewater utilities for energy conservation. Based on the successful Plan-Do-Check-Act process, the guidebook provides information on establishing and prioritizing energy conservation targets (Plan), implementing specific practices to meet these targets (Do), monitoring and measuring energy performance improvements and cost savings (Check), and periodically reviewing progress and making adjustments to energy programs (Act). This proven strategy requires a designated energy champion to organize the effort.

3.2 Energy Management Analyst Position

Designating a staff member as a part-time Energy Management Analyst is a critical component for the DWS to have a successful energy program. The Energy Management Analyst is the key person who leads an organization in achieving its efficiency goals by promoting energy performance as a core value and facilitating energy improvement projects.

Having a staff member take on Energy Management Analyst responsibilities is critical to manage the 22 million dollar annual energy budget for the DWS. As demonstrated in this report, just one successful energy saving adjustment can justify the allocation of staff resources.

For the DWS, the Energy Management Analyst position has previously included the following responsibilities:

<u>Monitoring Energy Data and Savings</u>

- Track energy use to maximize energy savings
- Manage DWS Energy and Pumpage Spreadsheets
- Research missing or inconsistent data
- Look for trends that effect efficiency
- Monitor and verify savings from projects

Training/Communication

- Review pump system optimization with operators on a regular basis
- Work with engineering to incorporate efficiency into system designs
- Coordinate data collection, recording, and analyzing with the DWS Water Services Investigation section, maintenance staff, pump station operators, and Microlab staff.
- Recognize staff for accomplishments through a recognition /accountability program that promotes efficiency at all levels within the department.
- Chair energy meetings on a regular basis with a designated energy management team, discuss progress of implementing identified ECMs, new ideas and projects and provide a summary of the meeting notes to all DWS managers and supervisors
- Spear-head energy related issues for the DWS by participating in and coordinating activities with other agencies and organizations.

Formalize Data Collection Efforts for Energy, Flow, and Water Use

- Develop pump system improvement plan based on testing
- Develop and implement Standard Operating Procedures to provide accurate and up-to-date energy, efficiency and flow information.
- Collect, record, analyze, and act upon, on a regular basis, the above data to optimize the operation of each district.
- Research, analyze and develop implementation plans for energy saving projects -This includes RFP development, technical specifications, financial analysis, energy savings calculations, developing project cost estimates, managing contractors, and follow-up verification of savings. Projects to include:

  -Power factor correction capacitors
  -Premium efficiency motors
  -Installing or removing variable speed drives
  -Pump efficiency improvements
  -Installing hydro turbine generators
  -Demand controls / SCADA systems to take advantage of Rider M rate schedules.
  -Assisting DWS staff with unaccounted for water projects

Research New Technologies / Projects to Reduce Long Term Energy Costs

- Optimizing flow from Waimea WTP (piping improvements).
- Develop specific solutions for using surface water sources.
- Working with HELCO to determine the best rate schedule for each pump station.
- Exploring alternative renewable energy sources for DWS facilities such as solar and wind and additional hydro sites.
- Evaluate selective water conservation projects to reduce energy use.

The Energy Management Analyst part-time position is the highest priority measure in this report (designated as EMP #1 in Table 1.2) and is an essential step that is needed to implement the projects proposed.

3.3 Establishing an Energy Policy and Energy Management Team

Formalizing an energy management program is essential to begin improving systems efficiency and maintaining low operating costs. The DWS has recognized the importance of energy management and has had an Energy Manager Analyst position for over 10 years. However, an Energy Management Analyst needs the support of management and a formal energy management program that emphasizes the importance of this effort to all staff members.

Even though this recommendation cannot be directly related to calculated savings, it is a critical step that will often determine if efficiency projects are successful. Some of the key building blocks of a successful energy management program include the following tasks:

Developing an Energy Policy

An Energy Policy provides the foundation for successful energy management. When developing an energy policy, the DWS should consider the following:

- Have the DWS Manager issue the policy.
- Involve key people in policy development to ensure buy-in.
- Tailor the policy to the organization's culture.
- Make it understandable to all of the staff and the public alike.
- Consider the skills and abilities of management and staff.
- Include detail that covers day-to-day operations.
- Communicate the policy to all staff, and encourage them to get involved.

Establishing an Energy Team

Creating an energy team helps integrate energy management into all areas of an organization. In addition to planning and implementing specific improvements, the team also measures and tracks energy performance and communicates with management, employees and vendors. The purpose of creating an energy management team is to develop the resources and tools needed to maximize the effectiveness of the energy manager. The energy management team's role should include:

- Organize and coordinate energy efficiency efforts.
- Develop technical skills to identify and implement projects.
- Assemble pertinent data to identify inefficiencies.
- Create a management focus on water and energy efficiency.

Creating an energy management team involves putting together the right group of people with the appropriate resources to identify opportunities, develop and implement projects, and track results. In addition to the Energy Management Analyst who leads the team, a representative from engineering, accounting, operations and management should also be included.

Meetings should be initially scheduled monthly to get the program started and then can be held every two months after projects have been initiated. These meetings provide an opportunity to present potential energy savings projects, request assistance from departments to obtain additional data, and to get feedback on the proposed projects.

Tools and Resources for the Team

During the process of organizing an energy management team, managers need to recognize and provide resources that the team needs for success. Some of these resources include:

- *Allocating a program annual budget*. Having a budget is critical for the energy management team to obtain needed tools and expertise, commissioning technical studies, implementing appropriate projects, and providing continuity.

- *Team members need time to focus their efforts on efficiency*. It is important that department managers recognize that energy management team members will need to occasionally devote time to help collecting data to support energy efficiency projects. This includes allowing team members the ability to access key people from both inside and outside the team.

- *Training*. Appropriate training provides team members with the tools to achieve efficiency goals. Training can acquaint team members with up to date efficiency technologies, teach energy conscious operations and maintenance practices, and show managers how best to enable their staff to achieve efficiency gains.

- *Documentation*: To improve facility efficiency, it is important to document existing system operations and energy use/savings through standard operating procedures.

- *Metering and Monitoring Equipment*. One of the first tasks of the team should be to assess the current metering and monitoring system to identify areas for improvement and determine additional equipment needs (flow meters, pressure gauges, etc…). Data can always be improved by increasing the scope and accuracy of the system's measuring capacity.

- *Pursue Projects*. To prevent a team's efforts from turning into a strictly academic exercise, identified opportunities need to be implemented. Management needs to support projects that meet certain payback goals, and recognize the value of using low or no-cost projects to help fund more capital-intensive projects.

This measure is an important part of a successful efficiency program to insure savings for all other energy projects are realized

3.4 Benchmarking/Baseline Development Team

Energy benchmarking can be accomplished using internal or external comparisons. Internal benchmarking allows an organization to evaluate facility energy use year to year to monitor facility efficiency changes. The results can be used within an organization to track performance over time, identify best practices, and to increase management's understanding of how to analyze and interpret energy data.

For external benchmarking, a facility can be compared to similar facilities. When process and energy use data is assembled, the information can be used to assess performance and motivate staff to investigate why performance is lower than expected or to confirm efficiency efforts by receiving a high performance rating relative to other facilities. As indicated for internal benchmarking efforts, this data can also be used to identify new best practices for improving facility performance and to increase understanding of how to analyze and evaluate energy performance.

Whether using the internal or external approach, benchmarking is a key measure of performance.

3.5 Energy Rate Schedule/Rider Strategies

The HELCO energy bills are comprised of a cost per kWh for energy consumption, a fuel charge that is based on kWh use and a demand charge that is determined every month by the highest peak kW use of the station during any 15-minute period. The DWS electric accounts are billed on HELCO Rates “G”, “J” and “P”. Copies of these rates are included in Appendix A.

The demand cost can often be a significant part of the energy bill, especially when a large horsepower pump system is used for a short period of time. When a peak demand is recorded, the utility automatically charges the DWS a peak demand charge for eleven months, even if the pump operates at a lower demand.

The carryover demand clause has been a significant portion of DWS energy costs over the years. The typical scenario where demand costs are higher than energy consumption costs is when one of the wells is used for one or two months or as little as a few hours during high flow demands. Even though these wells may not use one kWh of energy after the high demand use, the carryover of the demand charge (recorded during a 15 minute period) costs the DWS thousands of dollars over the next eleven months.

The DWS is in a difficult situation since they must periodically test the large horsepower wells to keep them reliable and ready for peak demand service, but as indicated this practice can result in a steep demand charge penalty for months after the well is tested for a short period of time.

HELCO has multiple rate schedules for different size electric accounts and “Riders” that offer some price relief for energy that is used during off-peak hours. The Rider M is a peak demand agreement that requires a specified amount of demand to be curtailed during 5:00 pm to 9:00 pm for the four-hour period or between 5:00 pm – 7:00 pm for the two-hour period (a copy of Rider M is included in Appendix A). The rider can provide savings for designated pump stations, as long as the DWS has enough tank capacity to sustain itself through the on-peak periods. For stations that do not have the flexibility to remain off during these periods or are typically used as back-up pumps, we have explored the potential of applying variable frequency drives (VFDs) to reduce demand charges.

Normally for high static head pump systems, a variable frequency drive would not be recommended since it has minimal frictional head savings and the efficiency is reduced as it moves down the system curve. However, for certain pump systems, it can be cost effective. Operating a pump for a short period of time at low efficiencies would not impact energy use significantly. Using a VFD at the minimum speed to discharge flow would help reduce demand charges on a regular basis. In the event that a well is needed for more hours, the VFD speed could be increased as needed. Although this would create a new peak demand value, the DWS would still benefit by reducing long term demand charges if the operator realizes that even just a slight VFD adjustment can provide long-term demand savings.

In addition to these equipment adjustments, application of the Rider M Rate Schedule can be pursued. The DWS has taken advantage of this option for many of the stations over the last 10 years. A summary of the

$206,949 Rider M savings in 2014 is shown in Table 3.1. To take full advantage of this rider, we have recommended applying it to additional pump stations as discussed in the report.

Table 3.1 2014 Rider M Savings

Month	Kalapana Wells	Piihonua Well C	Olaa #3 DW	Panaewa	Piihonua 3B	Saddle Rd	Paauilo Well	Parker Well #2	Hawi Well B
Jan	$1,056	$3,680	$1,774	$2,814	$2,481	-$8	$798	$4,244	$1,253
Feb	$1,062	$3,686	$1,769	$2,817	$2,478	$485	$783	$4,238	$1,213
Mar	$1,058	$3,677	$10	$2,586	$2,484	$485	$770	$4,251	$1,252
Apr	$1,065	$3,684	$4	$2,817	$4,290	$485	$752	$4,265	$1,215
May	$633	$3,683	$341	$2,595	$2,486	$485	$699	$4,259	$1,214
Jun	$1,070	$3,683	$1,770	$2,814	$2,355	$485	$713	$4,248	$1,249
Jul	$1,060	$3,690	$1,752	$1,746	$2,153	$485	$710	$4,275	$1,233
Aug	$505	$3,676	$1,801	$2,817	$1,956	$485	$709	$4,289	$1,227
Sep	$1,065	$3,686	$216	$2,634	$1,916	$485	$793	$4,304	$1,229
Oct	$1,065	$3,687	$217	$2,598	$1,511	$485	$270	$4,316	$1,231
Nov	$1,068	$3,681	$1	$2,814	$2,244	$323	$792	$4,314	$1,231
Dec	$1,083	$3,681	$2	$2,814	$2,244	$485	$792	$4,302	$1,251
Total	**$11,791**	**$44,195**	**$9,655**	**$31,865**	**$28,597**	**$5,166**	**$8,578**	**$51,305**	**$14,797**

Although the Rider M agreement has worked well for some systems, it has been a challenge for other areas with high demand and well reliability problems. In addition to pursuing Rider M Agreements, using VFDs to adjust equipment to minimize peak demand is another key strategy for the DWS to reduce demand charges. However, both of these strategies are still vulnerable to unexpected well repairs and high water demands, which will erase some of these savings. The high energy use requirement of the large horsepower deep well pumps will always be a cost burden on the DWS as long as it depends on wells for the majority of its water supply. Optimizing the use of surface water/spring sources is discussed in Section 3.6.

3.6 Using Surface/Spring Water Supply Sources

Making every effort to use spring and surface water sources is one of the best long-term solutions for the DWS to protect itself from rising energy costs and minimize its dependence on high-energy deep wells.

In the 1990s, more stringent federal surface water regulations were adopted as part of the Surface Water Treatment Rule (SWTR). Over time, the DWS made the decision to abandon many of the surface water sources that would have required water treatment systems and transition to more deep wells to satisfy water demands. The investment in deep wells was initially a good choice for the DWS to provide a consistent, high quality water supply. The wells were also regulated through less stringent groundwater regulations for water treatment. However, the deep wells have been energy intensive and have had reliability problems over the years.

The DWS was able to continue to use some of the springs that were not under the influence of surface water and is in the process of upgrading the South Kohala Waimea Water Treatment Plant that was originally constructed in the 1980s to increase the plant capacity.

The successful use of the Waimea Plant is an example of the significant energy savings that has been realized by the DWS over the last 30+ years. Based on an average flow of 2 million gallons/day, we estimate that since the plant was constructed (using an approximate 30 year average deep well energy cost of $1.00/1000 gallons) the DWS has saved over 21 million dollars in energy costs.

The DWS Water Quality Branch has indicated that a significant effort would be required to reactivate the abandoned springs/surface water sources that are located in the other water systems. This would include, but not be limited to, new source water quality testing, microscopic particulate analysis, determination of truly groundwater or groundwater under the influence of surface water (i.e. Waiulili springs and Alili Tunnel), design & construction plans, operation plans, etc. The land acquisition (if not already owned) and design of a new intake box or collection system, storage, and transmission waterlines. If the source were deemed under the influence of surface water, the source would be required to meet the requirements of the Surface Water Treatment Rule, which would require additional cost and effort.

The above issues are valid concerns, but until specific costs and savings are put together the DWS cannot make an informed decision if the long-term benefits outweigh the initial effort to invest in transmission lines and/or water treatment systems.

In EMP #4, a detailed evaluation has been recommended for all the viable spring/surface water sources. This evaluation would include a detailed assessment to determine if the source could be considered a spring without the influence of surface water or if water treatment was required. For a potential water treatment system, the evaluation would include the capital improvements for treatment (i.e. membrane filtration) versus future O&M costs, which could include but not be limited to; chemical requirements for cleaning of membranes, disposal of chemicals, replacement of membrane filters, added personnel (WTPO Grade 2 required), land acquisition, design/construction costs, and disinfection requirements.

To begin this process, we have summarized the water sources for each system in each section and included the potential energy savings that could be realized to provide justification for the initial evaluation phase in EMP #4.

3.7 Unaccounted for Water

In 2000, the Department of Water recognized that the Island of Hawaii water distribution system had significant amounts of non-revenue water (NRW) and designated a lead person for the Water Service Investigation (WSI) Program. As part of the program, the following key areas of data collection and record keeping were identified:

- Maintain the DWS Pumpage Report and customer service billing system-metered usage (consumption-monthly and bi-monthly).
- Obtain estimates and records of unmetered water used by contractors, fire department, field operation personnel (flushing purposes), and reservoir/tank overflow.
- Document known leaks, main pipeline breakages, reservoir seepage/overflow, unmetered usage (theft), and water hauling by private haulers.

The data collection process requires a significant effort to insure the data is as accurate as possible. This includes a thorough review of the pumpage report each month, identifying and repairing inaccurate meters, and a continuous effort to document non-revenue water.

Although the program has been successful, it has been difficult to have one person cover the entire Island to perform data logger monitoring, investigation work to identify the leak, quantify the savings, initiate the repair project, and follow through to be sure the work is performed in a timely manner.

A Water Service Investigator position had been previously approved years ago, but was not pursued due to budget constraints. Given the significant savings realized from each leak identified and corrected, this position should be filled as soon as possible and has been included as EMP #3.

Data Loggers

The DWS has made a substantial investment in leak detection equipment to reduce unaccounted for water. To begin the process the DWS contracted with Fluid Conservation Services (FCS) to perform a comprehensive Non-Revenue Water Loss Study of the Hilo area based on its high-unaccounted water figure. For the project, FCS installed over 625 PermaLog noise loggers throughout Hilo in existing valve boxes. Using a patroller hand held device, information was retrieved from each PermaLogger and then uploaded and analysed to a software program to determine each suspected leak location. A technician then investigated each of these locations with a leak noise correlator to pinpoint the leak location. DWS staff repaired the identified leaks and savings were verified based on flow data and station energy use.

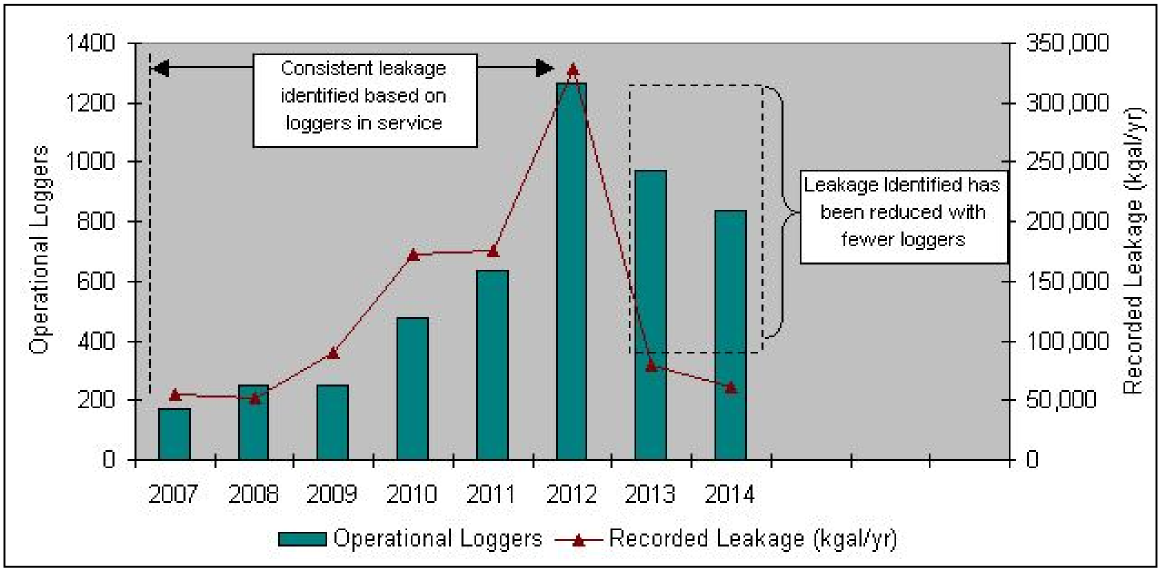
As shown in Table 3.2, this investment has resulted in over $840,000 in total savings over the last seven years. Based on an investment of almost 2 million dollars in loggers and piping repairs, the simple payback for the program has averaged 2.3 years since 2007.

Table 3.2: Leak Detection Program Loggers, Savings and Costs

Fiscal Year	Loggers Deployed	Loggers Removed	Loggers Net Operational	Recorded Leakage (Kgal/year)	Energy Savings	Allocated Cost for Repairs & Loggers	Simple Payback (yrs)	Savings/ Operational Logger
2007	325	153	172	55,061	$35,176	$165,283	4.7	$205
2008			249	51,385	$30,089	$204,082	6.8	$121
2009			249	89,722	$79,650	$312,216	3.9	$320
2010	225		474	172,185	$162,142	$263,326	1.6	$342
2011	164		638	175,855	$187,246	$263,005	1.4	$293
2012	625		1263	328,218	$183,364	$337,344	1.8	$145
2013		292	971	79,423	$68,594	$272,269	4.0	$71
2014		136	835	61,695	$94,389	$151,006	1.6	$113
Total/Avg	--	--	--	**1,013,544**	**$840,649**	**$1,968,530**	**2.3**	**$232**

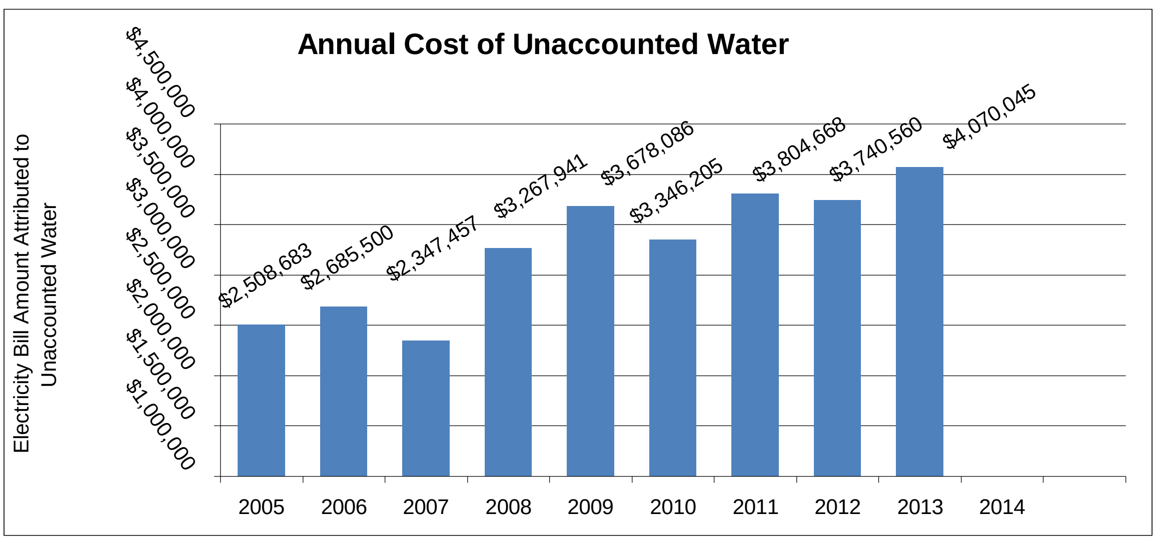
The DWS has been challenged to provide enough funding to keep up with data logger deployment. As shown in Figure 3.1, the result has been a drop off in operational loggers and a reduction in recorded leakage and energy savings.

Figure 3.1: Annual Loggers and Recorded Leakage



With energy costs increasing, the annual cost of unaccounted water reached a record level of over four million dollars in 2013 as shown in Figure 3.2.

Figure 3.2: Annual Cost of Unaccounted Water



Proposed New Equipment

To continue the high level of savings, the DWS is interested in continuing their relationship with Metrotech/Vivax by investing in 575 additional loggers, leak detection equipment and additional training. Based on historical savings, the proposed investment of $427,000 for the logger equipment and $200,000 for the leak repairs is expected to provide annual savings of $110,561 and a simple payback of less than 6 years. The details for this project are presented in ECM #1.

The partnership program with Hawaii Energy has yielded additional funds in the amount of $135,000 from the Business Energy Services and Maintenance (BESM) Program to the Department of Water Supply as incentive for procurement for leak detection equipment as part of the island wide unaccounted water program.

3.8 Hydro Generation

The installation of high elevation deep wells and large storage reservoirs provides the opportunity to install hydro-generation systems to convert water pressure into useful energy production. For water brought down from higher elevations, pressure is typically reduced with a series of pressure reducing valves (PRVs) to prevent excessive pressure from damaging pipes. The PRVs dissipate the pressure and absorb the energy created by these high pressures without providing any useful benefit.

When water flows can be maintained consistently, hydro generation systems can be utilized effectively for power generation. If the energy generated cannot be used to offset power use at the hydro turbine site location, HELCO has a specific rate schedule that allows the sale of power generation back to the utility (at a lower rate).

The DWS has installed hydro generation systems at three sites in the water distribution system. The sites were chosen based on consistent flow & pressure and a suitable piping configuration for installing the hydro unit. A summary of the sites and energy generation/revenue over the last several years is shown below.

Table 3.3: Existing Hydro Turbine Savings and Costs

Hydro Turbine Site	Years Data Collected	Average Energy Generated (kWh)	Average Annual Cost Value of Energy	Revenue Unit Cost/kWh	Project Cost	DOE Grant Funding	Adjusted Simple Payback
Waimea Treatment Plant	5	60,752	$16,960	$0.28/kWh	$200,000	--	11.8
Kaloko Tank	5	139,300	$22,133	$0.16/kWh	$400,000	$200,000	9.0
Kahaluu Shaft	1	105,430	$30,030	$0.28/kWH	$560,000	$280,000	9.3
Total	**--**	**305,482**	**$69,123**	**--**	**$1,200,000**	**$480,000**	**--**

Although the hydro turbine cost/benefit may not support additional hydro turbine projects unless DOE funding is available, we believe a more detailed review is needed to understand why the original energy/cost projections changed from the initial estimates. If the up front costs can be reduced and the cost/energy production risk is transferred to a third party, we believe future projects could still provide value to the DWS.

3.9 Equipment Efficiency

All of the electrical and mechanical components between the utility electric meter and the pump have some efficiency loss. The majority of these losses are found in the pump, motor and variable speed drives (where applicable).

The DWS has made it a standard practice to specify premium efficient motors when cost effective for all system pumps. Unfortunately, some of the largest horsepower motors used for the deep well systems are submersible type motors and are not easily upgraded to premium efficiency type motors. In some cases, the submersible motors are 7% less efficient than the same size standard vertical hollow shaft motor units used on the vertical turbine deep well pumps.

Optimizing pump system efficiencies includes replacing or repairing low efficiency pumps. On wells equipped with vertical turbine pumps, the DWS practice is to change the motor oil once or twice a year. Periodic efficiency tests are also performed to determine the condition of the pump. If the efficiency decreases significantly, the pump will be “pulled” and reconditioned or replaced. The cost to pull a pump is high ($30,000 to $150,000), so the DWS avoids this cost unless there is an obvious drop in efficiency or a mechanical and/or electrical problem with the pump or motor.

During our site visit, testing was performed on the many high-energy deep well systems and the larger booster pump stations to determine pump efficiency. Pump efficiencies that were significantly lower than original pump curve values were identified and included in ECM #2 to evaluate the cost effectiveness of pump replacement or repairs.

In addition to calculating pump efficiency; pumps equipped with VFDs were also evaluated to see how efficiency varied with speed based on where the pump was operated on the system curve.

3.10 Effective Use of Water Storage

The effective use of water storage in the system tanks is based on a number of factors including fire flow, adequate pressure for high elevation services and sufficient turnover for water quality. In regards to energy costs, using the maximum storage available allows staff to curtail operation of select pump stations between 5:00 PM and 9:00 PM to take advantage of the utility Rider M rate schedule to decrease energy costs.

An evaluation was performed in 2006 by RW Beck (*Titled: 20 year Master Plan*) to determine potential benefits and trade-offs between two strategies for providing storage capacity. The evaluation reviewed the potential of building larger reservoirs to allow the DWS to refill reservoirs at night, to take advantage of lower off-peak electricity prices.

Capital construction costs and pumping costs were determined to be the significant factors when comparing small and large storage facilities.

The two scenarios evaluated were:

- Construction of larger storage facilities and pump stations capable of refilling the reservoirs during off-peak periods for electricity rates (10 hours/day during the night).
- Construction of minimum storage capacity required to meet storage needs with pump operation similar to existing installations.

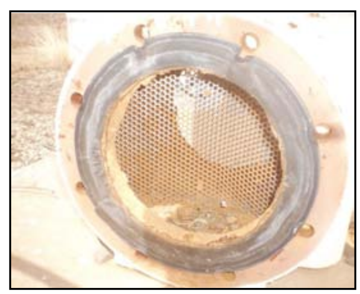
The evaluation results indicated that the total costs (including capital and pumping costs) are of similar magnitude for the two scenarios. The higher capital costs of putting in a larger reservoir are offset in the long term by decreased pumping costs (with breakeven results). This review was based on a generalized case and was not applied to a specific reservoir site. In FEM #1, we have recommended performing this analysis for future tank upgrade projects.

For near term savings, in ESM #2, we have recommended adjusting tank level setpoints to prevent a second pump from being activated unless necessary. If the setpoints could be adjusted, additional time could also be gained to help qualify for the utility Rider M rate.

3.11 Reducing System Friction Losses

Reducing system friction losses provides long term energy savings by moving the pump operating point further down the head curve which allows the pump to provide a slightly higher flow resulting in less run time.

The DWS has replaced many of the old globe type Cla-Valves with Masoneilan and Pratt ball type valves, which have a pressure drop of less than 2 psi or 4.6' of head (based on sample measurements). During our review, we were able to measure the pressure loss across the Piihonua #3 Booster Pump B Cla-Val and found the loss to be 10 psi or 23.1'of head. Even though Cla-Valve replacements projects have been done at several stations, there are still many pump systems that have not been improved. Stations that we initially identified are reviewed in ECM #3.



The DWS has installed new magnetic flow meters (virtually no head loss) at many of the pump stations in place of turbine meters and in-line strainers that are used for meter protection. During our site visit we were able to measure head loss for one of the strainers (Panaewa Well #1) which had a pressure drop of 3 psi (6.9'). Even though the DWS has replaced many of these flow meters/strainers, there are still multiple pump systems that have not been improved. Stations that were identified were reviewed in ECM #4.

3.12 Water System Energy Reviews

Many of the concepts discussed in this section have been reviewed in more detail for each of the DWS water systems. To evaluate potential energy savings, 2014 energy use data, run time and pumpage has been compiled for the high-energy use pump systems, and results of pump testing performed during our site visit has been included.

DWS operations staff does an excellent job collecting monthly pump hours and flow data. This information is transferred to the office staff, which inputs the data on the DWS Pumpage Report. In addition, the staff also transfers key energy data from the HELCO bills into spreadsheets, which is used to evaluate energy discrepancies and to identify energy savings opportunities. The Pumpage Report and Energy Input Files developed by the DWS provided valuable information that helped us evaluate the pump systems in this report. Updating this data on a regular basis and holding DWS staff accountable for operating the systems as efficiently as possible is an important follow-up step that should be included in the DWS Energy Management Program (EMP #2).

A review of 2014 data and summary of potential energy savings measures for each water system is included in Sections 4 through 12.

SECTION 4. PUNA SYSTEMS

The Puna system includes the Olaa-Mt View, Kalapana and Pahoa Systems. A summary of 2013 and 2014 energy use and costs for the system electric accounts is shown in Table 4.1.

Table 4.1: Puna Accounts

Service Account	2013 kWh	2013 Cost	2014 kWh	2014 Cost
Keaau Olaa Deep Well #1A & B	56,000	$44,237	200,960	$94,706
Olaa #2 Boosters	38,560	$27,111	175,040	$74,698
Olaa #3 Deep Well and Boosters	1,131,800	$410,648	600,600	$236,277
Olaa #4 Boosters	167,480	$66,934	97,680	$42,404
Olaa #5	123,300	$49,284	73,000	$31,440
Olaa #6 Deep Well & Boosters	0	$0	507,000	$238,977
N. Kopua Rd (Olaa #7 Boosters)	57,792	$23,880	57,410	$23,916
Olaa #8	9,851	$4,777	9,635	$4,711
Volcano Tank	291	$500	288	$500
Kalapana Deep Well	113,920	$47,044	115,520	$46,726
Keonepoko Nui Well	755,400	$296,693	679,600	$274,013
Pahoa Deep Well	3,200	$10,863	86,800	$42,208
Total	**2,457,594**	**$981,971**	**2,603,533**	**$1,110,576**

The pump system high-energy accounts (above $25,000) are reviewed in this section.

4.1 Olaa-Mt View

The Olaa-Mt. View water system extends along the Volcano Road from the former Puna Sugar Company mill to the Olaa Reservation Lots and along the Keaau-Pahoa Road to the vicinity of Kaloli Drive. It serves elevations between approximately 220 feet and 2,170 feet. The water system includes four wells, eight-booster pump stations and eleven storage tanks.

One of the most significant system changes in 2014 was the addition of Olaa #6 Deep Well, which was put in service in August. This high elevation well has reduced operating hours and energy costs for all of the lower elevation pump systems. Olaa #6 Well is expected to be the primary water source for the system initially and Olaa #3 Well will be used as needed.

The addition of Olaa #6 Well provides an additional water source that will improve system reliability. As shown in Table 4.1, even though the energy use of many stations will be reduced, the high energy use of the Olaa #6 will offset these costs and may even increase overall system costs due to electric demand charges that will still occur at the unused stations.

4.1.1 Olaa #1 Wells A&B

Olaa #1 Wells A & B are on the same electric account and are billed on the HELCO Rate Schedule J. Well A is equipped with a 125 hp motor and is rated to pump 975 gpm @ 380' total dynamic head (TDH) and Well B has a 150 hp motor and is rated to pump 800 gpm @ 350' TDH. The two wells pump into the Olaa #2 Tank. Energy use data from the HELCO electric bills is shown below in Table 4.2.

Table 4.2: Olaa #1 Well A & B 2014 Energy Use and Costs

Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill	Power Factor	Rider M Discount	Net Bill
1/6/14	4,480	160	182	$1,867	$1,111	$539	$3,517	$12	$0	$3,517
2/4/14	24,320	205	205	$2,102	$6,032	$2,399	$10,533	$8	$0	$10,533
3/5/14	45,760	205	205	$2,102	$11,350	$4,785	$18,237	$0	$0	$18,237
4/3/14	43,200	205	205	$2,102	$10,715	$4,133	$16,951	$0	$0	$16,951
5/5/14	50,240	205	205	$2,105	$12,461	$4,864	$19,431	$15	$0	$19,431
6/4/14	23,040	205	205	$2,104	$5,715	$2,407	$10,226	$8	$0	$10,226
7/2/14	4,800	204	205	$2,097	$1,191	$608	$3,896	$13	$0	$3,896
8/4/14	3,520	162	184	$1,884	$873	$480	$3,237	$11	$0	$3,237
9/4/14	320	0	205	$2,169	$0	$0	$2,169	$0	$0	$2,169
10/3/14	320	0	205	$2,169	$0	$0	$2,169	$0	$0	$2,169
11/3/14	320	0	205	$2,169	$0	$0	$2,169	$0	$0	$2,169
12/3/14	640	0	205	$2,172	$0	$0	$2,172	$0	$0	$2,172
Totals/Avg	**200,960**	**194**	**202**	**$25,044**	**$49,448**	**$20,214**	**$94,706**	**$67**	**$0**	**$94,706**

In September the wells were taken off line after Olaa Well #6 was activated. With the new well in service, the expectation is that these wells will now only be used for back up. A summary of 2014 pump hours and flow data from the DWS Pumpage Report is shown below.

Table 4.3: Olaa #1 Well A & B 2014 Hours & Pumpage

Month	Monthly Energy Use (kWh)	Monthly Bill	Well #1 Hours	Well #2 Hours	Total Well Hours	Well #1 Pumpage	Well #2 Pumpage	Total Pumpage (kgal)	Average GPM	kWh/ kgal	Cost/ kgal
Jan-14	4,480	$3,517	93	130	224	4,968	7,966	12,934	964	0.3	0.3
Feb-14	24,320	$10,533	56	378	434	2,840	23,693	26,533	1,018	0.9	0.4
Mar-14	45,760	$18,237	54	371	425	2,724	22,260	24,984	980	1.8	0.7
Apr-14	43,200	$16,951	133	322	455	7,115	19,290	26,405	968	1.6	0.6
May-14	50,240	$19,431	165	114	279	8,930	6,858	15,788	943	3.2	1.2
Jun-14	23,040	$10,226	30	23	53	1,615	1,302	2,917	919	7.9	3.5
Jul-14	4,800	$3,896	9	12	21	458	0	458	358		
Aug-14	3,520	$3,237	0	0	0	0	0	0			
Sep-14	320	$2,169	0	0	0	0	0	0			
Oct-14	320	$2,169	0	0	0	0	0	0			
Nov-14	320	$2,169	0	0	0	0	0	0			
Dec-14	640	$2,172	0	0	0	0	0	0			
Totals/Avg	**200,960**	**$94,706**	**541**	**1,350**	**1,891**	**28,650**	**81,369**	**110,019**	**879**	**2.6**	**1.1**

<u>Observations and Proposed Recommendations</u>

The primary potential for energy savings at this station will be to invest in improvements that reduce the $24,000 annual demand charges. Since the wells will need to be tested periodically to maintain water quality, we recommend the following improvements.

- As shown in Table 4.3, it appears that both wells are being operated together even though the operating hours suggest that demand did not justify both wells operating in parallel. This is most likely a tank setpoint issue, which can be corrected at minimal cost. The annual savings for operating one well instead of two will be approximately $12,600. This adjustment was reviewed as part of ESM #2.

- As part of a long-term strategy to have these wells available for back up service without incurring high demand charges, we recommend equipping at least one of the wells with a VFD. This will reduce the 112 kW of demand to approximately 43 kW if the well is operated at a reduced speed for testing. If a well is needed for short-term back up, we recommend operating at a reduced capacity to minimize peak demand charges. Although efficiency will be reduced, it will not impact cost savings if it is for a short duration. Savings for this improvement is expected to be $8,400 annually. This project is reviewed in ESM #5.

Even though these wells have not been repaired in over 20 years, as back-up units the expected low operating hours in the future would not benefit from efficiency improvements.

4.1.2 Olaa #2 Booster

The Olaa #2 Booster Pump Station is billed on the HELCO Rate Schedule J. Two of the booster pumps are no longer in use. The remaining two units are each rated for 520 gpm @ 338’ TDH. Booster Pump C is equipped with a 75 hp motor and Booster D has a 60 hp motor. Energy use data is shown in Table 4.4.

Table 4.4: Olaa #2 Booster Pumps 2014 Energy Use and Costs

Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill	Net Bill	Net Cost/ kWh
1/6/14	2,720	80	95	$976	$675	$345	$1,996	$1,996	$0.73
2/4/14	20,800	110	110	$1,132	$5,159	$2,054	$8,344	$8,344	$0.40
3/5/14	41,760	110	110	$1,132	$10,358	$4,372	$15,862	$15,862	$0.38
4/3/14	39,200	110	110	$1,132	$9,723	$3,756	$14,611	$14,611	$0.37
5/5/14	44,480	110	110	$1,132	$11,033	$4,301	$16,465	$16,465	$0.37
6/4/14	19,360	110	110	$1,132	$4,802	$2,026	$7,960	$7,960	$0.41
7/3/14	3,680	110	110	$1,132	$913	$471	$2,516	$2,516	$0.68
8/4/10	1,760	106	108	$1,107	$437	$266	$1,810	$1,810	$1.03
9/4/14	320	0	108	$1,107	$79	$101	$1,287	$1,287	$4.02
10/3/14	320	0	108	$1,107	$79	$97	$1,284	$1,284	$4.01
11/3/14	320	0	108	$1,107	$79	$96	$1,282	$1,282	$4.01
12/3/14	320	0	108	$1,107	$79	$95	$1,281	$1,281	$4.00
Totals/Avg	**175,040**	**106**	**108**	**$13,300**	**$43,416**	**$17,982**	**$74,698**	**$74,698**	**$1.70**

A summary of 2014 pump hours and flow data is shown in Table 4.5.

Table 4.5: Olaa #2 2014 Pump Hours and Flow

Month	Monthly Energy Use (kWh)	Monthly Bill	Bstr C Hours	Bstr D Hours	Total Bstr Hours	Total Pumpage (kgal)	Average GPM	kWh/ kgal	Cost/ kgal
Jan-14	2,720	$1,996	221	127	348	13,112	627	0.2	0.2
Feb-14	20,800	$8,344	540	184	724	27,405	631	0.8	0.3
Mar-14	41,760	$15,862	530	179	709	26,857	631	1.6	0.6
Apr-14	39,200	$14,611	558	190	748	28,335	631	1.4	0.5
May-14	44,480	$16,465	330	104	434	16,479	633	2.7	1.0
Jun-14	19,360	$7,960	62	9	70	2,676	636	7.2	3.0
Jul-14	3,680	$2,516	6	16	22	863	642	4.3	2.9
Aug-14	1,760	$1,810	0	0	0	0	0	0	0
Sep-14	320	$1,287	0	0	0	0	0	0	0
Oct-14	320	$1,284	0	0	0	0	0	0	0
Nov-14	320	$1,282	0	0	0	0	0	0	0
Dec-14	320	$1,281	0	0	0	0	0	0	0
Totals/Avg	**175,040**	**$74,698**	**2,246**	**809**	**3,056**	**115,727**	**633**	**2.6**	**1.2**

Observations and Proposed Recommendations

The proposed energy saving improvements for this station is similar to the recommendations for the Olaa Well 1 A & B Pump Station.

- As shown in Table 4.5, both pumps are being operated together. This is most likely a tank setpoint issue, which can be corrected at minimal cost. The annual savings for operating one booster pump instead of two will be approximately $6,658. This adjustment is reviewed as part of ESM #2.

This booster station will have minimal energy use in the future with flow coming down from the Olaa #6 Deep Well.

4.1.3 Olaa #3 Well and Booster Pump Station

Olaa #3 Well and the two booster pumps (A & B) at the station are on the same electric account and are billed on HELCO Rate Schedule J. The well is equipped with a 300 hp motor and is rated to pump 1400 gpm @ 610’ TDH. The two booster pumps are rated for 500 @ 340’ TDH and are equipped with 60 hp motors. Energy use data is shown in Table 4.6.

Table 4.6: Olaa #3 Well & Booster 2014 Energy Use and Cost

Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill	Power Factor	Rider M Discount	Net Bill	Net Cost/ kWh
1/15/14	99,400	279	303	$3,102	$24,654	$8,229	$35,985	-$28	$1,774	$34,212	$0.34
2/13/14	36,400	279	302	$3,098	$9,028	$1,912	$14,038	$12	$1,769	$12,269	$0.34
3/14/14	17,400	56	209	$2,145	$4,316	$1,823	$8,284	$13	$10	$8,274	$0.48
4/14/14	17,600	93	210	$2,149	$4,365	$1,747	$8,261	$20	$4	$8,257	$0.47
5/14/14	18,400	92	209	$2,145	$4,564	$1,528	$8,237	$20	$341	$7,897	$0.43
6/13/14	88,000	278	303	$3,102	$21,827	$7,435	$32,363	-$50	$1,770	$30,593	$0.35
7/15/14	89,800	322	324	$3,321	$22,273	$8,348	$33,942	-$51	$1,752	$32,190	$0.36
8/13/14	43,600	277	323	$3,313	$10,814	$3,278	$17,405	-$28	$1,801	$15,605	$0.36
9/15/14	49,800	260	293	$2,999	$12,352	$5,351	$20,702	-$46	$216	$20,486	$0.41
10/16/14	50,000	261	293	$3,007	$12,402	$4,932	$20,341	-$46	$217	$20,124	$0.40
11/13/14	42,600	275	300	$3,073	$10,566	$4,127	$17,766	-$41	$1	$17,766	$0.42
12/12/14	47,600	278	300	$3,074	$11,806	$4,071	$18,951	-$45	$2	$18,949	$0.40
Totals/Avg	**600,600**	**229**	**281**	**$34,528**	**$148,969**	**$52,780**	**$236,277**	**-$270**	**$9,655**	**$226,622**	**$0.40**

The DWS realized a $9,655 credit in 2014 by having this station on the Rider M Rate Schedule. A summary of 2014 well pump hours and flow is shown in Table 4.7.

Table 4.7: Olaa #3 Well Booster 2014 Hours & Pumpage

Month	Monthly Energy Use (kWh)	Monthly Net Bill	Total Well Hours	Total Pumpage (kgal)	Average GPM	kWh/ kgal	Cost/ kgal
Jan-14	99,400	$34,212	222	15,274	1,149	6.5	2.2
Feb-14	36,400	$12,269	0	0			
Mar-14	17,400	$8,274	0	0			
Apr-14	17,600	$8,257	0	0			
May-14	18,400	$7,897	206	13,956	1,128	1.3	0.6
Jun-14	88,000	$30,593	310	20,824	1,119	4.2	1.5
Jul-14	89,800	$32,190	209	13,878	1,107	6.5	2.3
Aug-14	43,600	$15,605	181	11,649	1,070	3.7	1.3
Sep-14	49,800	$20,486	204	13,862	1,130	3.6	1.5
Oct-14	50,000	$20,124	208	13,724	1,100	3.6	1.5
Nov-14	42,600	$17,766	192	12,583	1,094	3.4	1.4
Dec-14	47,600	$18,949	0	0			
Totals/Avg	**600,600**	**$226,622**	**1,732**	**115,750**	**1,112**	**4.1**	**1.5**

A summary of 2014 booster pump hours and flow data is shown in Table 4.8.

Table 4.8: Olaa #3 Well Booster 2014 Hours & Pumpage

Month	Bstr A Hrs	Bstr B Hrs	Total	Bstr A Pumpage	Bstr B Pumpage	Bstr Pumpage	Average GPM
Jan-14	0	457	457	0	16,150	16,150	590
Feb-14	0	284	284	2,739	9,997	12,736	748
Mar-14	0	342	342	277	12,023	12,300	600
Apr-14	0	364	364	15	12,845	12,860	589
May-14	206	440	646	67	15,529	15,596	402
Jun-14	310	386	696	12	13,656	13,668	327
Jul-14	209	222	431	144	7,858	8,002	309
Aug-14	181	29	211	71	1,025	1,096	87
Sep-14	204	2	206	57	55	112	9
Oct-14	208	2	210	1,082	69	1,151	91
Nov-14	192	19	211	880	660	1,540	122
Dec-14	0	0	0	0	0	0	0
Totals/Avg	**1,510**	**2,547**	**4,058**	**5,344**	**89,867**	**95,211**	**3,874**

Well Pump Testing

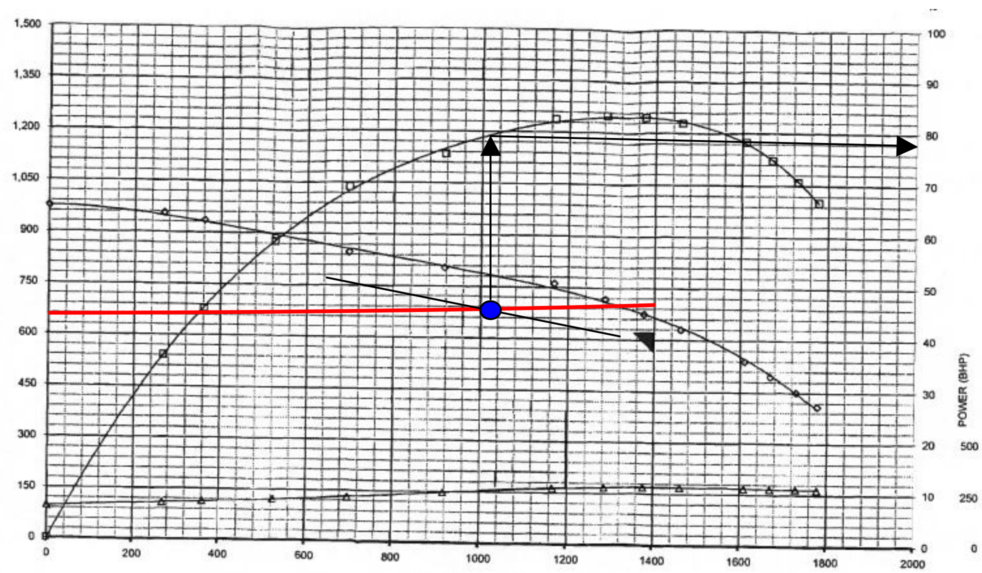
To evaluate existing pump performance, we collected instantaneous flow using the existing well flow meter. Power was measured with a Fluke 43B kW meter, and discharge pressure was determined using a Fluke PV-350 pressure transducer.

Table 4.9: Olaa #3 Well Test Data

Pump Measurements / Calculations	Data
Total Flow (gpm)	1145
Discharge Pressure (psi)	8.2
Baseline Ground Elevation (ft)	600
Tank Water Level Elevation (ft)	624
Well Depth to Baseline (ft)	625
Static Head (ft)	649
Gauge Height from Baseline (ft)	3
Estimated Column/Velocity Losses (ft) 1ft/100ft	6.25
Estimated Total Head (ft): P * 2.31 + well depth + losses)	653
Total Measured Power (kW)	230
Estimated Motor Efficiency (%)	89%
Calculated Pump Efficiency	**69%**
Original Pump Efficiency at Flowrate	**79%**

The original well pump curve shown in Figure 4.1 was used to compare the tested operating point with the original value at 1400 gpm.

Figure 4.1: Olaa #3 Well Pump Curve



Observations and Proposed Recommendations

Based on our review of the energy billing data and the flow/pump hours, we have the following recommendations:

- The DWS did not get the full Rider M discount in September/October/November 2014 even though the measured demand was approximately 260 kW. The DWS may have operated the pumps in the 5-9 PM curtailment window or it could have been when a transformer replacement was being done. This is an example of possible lost savings because of the current Energy Management Analyst position vacancy. The Energy Analyst had previously worked closely with HELCO on these issues.

- The pump efficiency is approximately 10% lower than the original efficiency (at the tested flow rate of 1145 gpm). Although there could be pump wear, the efficiency loss is not great enough to justify pulling the pump with the probability that only a portion of the loss could be gained with pump improvements.

- The average power factor for the station in 2014 was 0.86. With the value being slightly higher than the 0.85 required value by HELCO, a $270 annual credit was provided. This credit could be increased by another $1284 annually if capacitors are added to bring the power factor up to 0.95. This improvement is included in ESM #1.

Even with the Olaa #6 Well operating the majority of the time, the DWS is expected to still operate this well on a regular basis.

4.1.4 Olaa #4 Booster Pump Station

The Olaa #4 Booster Pump Station is billed on HELCO Rate Schedule J. Booster A is rated for 375 gpm @ 325 TDH and has a 40 hp motor. Booster C is rated for 325 gpm @ 350 TDH and has a 30 hp motor. Booster D is rated for 325 gpm @ 318 TDH and has a 40 hp motor. Energy use data is shown below.

Table 4.10: Olaa #4 Booster 2014 Energy Use Data and Costs

Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill	Net Cost/ kWh
1/16/14	14,040	64	64	$662	$3,482	$1,462	$5,607	$0.40
2/14/14	13,760	65	65	$664	$3,413	$1,432	$5,509	$0.40
3/17/14	13,280	64	65	$662	$3,294	$1,380	$5,336	$0.40
4/15/14	11,640	54	60	$611	$2,887	$1,161	$4,659	$0.40
5/15/14	13,080	66	66	$672	$3,244	$1,335	$5,252	$0.40
6/16/14	14,280	66	66	$672	$3,542	$1,565	$5,779	$0.40
7/16/14	12,280	65	65	$670	$3,046	$1,447	$5,163	$0.42
8/14/14	1,840	65	66	$672	$456	$277	$1,406	$0.76
9/16/14	2,080	66	66	$672	$516	$295	$1,483	$0.71
10/16/14	440	1	66	$736	$0	$0	$736	$1.67
11/14/14	480	23	66	$736	$0	$0	$736	$1.53
11/14/14	480	23	66	$736	$0	$0	$736	$1.53
Totals/Avg	**97,680**	**52**	**65**	**$8,169**	**$23,881**	**$10,354**	**$42,404**	**$0.75**

A summary of 2014 pump hours and flow data from the DWS Pumpage Report is shown in Table 4.11.

Table 4.11: Olaa #4 Booster 2014 Pumpage and Hours

Month	Monthly Energy Use (kWh)	Monthly Net Bill	Bstr A Hours	Bstr C Hours	Bstr D Hours	Total Hours	Bstr A Pumpage	Bstr C Pumpage	Bstr D Pumpage	Total Pumpage (kgal)	Average GPM	kWh/ kgal	Cost/ kgal
Jan-14	14,040	$5,607	47	316	208	570	656	4,200	5,015	9,871	288	1.4	0.6
Feb-14	13,760	$5,509	18	273	167	458	255	3,656	4,039	7,950	290	1.7	0.7
Mar-14	13,280	$5,336	30	279	168	476	411	3,734	4,064	8,209	287	1.6	0.7
Apr-14	11,640	$4,659	0	315	151	466	1	4,233	3,668	7,903	282	1.5	0.6
May-14	13,080	$5,252	31	328	187	546	477	4,395	4,539	9,411	287	1.4	0.6
Jun-14	14,280	$5,779	60	283	193	536	818	3,797	4,678	9,293	289	1.5	0.6
Jul-14	12,280	$5,163	0	90	74	164	933	1,200	1,802	3,935	400	3.1	1.3
Aug-14	1,840	$1,406	0	0	0	0	--	--	--	--	--	--	--
Sep-14	2,080	$1,483	0	0	0	0	--	--	--	--	--	--	--
Oct-14	440	$736	0	0	0	0	--	--	--	--	--	--	--
Nov-14	480	$736	0	0	0	0	--	--	--	--	--	--	--
Dec-14	480	$736	0	0	0	0	--	--	--	--	--	--	--
Totals/Avg	**97,680**	**$42,404**	**186**	**1,883**	**1,147**	**3,216**	**3,551**	**25,215**	**27,805**	**56,570**	**304**	**1.8**	**0.7**

Pump Testing

We were able to test all the pumps during the site visit. Instantaneous flow was determined using the existing flow meters, power was measured with a Fluke 43B kW meter, and discharge pressure was determined using a Fluke PV-350 pressure transducer. The data collected is summarized in Table 4.12.

Table 4.12: Olaa #4 Booster Test Data

Pump Measurements / Calculations	Bstr A	Bstr C	Bstr D
Total Flow (gpm)	254	231	419
Discharge Pressure (psi)	132	130	127
Suction Pressure	4.5	4.5	4.5
Estimated Total Head (ft)	295	290	283
Total Measured Power (kW)	32.8	21.9	31.9
Estimated Motor Efficiency (%)	93%	92%	93%
Calculated Pump Efficiency	**46%**	**63%**	**75%**
Original Pump Efficiency at Flowrate	N/A	N/A	N/A

Observations and Proposed Recommendations

- The test data shows that Booster A Pump efficiency is lower than the other two pumps. It looks like the DWS staff has realized this and runs the pump less often than Booster C and D. Although we were not able to get the original pump efficiency data, we would expect 75% to be typical for this size pump.

- DWS staff believes that tank setpoints could be adjusted to prevent two pumps from operating at the same time. If this can be corrected (without having any two pump occurrences), annual demand savings of $5,094 could be realized. This improvement is included in ESM #2.

4.1.5 Olaa #5 Booster Pump Station

The Olaa #5 Booster Pump Station is billed on Rate Schedule J. Booster A is rated for 250 gpm @ 313 TDH and has a 30 hp motor. Booster B is rated for 250 gpm @ 313 TDH and has a 30 hp motor. Booster D is rated for 225 gpm @ 310 TDH and has a 25 hp motor. Energy use data from the electric bills is shown in Table 4.13.

Table 4.13: Olaa #5 Booster 2014 Energy Use and Costs

Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill	Net Cost/ kWh
1/16/14	10,100	29	43	$436	$2,505	$1,070	$4,011	$0.40
2/14/14	10,100	29	43	$437	$2,505	$1,068	$4,010	$0.40
3/17/14	9,700	29	43	$437	$2,406	$1,025	$3,868	$0.40
4/15/14	8,900	29	43	$437	$2,207	$903	$3,547	$0.40
5/15/14	9,400	29	43	$437	$2,332	$978	$3,746	$0.40
6/16/14	10,400	29	43	$437	$2,580	$1,157	$4,173	$0.40
7/16/14	9,200	56	56	$576	$2,282	$1,100	$3,958	$0.43
8/14/14	1,500	33	45	$458	$372	$238	$1,068	$0.71
9/16/14	1,600	33	45	$458	$397	$242	$1,097	$0.69
10/16/14	700	1	56	$638	$0	$0	$638	$0.91
11/14/14	700	16	36	$371	$174	$131	$676	$0.97
12/15/14	700	1	56	$638	$0	$11	$649	$0.93
Totals/Avg	**73,000**	**26**	**46**	**$5,758**	**$17,759**	**$7,923**	**$31,440**	**$0.59**

A summary of 2014 pump hours and flow data is shown below.

Table 4.14: Olaa #5 Booster 2014 Run Time & Pumpage

Month	Monthly Energy Use (kWh)	Monthly Net Bill	Bstr A Hours	Bstr B Hours	Total Hours	Bstr A Pumpage	Bstr B Pumpage	Total Pumpage (kgal)	Average GPM	kWh/ kgal	Cost/ kgal
Jan-14	10,100	$4,011	113	258	371	2,637	6,002	8,639	388	1.2	0.5
Feb-14	10,100	$4,010	195	116	311	4,553	2,687	7,240	388	1.4	0.6
Mar-14	9,700	$3,868	168	152	321	3,937	3,520	7,457	388	1.3	0.5
Apr-14	8,900	$3,547	219	79	299	5,134	1,834	6,968	389	1.3	0.5
May-14	9,400	$3,746	0	366	366	0	8,465	8,465	385	1.1	0.4
Jun-14	10,400	$4,173	353	2	355	8,157	45	8,202	385	1.3	0.5
Jul-14	9,200	$3,958	63	88	150	1,461	2,022	3,483	387	2.6	1.1
Aug-14	1,500	$1,068	0	0	0	3	3				
Sep-14	1,600	$1,097	0	0	0	0	0				
Oct-14	700	$638	0	0	0	3	0				
Nov-14	700	$676	0	0	0	0	0				
Dec-14	700	$649	0	0	0	0	0				
Totals/Avg	**73,000**	**$31,440**	**1,111**	**1,062**	**2,172**	**25,885**	**24,578**	**50,454**	**387**	**1.5**	**0.6**

<u>Pump Testing</u>

Only one pump was available for testing during the site visit. The remaining two boosters had maintenance issues. The data collected is summarized in Table 4.15.

Table 4.15: Olaa #5 Booster Test Data

Pump Measurements / Calculations	Bstr A
Total Flow (gpm)	400
Discharge Pressure (psi)	124
Suction Pressure	3
Estimated Total Head (ft)	280
Total Measured Power (kW)	27
Estimated Motor Efficiency (%)	93%
Calculated Pump Efficiency	**84%**
Original Pump Efficiency at Flowrate	**N/A**

<u>Observations and Proposed Recommendations</u>

With the Olaa #6 Well on line, this station will have much lower operating hours in the future. Our only recommendation is to adjust the pump activation setpoints to insure that two booster pumps are not operated together to prevent a high demand charge. Savings for this measure is reviewed in ESM #2.

4.1.6 Olaa #6 Well & Booster Pump Station

The Olaa #6 Pump Station Account includes the new deep well, three booster pumps (A, B & C) and the two Pacific Paradise Booster pumps. The pump station is billed on HELCO Rate Schedule P. The well is equipped with a 600 hp motor and is rated to pump 1400 gpm @ 1550' TDH. The three booster pumps are rated for 225 gpm and are equipped with a 30 hp motors and the Pacific Paradise motors are rated for 200 gpm and have 20 hp motors. Energy use data from the electric bills is shown in Table 4.16.

Table 4.16: Olaa #6 Well & Booster 2014 Energy Use and Costs

Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill	Power Factor	Rider M Discount	Net Bill	Net Cost/ kWh
--	--	--	--	--	--	--	$0	$0	$0	$0	--
--	--	--	--	--	--	--	$0	$0	$0	$0	--
--	--	--	--	--	--	--	$0	$0	$0	$0	--
--	--	--	--	--	--	--	$0	$0	$0	$0	--
5/15/14	5,100	513	513	$4,999	$1,113	$756	$6,868	$0	$0	$6,868	$1.35
6/16/14	9,900	40	513	$10,398	$0	$0	$10,398	$0	$0	$10,398	$1.05
7/16/14	11,100	521	521	$10,150	$2,422	$1,677	$14,248	$0	$0	$14,248	$1.28
8/14/14	10,800	521	521	$10,150	$2,356	$1,681	$14,188	$0	$0	$14,188	$1.31
9/16/14	177,600	541	541	$10,548	$38,749	$19,662	$68,959	$0	$0	$68,959	$0.39
10/16/14	102,600	555	555	$10,823	$22,386	$10,669	$43,877	$0	$0	$43,877	$0.43
11/14/14	89,400	541	548	$10,686	$19,506	$8,786	$38,978	$0	$0	$38,978	$0.44
12/15/14	100,500	541	548	$10,688	$21,927	$8,847	$41,463	$0	$0	$41,463	$0.41
Totals/Avg	**507,000**	**471**	**532**	**$78,440**	**$108,459**	**$52,078**	**$238,977**	**$0**	**$0**	**$238,977**	**$0.83**

A summary of 2014 pump hours and flow data is shown in Table 4.17.

Table 4.17: Olaa #6 Well 2014 Hours and Flow

Month	Monthly Energy Use (kWh)	Monthly Net Bill	Total Well Hours	Total Pumpage (kgal)	Average GPM	kWh/ kgal	Cost/ kgal
Jan-14		$0	0	0			
Feb-14		$0	0	0			
Mar-14		$0	0	0			
Apr-14		$0	0	0			
May-14	5,100	$6,868	0	0			
Jun-14	9,900	$10,398	0	0			
Jul-14	11,100	$14,248	0	5,360			
Aug-14	10,800	$14,188	184	15,275	1,385	0.7	0.9
Sep-14	177,600	$68,959	188	15,693	1,395	11.3	4.4
Oct-14	102,600	$43,877	171	13,418	1,308	7.6	3.3
Nov-14	89,400	$38,978	170	12,632	1,237	7.1	3.1
Dec-14	100,500	$41,463	170	12,632	1,238	8.0	3.3
Totals/Avg	**507,000**	**$238,977**	**883**	**75,010**	**1,313**	**6.9**	**3.0**

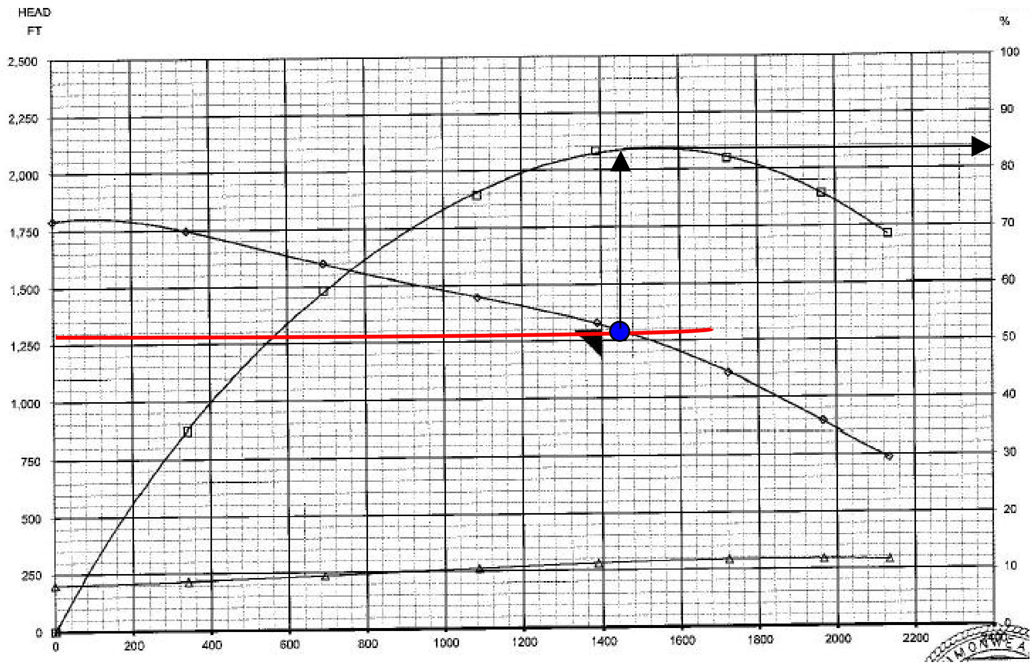
Well Pump Testing

To evaluate existing pump performance, we collected instantaneous flow using the existing well flow meter. Power was estimated using the meter displayed voltage (4133V), amperage (85 amps) and power factor (0.84). Discharge pressure was determined using a Fluke PV-350 pressure transducer. As expected for the new pump, the calculated pump efficiency was the same as the curve value.

Table 4.18: Olaa #6 Well Test Data

Pump Measurements / Calculations	Data
Total Flow (gpm)	1452
Discharge Pressure (psi)	5.8
Baseline Ground Elevation (ft)	*1379*
Tank Water Level Elevation (ft)	*1399*
Well Depth to Baseline (ft)	*1400*
Static Head (ft)	1385
Gauge Height from Baseline (ft)	3
Estimated Column/Velocity Losses (ft) 1ft/100ft	14
Estimated Total Head (ft): P * 2.31 + well depth + losses)	1430
Total Measured Power (kW)	511
Estimated Motor Efficiency (%)	91%
Calculated Pump Efficiency	**84%**
Original Pump Efficiency at Flowrate	**84%**

Figure 4.2: Olaa #6 Well Pump Curve



A summary of 2014 booster pump hours and flow data from the DWS Pumpage Report is shown below.

Table 4.19: Olaa #6 Booster 2014 Hours and Pumpage

Month	Bstr A Hours	Bstr B Hours	Bstr C Hours	Total Hours	Bstr A Pumpage	Bstr B Pumpage	Bstr C Pumpage	Total Pumpage (kgal)	Average GPM
Jan-14	124	96	0	220	1,744	1,339	0	3,083	234
Feb-14	80	185	0	265	1,153	2,619	0	3,772	237
Mar-14	88	94	0	182	1,264	1,338	0	2,602	238
Apr-14	77	134	0	211	1,109	1,908	0	3,017	238
May-14	194	0	0	194	2,771	0	0	2,771	239
Jun-14	0	81	0	81	0	2,574	0	2,574	530
Jul-14	0	220	0	221	7	3,131	0	3,138	237
Aug-14	179	82	0	261	2,557	1,156	0	3,713	237
Sep-14	128	118	0	246	1,828	1,667	0	3,495	237
Oct-14	145	112	0	256	2,068	1,577	0	3,645	237
Nov-14	150	93	0	243	2,146	1,313	0	3,459	237
Dec-14	0	0	0	0	0	0	0	0	
Totals/Avg	**1,166**	**1,214**	**0**	**2,380**	**16,647**	**18,622**	**0**	**35,269**	**264**

Table 4.20: Olaa #6 Pacific Paradise 2014 Pumpage and Hours

Month	Bstr A Hours	Bstr B Hours	Total Hours	Bstr A Pumpage	Bstr B Pumpage	Total Pumpage (kgal)	Average GPM
Jan-14	137	72	209	1,913	999	2,912	232
Feb-14	137	41	178	1,906	571	2,477	232
Mar-14	4	181	185	56	2,525	2,581	233
Apr-14	173	0	173	2,403	0	2,403	232
May-14	205	6	211	2,860	86	2,946	232
Jun-14	3	194	197	36	2,700	2,736	232
Jul-14	1	203	204	16	2,822	2,838	232
Aug-14	194	71	265	2,701	984	3,685	232
Sep-14	111	106	217	1,536	1,471	3,007	231
Oct-14	137	86	223	1,889	1,174	3,063	229
Nov-14	123	75	198	1,695	1,039	2,734	230
Dec-14	--	--	--	--	--	--	--
Totals/Avg	**1,166**	**1,034**	**2,259**	**17,011**	**14,371**	**31,382**	**232**

Observations and Proposed Recommendations

Based on our review of the energy billing data and the flow/pump hours, we have the following recommendations:

- Using the Olaa #6 Well operating hours in 2014, the station could qualify for the Rider M option. The key issue would be to split the time between Olaa #3 and Olaa #6 each month, which would require staff time. Since Olaa #6 Well is on the Rate Schedule P, this effort should be first priority with annual savings of $89,681 for a 4-hour curtailment. This is reviewed in ESM #4.

- The average power factor for the station in 2014 is assumed to be 0.85 (not shown on data input files) since there was no power factor penalty. The DWS could receive a credit of $3,408 if power factor was increased to 0.95. This is reviewed in ESM #1.

4.1.7 Olaa #7 Booster Pump Station

The Olaa #7 Booster Pump Station is billed on Rate Schedule J. Booster A & B are rated for 150 gpm @ 432 TDH and have 15 hp motors. Energy use data from the electric bills is shown in Table 4.21.

Table 4.21: Olaa #7 Booster Pump 2014 Energy Use and Cost

Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill	Power Factor
1/16/14	5,051	18.9	25.0	$256.25	$1,252.81	$566.97	$2,076.03	$0
2/14/14	4,730	19.1	25.0	$256.25	$1,173.20	$534.20	$1,963.65	$0
3/17/14	4,695	19.1	25.0	$256.25	$1,164.51	$529.18	$1,949.94	$0
4/15/14	4,374	19.0	25.0	$256.25	$1,084.90	$476.39	$1,817.54	$0
5/15/14	4,628	19.0	25.0	$256.25	$1,147.90	$513.78	$1,917.93	$0
6/16/14	4,988	19.0	25.0	$256.25	$1,237.19	$588.34	$2,081.78	$0
7/16/14	4,652	19.1	25.0	$256.25	$1,153.85	$587.83	$1,997.93	$0
8/14/14	4,497	19.1	25.0	$256.25	$1,115.40	$584.52	$1,956.17	$0
9/16/14	5,344	20.4	25.0	$256.25	$1,325.49	$657.52	$2,239.26	$0
10/16/14	4,933	19.0	25.0	$256.25	$1,223.55	$569.82	$2,049.62	$0
11/14/14	4,571	19.2	25.0	$256.25	$1,133.76	$503.52	$1,893.53	$0
12/15/14	4,947	18.9	25.0	$256.25	$1,227.02	$489.44	$1,972.71	$0
Totals/Avg	**57,410**	**19**	**25**	**$3,075**	**$14,240**	**$6,602**	**$23,916**	**$0**

A summary of 2014 booster pump hours and flow data from the DWS Pumpage Report is shown below.

Table 4.22: Olaa #7 Booster Pump Hours and Pumpage

Month	Monthly Energy Use (kWh)	Monthly Net Bill	Bstr A Hours	Bstr B Hours	Total Hours	Bstr A Pumpage	Bstr B Pumpage	Total Pumpage (kgal)	Average GPM
Jan-14	0	$0	95	169	264	0	1,589	1,589	100
Feb-14	0	$0	0	210	210	0	1,111	1,111	88
Mar-14	0	$0	208	22	230	0	155	155	11
Apr-14	0	$0	0	213	213	0	1,513	1,513	118
May-14	0	$0	243	0	243	0			
Jun-14	0	$0	1	255	256	0	1,812	1,812	118
Jul-14	0	$0	178	54	232	0	378	378	27
Aug-14	0	$0	117	104	221	0	744	744	56
Sep-14	0	$0	0	229	229	0	1,635	1,635	119
Oct-14	0	$0	111	148	260	0	0	0	
Nov-14	0	$0	113	107	220	0	0	0	
Dec-14	0	$0	0	0	0	0	0	0	
Totals/Avg	**0**	**$0**	**1,065**	**1,511**	**2,576**	**0**	**8,936**	**8,936**	**80**

We have no recommendations for this small booster station.

4.2 Kalapana System

The Kalapana System is located in the Puna District and extends from the Keauohana Forest Reserve along Highway 13 down to the Kaimu Beach intersection and continues in a southwesterly direction along Highway 13, ending near the Queen's Bath. The system includes two Keauohana (Kalapana) Deep Wells and the Kalapana #1 and #2 Storage Tanks. A summary of Keauohana Deep Well 2014 energy use data is shown in Table 4.23.

Table 4.23: Keauohana 2014 Energy Use and Costs

Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill	Rider M Discount	Net Bill	Net Cost/ kWh
1/13/14	10,560	138.9	140.4	$1,439	$2,619	$74	$4,132	$1,056	$3,076	$0.29
2/11/14	8,640	139.8	140.8	$1,443	$2,143	-$149	$3,437	$1,062	$2,375	$0.27
3/12/14	10,560	139.2	140.5	$1,440	$2,619	$68	$4,127	$1,058	$3,069	$0.29
4/10/14	9,280	140.2	141.0	$1,445	$2,302	-$127	$3,620	$1,065	$2,555	$0.28
5/12/14	10,880	141.8	141.8	$1,453	$2,699	$481	$4,633	$633	$4,000	$0.37
6/11/14	11,200	140.8	141.3	$1,448	$2,778	$156	$4,382	$1,070	$3,312	$0.30
7/11/14	10,880	139.5	140.7	$1,442	$2,699	$221	$4,362	$1,060	$3,302	$0.30
8/11/14	8,000	140.5	141.2	$1,447	$1,984	$483	$3,915	$505	$3,410	$0.43
9/11/14	8,640	140.2	141.0	$1,445	$2,143	-$28	$3,560	$1,065	$2,495	$0.29
10/11/14	8,960	140.2	141.0	$1,445	$2,222	-$75	$3,592	$1,065	$2,527	$0.28
11/10/14	7,360	140.5	141.2	$1,447	$1,826	-$286	$2,987	$1,068	$1,919	$0.26
12/10/14	10,560	142.4	142.4	$1,460	$2,619	-$101	$3,978	$1,083	$2,895	$0.27
Totals/Avg	**115,520**	**140.3**	**141.1**	**$17,356**	**$28,653**	**$717**	**$46,726**	**$11,791**	**$34,935**	**$0.30**

A summary of 2014 pump hours and flow data from the DWS Pumpage Report is shown in Table 4.24.

Table 4.24: Keauohana 2014 Pumpage and Hours

Month	Monthly Energy Use (kWh)	Monthly Net Bill	Well #1 Hours	Well #2 Hours	Total Well Hours	Well #1 Pumpage	Well #2 Pumpage	Total Pumpage (kgal)	Average GPM	kWh/ kgal	Cost/ kgal
Jan-14	10,560	$3,076	114	39	153	831	647	1478	161	7.1	2.1
Feb-14	8,640	$2,375	136	20	156	912	322	1234	132	7.0	1.9
Mar-14	10,560	$3,069	151	15	166	993	248	1241	125	8.5	2.5
Apr-14	9,280	$2,555	120	35	156	756	569	1325	142	7.0	1.9
May-14	10,880	$4,000	103	65	167	636	1086	1722	172	6.3	2.3
Jun-14	11,200	$3,312	112	54	166	672	900	1572	158	7.1	2.1
Jul-14	10,880	$3,302	104	44	147	623	712	1335	151	8.1	2.5
Aug-14	8,000	$3,410	46	45	91	501	748	1249	228	6.4	2.7
Sep-14	8,640	$2,495	77	56	133	863	909	1772	222	4.9	1.4
Oct-14	8,960	$2,527	47	55	102	532	910	1442	235	6.2	1.8
Nov-14	7,360	$1,919	88	63	151	948	1065	2013	222	3.7	1.0
Dec-14	10,560	$2,895	0	0	0	0	0	0	--	--	--
Totals/Avg	**115,520**	**$34,935**	**1097**	**491**	**1589**	**8267**	**8116**	**16383**	**--**	**--**	**--**

Pump Testing

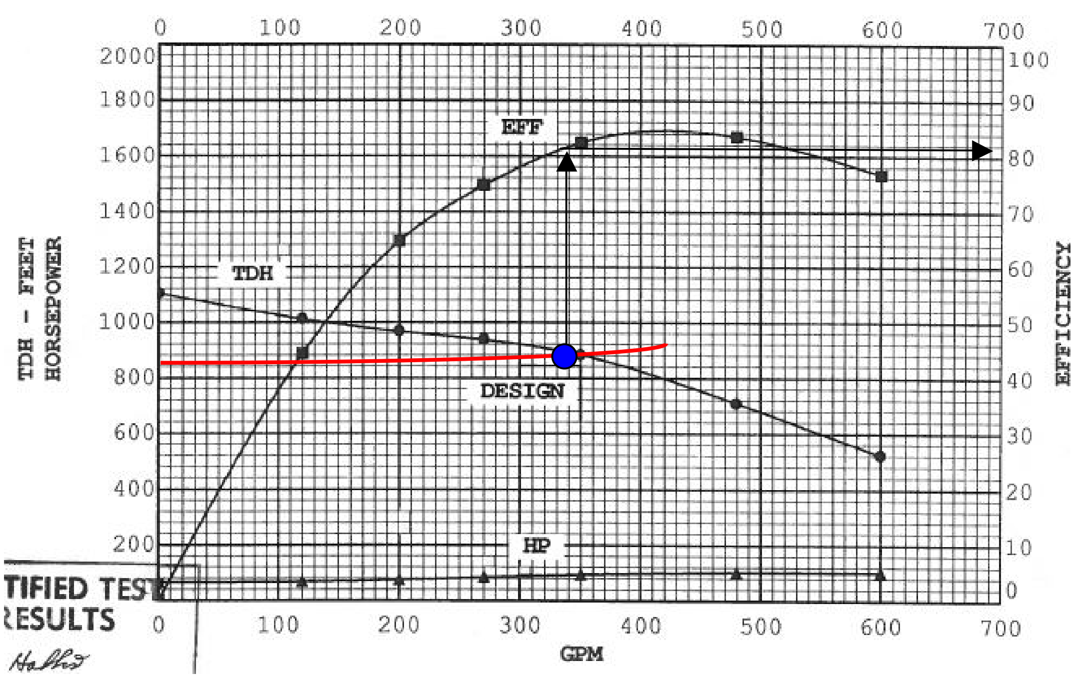
To evaluate existing pump performance, we collected instantaneous flow data using the existing well flow meters Power was measured with a Fluke 43B kW meter, and discharge pressure was determined using a Fluke PV-350 pressure transducer. The data collected is summarized in Table 4.25.

Table 4.25: Keauohana Well #1 and #2 Field Measurements

Pump Measurements / Calculations	Well #1	Well #2
Total Flow (gpm)	193	337
Discharge Pressure (psi)	17.7	19.4
Baseline Ground Elevation (ft)	755	753
Tank Water Level Elevation (ft)	842	842
Well Depth to Baseline (ft)	782	782
Static Head (ft)	869	871
Gauge Height from Baseline	2	2
Estimated Column/Velocity Losses (ft) 1ft/100ft	7.8	7.8
Estimated Total Head (ft): P * 2.31 + well depth + losses)	833	837
Total Measured Power (kW)	55.6	80.7
Estimated 100 hp Motor Efficiency (%)	89%	93%
Calculated Pump Efficiency	**61%**	**71%**
Original Pump Efficiency at Flowrate	**80% (est)**	**80%**

Based on the field data, both pumps are operating at an efficiency that is approximately 10% less than if the pumps were in new condition.

Figure 4.3: Keaohana #2 Pump Curve



Observations and Proposed Recommendations

- As shown above, the DWS realized an $11,791 credit in 2014 by having this station on the Rider M Rate Schedule. For two months last year the DWS did not get the full discount due to the County using water for dust control and for construction of temporary roads to address the lava flow.

- The 140 kW demand that occurs consistently each month appears to be for operating both wells together which does not appear to be necessary with the low water demand. As discussed, DWS staff feels that lava flow issues could have caused this high water use. We recommend verifying that operating two pumps in parallel is not due to tank controls. Savings for this change would be $10,468 (if the smaller well is used first) and is included in ESM #2.

DWS staff indicated that Well #1 (smaller well) is used during the day and Well #2 (submersible) is used during the evening hours to avoid noise complaints from the nearby residents.

4.3 Kapoho System

The Kapoho water system provides water to farm lots in the service area. Two privately owned subdivisions are adjacent to DWS's Kapoho water system. This water system serves Zone 1000 with elevations ranging from 13 to 357 feet. Kapoho receives all of its water from DWS's Pahoa system through a series of PRVs. There is one interconnection with the Pahoa water system, which supplies all of Kapoho's water demands.

4.4 Pahoa System

The Pahoa water system is located in the lower Puna area and extends from Keonepoko Homesteads down along portions of the Kapoho and Pohoiki Roads to Kapoho. Elevations in this water system are between 350 feet and 830 feet. The Pahoa system is supplied by the Pahoa and Keonepoko-Nui wells and has one booster pump station and four water storage tanks.

The Pahoa system is connected to the Olaa-Mt. View water system to provide a back-up water supply. According to DWS staff this has never been used and would only be required if five system wells were down. There is a system connection between the Pahoa and the Kapoho water system, which allows one-way flow from Pahoa to Kapoho.

The system is typically supplied with the Nui Wells with flow boosted with the Nui Booster Pumps. In 2014, the Pahoa Wells were used in November and December when the Nui Wells were down for maintenance and due to lava flow issues.

4.4.1 Pahoa Well

The Pahoa Wells are billed on Rate Schedule J. Well A is rated to pump 200 gpm @ 860' TDH and has a 60 hp motor, and Well B is rated to pump 350 gpm @ 855' TDH and has a 125 hp motor. A summary of 2014 energy use data for the Pahoa is shown below in Table 4.26.

Table 4.26: Pahoa Well 2014 Energy Use and Costs

Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill	Rider M Discount	Net Bill	Net Cost/ kWh
1/13/14	200	0.0	0.0	$256	$50	$84	$390	$0	$390	$1.95
2/11/14	400	40.0	40.0	$410	$99	$103	$613	$0	$613	$1.53
3/12/14	9,000	92.0	92.0	$943	$2,232	$969	$4,144	$0	$4,144	$0.46
4/10/14	16,200	116.0	116.0	$1,189	$4,018	$1,591	$6,798	$0	$6,798	$0.42
5/12/14	200	0.0	116.0	$1,189	$50	$83	$1,322	$0	$1,322	$6.61
6/11/14	400	0.0	116.0	$1,189	$99	$106	$1,394	$0	$1,394	$3.48
7/11/14	200	0.0	116.0	$1,189	$50	$86	$1,325	$0	$1,325	$6.62
8/11/14	200	0.0	116.0	$1,189	$50	$87	$1,326	$0	$1,326	$6.63
9/11/14	400	0.0	116.0	$1,189	$99	$109	$1,397	$0	$1,397	$3.49
10/11/14	1,400	88.0	102.0	$1,046	$347	$209	$1,601	$0	$1,601	$1.14
11/10/14	19,400	88.0	102.0	$1,046	$4,812	$1,958	$7,815	$0	$7,815	$0.40
12/10/14	38,800	88.0	102.0	$1,046	$9,624	$3,414	$14,084	$0	$14,084	$0.36
Totals/Avg	**86,800**	**42.7**	**94.5**	**$11,880**	**$21,529**	**$8,799**	**$42,208**	**$0**	**$42,208**	**$2.76**

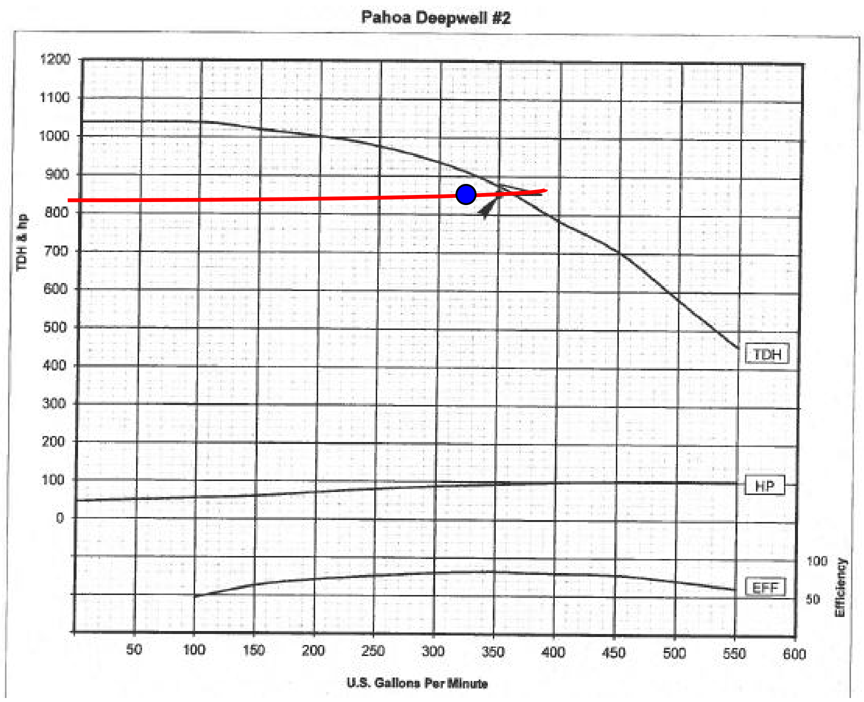
A summary of 2014 pump hours and flow data from the DWS Pumpage Report is shown below.

Table 4.27: Pahoa Well 2014 Pumpage and Hours

Month	Monthly Energy Use (kWh)	Monthly Net Bill	Well #1 Hours	Well #2 Hours	Total Well Hours	Well #1 Pumpage	Well #2 Pumpage	Total Pumpage (kgal)	Average GPM	kWh/ kgal	Cost/ kgal
Jan-14	200	$390	0	0	0	0	0	0	0	0.0	0.0
Feb-14	400	$613	0	25	25	0	486	486	324	0.8	1.3
Mar-14	9,000	$4,144	0	243	243	0	5,051	5,051	347	1.8	0.8
Apr-14	16,200	$6,798	0	0	0	0	0	0	0	0.0	0.0
May-14	200	$1,322	0	0	0	0	0	0	0	0.0	0.0
Jun-14	400	$1,394	0	0	0	0	0	0	0	0.0	0.0
Jul-14	200	$1,325	0	0	0	0	0	0	0	0.0	0.0
Aug-14	200	$1,326	0	0	0	0	0	0	0	0.0	0.0
Sep-14	400	$1,397	0	0	0	0	0	0	0	0.0	0.0
Oct-14	1,400	$1,601	0	94	94	0	1,396	1,396	246	1.0	1.1
Nov-14	19,400	$7,815	0	446	446	0	9,503	9,503	355	2.0	0.8
Dec-14	38,800	$14,084	0	0	0	0	0	0			
Totals/Avg	**86,800**	**$42,208**	**0**	**808**	**808**	**0**	**16,436**	**16,436**			

With the low hours in 2014, these wells did not justify testing. However, using the rated head and average flow of 318 gpm from the pumpage/runtime data, the pump appears to be operating slightly under its design point of 350 gpm as shown on the pump curve below.

Figure 4.4: Pahoa Well #2 Pump Curve



Observations and Proposed Recommendations

The infrequent use of the pumps (with the exception of December) has resulted in high-billed demand costs even when the pumps are not operated. Although we did not perform testing on these pumps (hours low in 2014), based on previous pump data, if Well #1 were used instead of Well #2, the billed demand would have only been 55 kW resulting in approximately $4,059 in annual savings. This adjustment is reviewed in OM #5.

4.4.1 Keonepoko Nui Well & Booster

The Keonepoko Wells and Boosters are billed on Rate Schedule J. Well A is rated to pump 700 gpm @ 671’ TDH and has a 200 hp motor, and Well B is rated to pump 700 gpm @ 640’ TDH and also has a 200 hp motor. Booster Pump A is rated for 350 @ 260’ TDH and Booster B is rated for 400 gpm @ 300’ TDH Both pumps are equipped with 30 hp motors. A summary of 2014 energy use data is shown in Table 4.28.

Table 4.28: Keonepoko Nui Well & Booster 2014 Energy Use and Costs

Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill	Power Factor Penalty	Rider M Discount	Net Bill	Net Cost/ kWh
1/10/14	55,200	189	250	$2,558	$13,691	$5,762	$22,012	$81	$0	$22,012	$0.40
2/10/14	60,000	189	250	$2,559	$14,882	$6,011	$23,453	$87	$0	$23,453	$0.39
3/11/14	53,600	190	250	$2,561	$13,295	$5,505	$21,361	$32	$0	$21,361	$0.40
4/9/14	38,200	236	273	$2,798	$9,475	$3,713	$15,986	$49	$0	$15,986	$0.42
5/9/14	64,400	284	297	$3,046	$15,973	$6,365	$25,384	$114	$0	$25,384	$0.39
6/10/14	78,600	190	250	$2,564	$19,495	$8,308	$30,367	$132	$0	$30,367	$0.39
7/10/14	72,400	190	250	$2,564	$17,958	$8,440	$28,961	$287	$0	$28,961	$0.40
8/11/14	77,200	190	250	$2,564	$19,148	$9,279	$30,991	$304	$0	$30,991	$0.40
9/10/14	69,600	310	310	$3,180	$17,263	$7,880	$28,323	-$41	$0	$28,323	$0.41
10/9/14	62,000	286	298	$3,055	$15,378	$6,610	$25,043	$129	$0	$25,043	$0.40
11/8/14	37,200	217	263	$2,700	$9,227	$3,785	$15,712	$72	$0	$15,712	$0.42
12/9/14	11,200	190	250	$2,563	$2,778	$1,081	$6,421	$37	$0	$6,421	$0.57
Totals/Avg	**679,600**	**222**	**266**	**$32,711**	**$168,563**	**$72,739**	**$274,013**	**$1,284**	**$0**	**$274,013**	**$0.42**

A summary of 2014 pump hours and flow data is shown below in Table 4.29.

Table 4.29: Keonepoko Nui Well & Booster 2014 Pumpage and Hours

Month	Monthly Energy Use (kWh)	Monthly Net Bill	Well #1 Hours	Well #2 Hours	Bstr #1 Hours	Bstr #2 Hours	Well #1 Pumpage	Well #2 Pumpage	Total Pumpage (kgal)	Average Well GPM	kWh/ kgal	Cost/ kgal
Jan-14	55,200	$22,012	186	150	149	412	8,710	6,244	14,954	741	3.7	1.5
Feb-14	60,000	$23,453	83	236	565	59	3,891	9,802	13,693	715	4.4	1.7
Mar-14	53,600	$21,361	72	116	201	131	3,377	4,803	8,180	722	6.6	2.6
Apr-14	38,200	$15,986	101	245	266	331	4,718	10,228	14,946	720	2.6	1.1
May-14	64,400	$25,384	262	146	79	591	12,289	6,099	18,388	751	3.5	1.4
Jun-14	78,600	$30,367	279	137	36	620	13,083	5,722	18,805	754	4.2	1.6
Jul-14	72,400	$28,961	215	185	459	157	10,087	7,734	17,821	742	4.1	1.6
Aug-14	77,200	$30,991	247	199	283	368	11,604	8,311	19,915	744	3.9	1.6
Sep-14	69,600	$28,323	189	154	173	410	8,854	6,434	15,288	743	4.6	1.9
Oct-14	62,000	$25,043	79	204	129	327	3,678	8,474	12,152	717	5.1	2.1
Nov-14	37,200	$15,712	19	23	19	41	876	949	1,825	722	20.4	8.6
Dec-14	11,200	$6,421	0	0	0	0	0	0	0	--	--	--
Totals/Avg	**679,600**	**$274,013**	**1732**	**1796**	**2358**	**3446**	**81,167**	**74,800**	**155,967**	**--**	**--**	**--**

Well & Booster Pump Testing

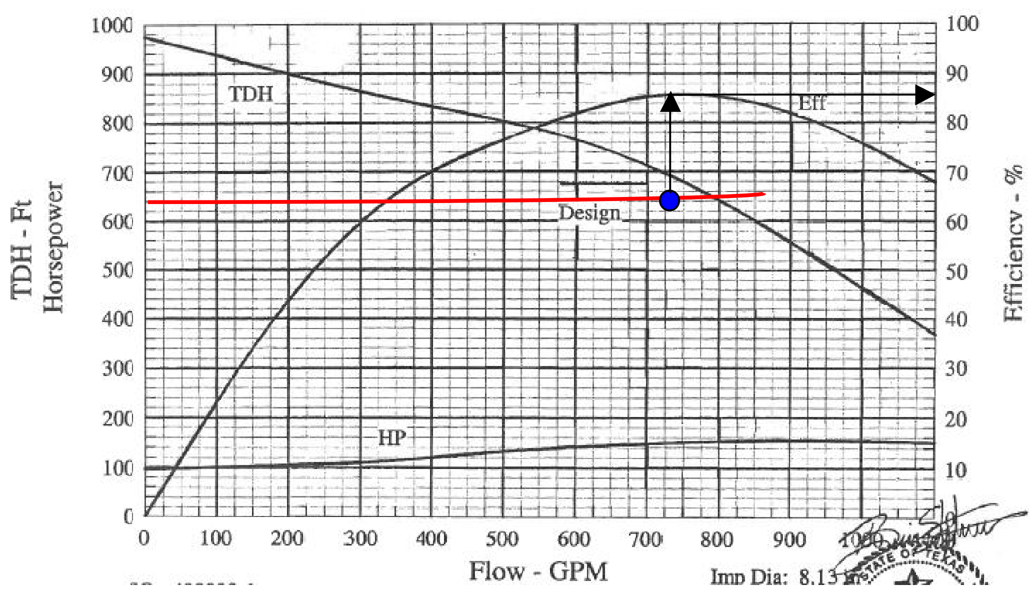
To evaluate existing pump performance, we collected flow using the existing well flow meter. Power was measured using a portable Fluke 43B meter, and discharge pressure with a Fluke PV-350 pressure transducer. The results are summarized in Table 4.30.

Table 4.30: Keonepoko Nui Well & Booster Test Data

Pump Measurements / Calculations	Well #1	Well #2	Bstr #1	Bstr #2
Total Flow (gpm)	833	732	*450*	*450*
Discharge Pressure (psi)	5.1	5.2	74	74
Baseline Ground Elevation (ft)	605	605	605	605
Tank Water Level Elevation (ft)	620.4	620.4	840.4	840.4
Well Depth or Suction Tank to Baseline (ft)	613	613	620.4	620.4
Static Head (ft)	628.4	628.4	220	220
Gauge Height from Baseline (ft)	2	2	2	2
Estimated Column/Velocity Losses (ft) 1ft/100ft	6.13	6.13	2	2
Estimated Total Head (ft): P * 2.31 + well depth + losses)	633	633	160	160
Total Measured Power (kW)	127.6	119.1	24.7	33.9
Estimated Motor Efficiency (%)	93%	93%	90%	90%
Calculated Pump Efficiency	**84%**	**79%**	**47%**	**39%**
Original Pump Efficiency at Flowrate	***85%***	**85%**	--	--

Well #2 pump efficiency was compared to the curve value at the same flow, and Well #1 was estimated to be similar (no curve was available). The pump efficiency values for both booster pumps appear to be low but without working flow meters on either pump, this is based on an estimated flow.

Figure 4.5: Keonepoko Well B Pump Curve



Observations and Proposed Recommendations

- Based on power measurements taken during field testing, the peak demand reached in 4 months during the year in Table 4.28 appears to be due to operating two wells and a booster pump together (128 kW + 121 kW + ~30 kW for one of the booster pumps). With 2014 average well capacity of 730 gpm, there should be more than enough flow to avoid having two pumps operating in parallel. This could have been caused by operating the wells manually for testing or tank setpoints that are set too close which would not allow one pump to catch up with demand. If this can be avoided, over $14,999 in annual demand savings would be realized. This adjustment is reviewed in ESM #2

- The average power factor for the station was 0.79. This low value resulted in power factor penalty charges of $1,284 for the year. This penalty could be avoided and additional credit could be applied to the bill by installing power factor correction capacitors. The economics for this project is reviewed as part of ESM #1.

- We have not recommended booster pump upgrades at this time since the flow data was estimated. Once the flow meters are fixed, we recommend re-evaluating the pumps to determine the savings for improvements.

SECTION 5. SOUTH HILO

5.1 Hilo System

The Hilo water system extends as far as Honolii Cove to the north, Panaewa Agricultural Park approximately six miles south, just east of Richardson Ocean Park, and Kaumana to the west. The water system serves Hilo and the communities of Kaiwiki, Wainaku, Puueo, Kaumana, Keaukaha, Panaewa, and Waiakea Uka. The water is supplied with eight wells and eleven booster pump stations. There are also 27 tanks used for storage between pressure zones. There is an intertie between the Hilo system and the Paukaa-Papaikou water system**.** This connection is normally closed; if opened water could flow either way, depending on water pressure in either system.

A summary of 2013 and 2014 energy use and costs for the system electric accounts is shown in Table 5.1.

Table 5.1: Hilo Electric Accounts

Service Account	2013 kWh	2013 Cost	2014 kWh	2014 Cost
Panaewa Deep Well and Boosters	2,603,200	$930,451	2,620,000	$940,795
Piihonua Reservoir #3 Well A and Bstr A	631,680	$256,777	576,960	$236,459
Piihonua Reservoir #3 Well B and Bstr B	950,400	$342,111	950,720	$347,421
Piihonua Well C	889,600	$333,670	913,000	$337,139
Saddle Rd Well	592,200	$223,423	572,800	$220,336
Camp 6 Boosters	331,360	$128,309	331,040	$129,157
Haihai #1 Boosters	261,920	$105,350	262,720	$105,122
Camp 7 Boosters	58,272	$26,396	60,658	$27,413
Kaiwiki #4 Boosters	17,337	$7,924	17,922	$8,943
Kaiwiki #3 Boosters	21,890	$9,794	22,604	$10,203
Kihalani Boosters	1,870	$1,158	1,857	$1,163
Leilani Microlab	41,600	$18,896	43,520	$19,701
Leilani Hilo Baseyard MS	113,360	$44,489	118,440	$46,674
Leilani Hilo Baseyard AC	1,947	$1,470	3,005	$1,922
Piihonua CP4 Boosters	7,697	$3,880	7,817	$3,953
Haaheo #1 Boosters	57,211	$23,704	53,101	$22,441
Alameda Boosters	3,296	$1,760	3,503	$1,854
Haaheo #2 Boosters	51,299	$21,806	54,748	$23,155
Kaieie Rd/Medeiros Tanks	3,624	$1,892	3,690	$1,937
Haaheo Bstr Pump	9,800	$4,749	9,700	$4,752
Kaieie Bstrs	1,628	$1,056	1,333	$941
Wailea Well (Hakalau School Well)	28,909	$12,746	29,279	$13,037
Saddle Rd Tank	231	$475	225	$473
DWS Office	478,200	$187,957	535,200	$212,515
Delima Tank	60	$403	12	$382
Papaikou Well	112,320	$44,618	115,200	$47,038
Pepeekeo Deep Well	215,840	$83,151	1,600	8,054
Pepeekeo Tank	13,196	$5,881	421	$556
Total	**7,158,591**	**$2,690,646**	**7,193,854**	**$2,717,888**

The pump system high-energy accounts (above $25,000) are reviewed in this section.

5.1.1 Spring/Surface Water Sources

In the past, the Hilo water system was supplied with multiple surface water sources shown in Table 5.2.

Table 5.2: Hilo Spring/Surface Water Sources

Water Source	Status on Drawing	Type	1994 Flow Data (MGD)
Olaa Flume	Line cut	Tunnel	5.0
Lyman Spring	Line cut	Spring	3.0
Kohoama Intake	Line cut	Part of Wailuka Intake (surface)	3.0
Waiakea-Uka	Line cut	Spring (water quality issue in 1990s)	.08

In the 1990s, more stringent federal surface water regulations were adopted as part of the Surface Water Treatment Rule (SWTR). Over time, the DWS made the decision to abandon these surface water sources that would have required water treatment systems and installed more deep wells to satisfy water demands.

The Olaa Flume has been of interest over the years due to its high flow rates. It is our understanding that the water rights are owned by the United Church of Christ and that the DWS previously had a 50-year agreement to use the source if needed. The cost of water established in the agreement was $25/million gallons. In 1999, the County purchased 761.5 million gallons at a cost of $19,037 (last data found).

Based on input from DWS staff, the Church had expressed in interest in renegotiating the stand-by and use charges. There have also been discussions with several private companies that were interested in putting together a design-build-operate water treatment plant and selling the water to the DWS. Recently *Waimea Water Services* was pursuing the installation of piping back to the spring source. DWS staff indicated that they are currently working with the Department of Health to see if they could get the source deemed as not under the direct influence of surface water.

In 2014, the energy cost of pumping water in Hilo was approximately $1.1 million for 1,912 million gallons. Based on the potential of using 80% of the 3 mgd rated capacity of the Olaa Flume, the following energy savings could be realized:

Annual flow: 3.0 MGD * 80% * 365 days = 876 MG
Energy pumping cost: $575/MG
Potential Annual Energy Savings: $503,975 (this figure does not include the energy costs for water treatment)

In addition to energy savings, making use of the available surface water would also improve the reliability of the system and reduce the cost exposure the DWS has to rising energy prices. In EMP #4, we have recommended hiring a consultant to perform a more in depth evaluation of the Hilo surface/spring sources.

5.1.2 Panaewa Wells

The Panaewa Pump Station includes Wells #1, #2, and #3 and Booster Pumps #1 and #2. The pump systems provide flow to the east half of the Hilo water system. Well #1 is rated for 1700 gpm @ 300’ TDH and is equipped with a 150 hp motor. Well #2 is rated to pump 2200 gpm @ 300’ TDH and has a 250 hp motor. Well #3 is rated to pump 2100 gpm @ 320’ TDH and has a 250 hp motor. Booster Pump #1 is rated for 1500 gpm @ 260’ TDH and Booster Pump #2 is rated for 1500 gpm @ 331’ TDH. Both pumps are equipped with 150 hp motors. Energy use data from the electric bills is shown below in Table 5.3.

Table 5.3: Panaewa Pump Station 2014 Energy Use and Costs

Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill	Power Factor Penalty	Rider M Discount	Net Bill
1/28/14	228,000	698	701	$13,666	$49,746	$16,707	$80,119	-$254	$2,814	$77,305
2/26/14	207,200	690	696	$13,580	$45,208	$16,732	$75,519	-$176	$2,817	$72,702
3/27/14	214,400	694	699	$13,627	$46,779	$15,692	$76,098	-$181	$2,586	$73,511
4/28/14	228,800	688	698	$13,619	$49,921	$16,570	$80,109	-$191	$2,817	$77,292
5/28/14	224,800	695	699	$13,634	$49,048	$17,230	$79,912	-$251	$2,595	$77,317
6/26/14	206,400	694	699	$13,627	$45,033	$17,335	$75,995	-$235	$2,814	$73,181
7/28/14	227,200	602	656	$12,792	$49,571	$20,856	$83,219	-$187	$1,746	$81,473
8/27/14	220,000	690	697	$13,588	$48,000	$20,519	$82,107	-$185	$2,817	$79,290
9/26/14	228,000	695	699	$13,634	$49,746	$19,283	$82,663	-$127	$2,634	$80,029
10/28/14	235,200	692	698	$13,603	$51,317	$18,678	$83,598	-$195	$2,598	$81,001
11/25/14	200,000	607	696	$13,580	$43,637	$13,511	$70,728	-$229	$2,814	$67,914
11/25/14	200,000	607	696	$13,580	$43,637	$13,511	$70,728	-$229	$2,814	$67,914
Total/Avg	**2,620,000**	**671**	**695**	**$162,529**	**$571,642**	**$206,625**	**$940,795**	**-$2,438**	**$31,865**	**$908,930**

A summary of 2014 pump hours, flow data and estimated energy use just for the wells is shown below in Tables 5.4. The calculated energy use for the booster pumps is shown in Table 5.5

Table 5.4: Panaewa 2014 Well Hours, Pumpage & Estimated Energy Use

Month	Well #1 Hours	Well #2 Hours	Well #3 Hours	Total Hrs	Well #1 Pumpage (kgal)	Well #2 Pumpage (kgal)	Well #2 Pumpage (kgal)	Total Pumpage (kgal)	Average Well GPM	Calculated Energy Use (kWh)
14-Jan	554	455	125	1,134	53,596	55,218	17,546	126,360	1,857	170,053
14-Feb	612	331	90	1,033	59,450	39,947	12,462	111,859	1,804	148,859
14-Mar	621	381	144	1,146	59,958	45,466	19,971	125,395	1,823	168,755
14-Apr	643	325	74	1,042	62,689	39,108	10,218	112,015	1,791	148,566
14-May	633	147	348	1,128	61,462	17,630	50,036	129,128	1,908	167,373
14-Jun	620	251	174	1,044	60,080	29,571	24,620	114,271	1,825	151,277
14-Jul	706	409	100	1,214	68,600	49,198	13,902	131,700	1,808	175,580
14-Aug	637	344	84	1,065	62,236	41,165	11,818	115,219	1,804	152,917
14-Sep	639	344	146	1,128	62,149	41,151	20,323	123,623	1,826	164,735
14-Oct	707	394	968	2,070	68,765	47,521	13,507	129,793	1,045	335,607
14-Nov	613	337	61	1,011	56,510	41,582	8,467	106,559	1,758	144,487
14-Dec	767	180	334	1,281	74,676	22,073	48,097	144,846	1,885	186,778
Totals/Avg	**7,750**	**3,898**	**2,647**	**14,296**	**750,171**	**469,630**	**250,967**	**1,470,768**	**1,761**	**2,114,987**

Table 5.5: Panaewa 2014 Booster Hours, Pumpage & Estimated Energy Use

Month	Bstr #1 Hours	Bstr #2 Hours	Total Hours	Bstr #1 Pumpage (kgal)	Bstr #2 Pumpage (kgal)	Total Pumpage (kgal)	Average Booster GPM	Calculated Energy Use (kWh)
14-Jan	75	462	537	7,910	46,689	54,599	1,695	51,876
14-Feb	396	48	444	43,154	4,677	47,831	1,794	43,281
14-Mar	226	271	497	24,011	26,910	50,921	1,708	48,176
14-Apr	212	250	463	22,740	24,946	47,686	1,718	44,843
14-May	351	189	540	37,681	17,860	55,541	1,715	52,432
14-Jun	116	371	487	12,238	37,044	49,282	1,687	47,111
14-Jul	331	217	548	35,902	21,678	57,580	1,752	53,203
14-Aug	238	245	483	25,850	24,543	50,393	1,740	46,809
14-Sep	362	157	520	38,953	14,568	53,521	1,716	50,513
14-Oct	339	197	536	36,693	19,422	56,115	1,746	52,034
14-Nov	20	462	482	1,699	46,546	48,245	1,670	46,494
14-Dec	430	147	577	47,021	14,972	61,993	1,790	56,121
Totals/Avg	**3,096**	**3,016**	**6,112**	**333,852**	**299,855**	**633,707**	**1,728**	**592,894**

The energy cost data shows that the DWS received a $31,865 Rider M credit in 2014. The Rider M savings were realized by taking Well #2 and Booster Pump #2 off line during the 4-hour curtailment period. The DWS also received a credit of $2,438 for having a power factor higher than 0.85.

<u>Well Pump Testing</u>

To evaluate existing well performance, we collected instantaneous flow using the existing flow meters. Power was measured with a Fluke 43B kW meter, and discharge pressure was determined using a Fluke PV-350 pressure transducer. The data for the three wells is summarized in Table 5.6.

Table 5.6: Panaewa Well Test Data

Pump Measurements / Calculations	Well 1	Well 2	Well 3
Total Flow (gpm)	1690	2182	2455
Discharge Pressure (psi)	35	39.4	38
Baseline Ground Elevation (ft)	206	202	206
Tank Water Level Elevation (ft)	295	295	295
Well Depth to Baseline (ft)	195	188	188
Static Head (ft)	284	281	277
Gauge Height from Baseline (ft)	3	3	3
Estimated Column/Velocity Losses (ft) 1ft/100ft	1.95	1.88	1.88
Estimated Total Head (ft): P * 2.31 + well depth + losses)	281	284	281
Total Measured Power (kW)	123.6	174.6	187
Estimated Motor Efficiency (%)	95%	95%	95%
Calculated Pump Efficiency	**76%**	**70%**	**73%**
Original Pump Efficiency at Flowrate	**82%**	**83%**	**80%**

The operating point was plotted on the pump curves to determine the original rated efficiency.

Figure 5.1: Panaewa Well 1 Pump Curve

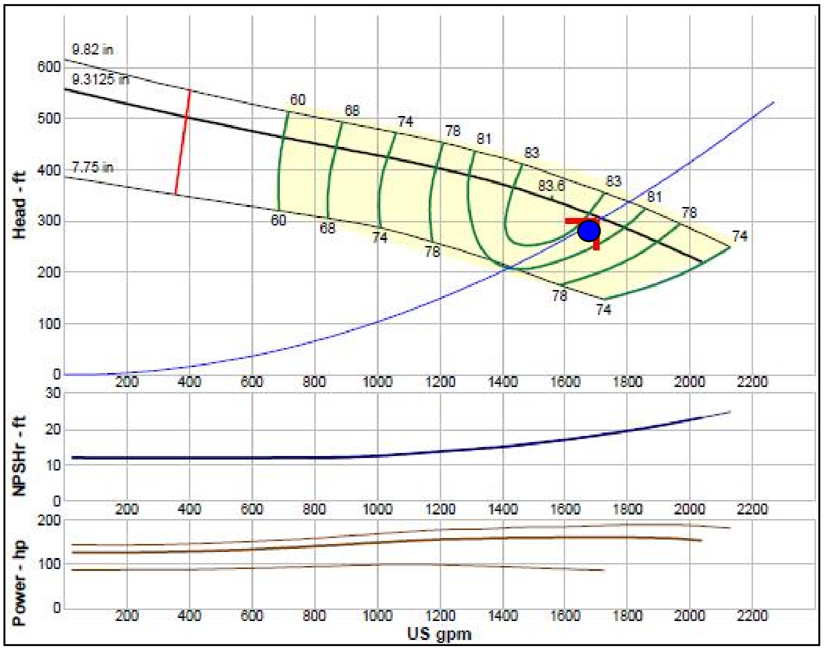


Figure 5.2: Panaewa Well 2 Pump Curve

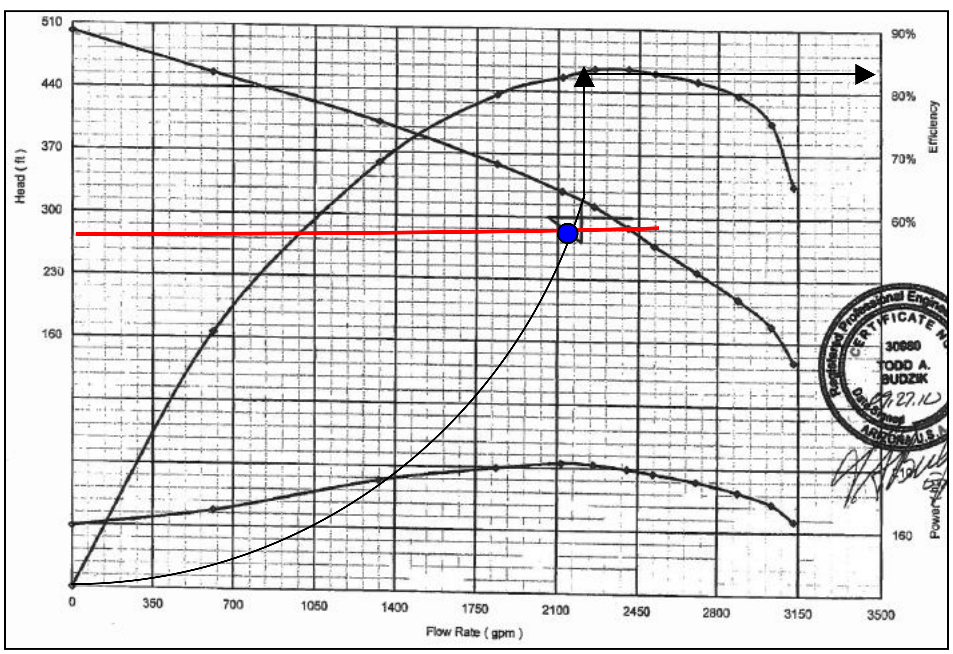
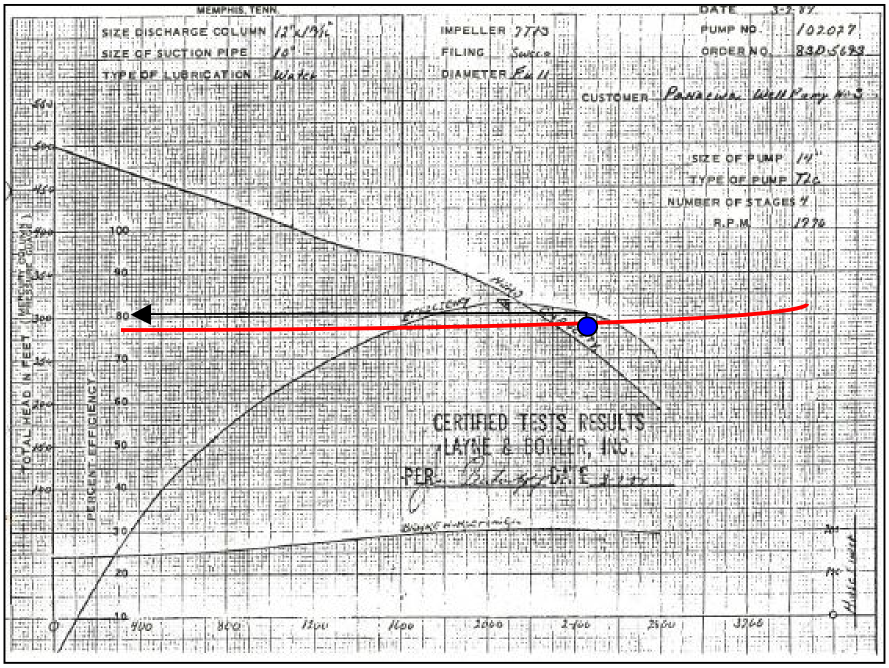


Figure 5.3: Panaewa Well 3 Pump Curve



The operating points on the pump curves for Well #1 and #2 were close to the original operating point. However, Well #3 appears to be operating beyond the head curve limits. This could be a bad flow measurement, incorrect assumption of well depth or an outdated pump curve.

Booster Pump Testing

To evaluate existing booster pump performance, we collected instantaneous flow using the existing flow meters. Power was measured with a Fluke 43B kW meter, and discharge pressure (for one of the pumps) was determined using a Fluke PV-350 pressure transducer. Suction pressure was estimated based on a 295' elevation in the Piihonua #3 Tank (295'- 206'+ 3' gauge level /2.31 = 37 psi) since there were no taps to install suction gauges. The data for the pumps is summarized in Table 5.7.

Table 5.7: Panaewa Booster Pump Test Data

Pump Measurements / Calculations	Bstr 1	Bstr 2
Total Flow (gpm)	1753	1688
Discharge Pressure (psi)	128	128
Suction Pressure (psi)	37	37
Estimated Total Head (ft): P * 2.31 + well depth + losses)	210	210
Total Measured Power (kW)	97.5	96.5
Estimated Motor Efficiency (%)	94%	94%
Calculated Pump Efficiency	**76%**	**74%**
Original Pump Efficiency at Flowrate	**82%**	**82%**

We did not have pump curves for the booster pumps but have estimated the original efficiency to be 82% based on past data.

Observations and Proposed Recommendations

- The average monthly demand at the station was 671 kW. Based on power measurements of two well pumps and one of the booster pumps, total power use would be approximately 397 kW. However, it appears that at least one time each month, all five pumps are activated at the same time (field measurements add up to 680 kW). Based on the storage available and the pump hours, we would expect that two well pumps and one booster pump could be used the majority of the time. This has the potential of reducing monthly demand charges by 274 kW. These savings are included in ESM #2.

- The DWS has benefited from an average power factor of 0.88, which has provided a credit of $2,438 in 2014. If this can be improved to 0.95 by adding additional capacitance, an additional $5,139 in annual saving would be provided. These savings are included in ESM #1.

- All of the pump efficiencies are lower than the original values. Although some data has been estimated as discussed. The potential savings makes it worthwhile to verify the data and develop an improvement plan for the pumps. Annual savings for bringing the pumps up to 80% efficiency (lower than the original ratings) would be approximately $50,200. This project is reviewed as part of ECM #2.

- During our review, we were able to measure the pressure loss across Booster Pump #2 Cla Valve and found the loss to be 10 psi or 23.1'. The DWS has replaced many of the old globe type Cla-Valves with Masoneilan and Pratt ball type valves. Even though this project has been done at several other stations, there are still many pump systems that have not been improved (including Booster Pump #2). The savings for this project is reviewed in ECM #3.

- For Well #1, we measured the pressure loss across a strainer on the pump discharge. These strainer units had been installed at many well sites to protect the old turbine style flow meters. The DWS has been replacing the strainer/flow meter assemblies with new flow meter units at some stations that do not require the strainers. We measured the pressure drop across the Well #1 strainer to be 2.9 psi or 6.7' of head. The new flow meter is already in place, so removing the strainer can be done to reduce head losses. The savings for this improvement is included in ECM #4.

5.1.3 Piihonua #3 Well A/Booster A

The Piihonua #3 Well A/Booster A energy account includes Well A and Booster A. Well B & Booster B are billed on a separate account. The Piihonua wells pump to the Piihonua #3 Tank, and the booster units typically pump flow to the Piihonua #2 Tank. Well #A is rated for 2100 gpm @ 288' TDH and is equipped with a 200 hp motor. Energy use data is shown below in Table 5.8.

Table 5.8: Piihonua #3 Well A/Booster A 2014 Energy Use and Costs

Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill	Power Factor Penalty	Rider M Discount
1/22/14	77,760	311	311	$3,188	$19,287	$7,631	$30,106	-$45	$0
2/20/14	89,280	311	311	$3,188	$22,144	$9,064	$34,396	-$76	$0
3/21/14	41,280	174	242	$2,485	$10,239	$4,037	$16,760	-$38	$0
4/22/14	15,360	174	242	$2,485	$3,810	$1,500	$7,795	-$13	$0
5/21/14	59,520	311	311	$3,188	$14,763	$5,887	$23,838	-$36	$0
6/20/14	58,560	174	242	$2,485	$14,525	$6,269	$23,278	-$51	$0
7/22/14	21,120	174	242	$2,485	$5,238	$2,433	$10,156	-$23	$0
8/21/14	14,400	174	242	$2,485	$3,572	$1,732	$7,788	-$6	$0
9/22/14	52,800	311	311	$3,188	$13,096	$5,766	$22,050	-$33	$0
10/22/14	47,040	311	311	$3,188	$11,667	$4,817	$19,672	-$30	$0
11/20/14	49,920	311	311	$3,188	$12,382	$4,739	$20,309	-$31	$0
11/20/14	49,920	311	311	$3,188	$12,382	$4,739	$20,309	-$31	$0
Total/Avg	**576,960**	**254**	**282**	**$34,737**	**$143,105**	**$58,616**	**$236,459**	**-$412**	**$0**

A summary of 2014 well and booster pump hours and flow data is shown below.

Table 5.9: Piihonua #3 Well A/Booster A 2014 Pump Hours and Pumpage

Month	Monthly Billed Energy Use (kWh)	Well A Hours	Well A Pumpage (kgal)	Average Well GPM	Estimated Well Energy kWh Using Measured kW	Bstr A Hours	Bstr Pumpage (kgal)	Average Booster GPM	Estimated Bstr Energy kWh Using Measured kW
14-Jan	77,760	454	63,152	2,318	76,743	198	15,490	1,306	26,887
14-Feb	89,280	458	63,403	2,310	77,318	0	0		0
14-Mar	41,280	81	11,654	2,404	13,655	0	0		0
14-Apr	15,360	82	11,928	2,424	13,858	0	0		0
14-May	59,520	391	54,435	2,321	66,062	173	13,609	1,310	23,555
14-Jun	58,560	200	25,529	2,127	33,800	0	0		0
14-Jul	21,120	71	10,291	2,429	11,931	0	0		0
14-Aug	14,400	93	13,387	2,404	15,683	40	313		5,399
14-Sep	52,800	91	13,281	2,427	15,413	297	23,521	1,322	40,338
14-Oct	47,040	103	14,970	2,432	17,339	235	18,535	1,313	32,001
14-Nov	49,920	100	14,400	2,400	16,900	230	17,940	1,300	31,280
14-Dec	49,920	100	14,400	2,400	16,900	230	17,940	1,300	31,280
Totals/Avg	**576,960**	**2,223**	**310,830**	**2,331**	**375,603**	**1,403**	**107,348**	**1,276**	**190,740**

This station is not on the Rider M rate since it is used to maintain flow when Piihonua #3 Well B/Booster B is turned off during the four hour Rider M curtailment period. The DWS did receive an account credit of $2,438 for having a power factor higher than 0.85.

Well Pump Testing

To evaluate existing well performance, we collected instantaneous flow using the existing flow meter. Power was measured with a Fluke 43B kW meter, and discharge pressure was determined using a Fluke PV-350 pressure transducer.

Table 5.10: Well A Test Data

Pump Measurements / Calculations	Data
Total Flow (gpm)	2300
Discharge Pressure (psi)	8.6
Baseline Ground Elevation (ft)	280
Tank Water Level Elevation (ft)	300
Well Depth to Baseline (ft)	283
Static Head (ft)	303
Gauge Height from Baseline (ft)	2
Estimated Column/Velocity Losses (ft) 1ft/100ft	2.83
Estimated Total Head (ft): P * 2.31 + well depth + losses)	308
Total Measured Power (kW)	169
Estimated Motor Efficiency (%)	94%
Calculated Pump Efficiency	**84%**
Original Pump Efficiency at Flowrate	**84%**

Booster Pump test data is shown below.

Table 5.11: Booster Pump A Test Data

Pump Measurements / Calculations	Data
Total Flow (gpm)	1312
Discharge Pressure (psi)	168
Suction Pressure (psi)	6
Estimated Total Head (ft): P * 2.31 + well depth + losses)	374
Total Measured Power (kW)	136
Estimated Motor Efficiency (%)	94%
Calculated Pump Efficiency	**72%**
Original Pump Efficiency at Flowrate	**82%**

We did not have pump curve data but estimated the original efficiency to be 84% for the well and 82% for the booster pump based on old specification data.

Observations and Proposed Recommendations

- This pump station is unusual since there are two electric accounts for two sets of pumps (Well B and Booster B is discussed in the next section). Based on the pump hours, DWS staff operates one well or one booster at a time, which has allowed Well B/Booster B to be on Rider M to realize $28,000 in annual savings.

- The DWS has benefited from an average power factor of 0.87, which has provided a credit of $412 in 2014. If this can be improved to 0.95 by adding additional capacitance, an additional $1,423 in annual saving would be provided. These savings are included in ESM #1.

- The well pump efficiency was excellent. The booster pump efficiency was lower, but with the low operating hours it was not a high priority project.

- For Well A, the old style strainer/flow meter equipment is used. The DWS has been replacing the strainer/flow meter assemblies with new flow meter units at some stations that do not require the strainers. The savings for this improvement is included in ECM #4.

The above recommendations are cost effective improvements that can be pursued immediately. An additional measure that will require more investigation is to combine the Well A/Booster A electric account with the Well B/Booster B account. This improvement would require electrical system changes and discussions with HELCO to evaluate the most cost effective approach. The change would increase the demand high enough to qualify for Rate Schedule P, which would reduce overall cost/kWh even though demand charges will be higher. Rider M could also still be applied as it is now for Well B/Booster B. This proposed improvement is included as FEM #3

5.1.4 Piihonua #3 Well B/Booster B

The Piihonua #3 Well B energy account includes Well B and Booster B. The well pumps to the Piihonua #3 Tank, and the booster unit typically pumps to the Piihonua #2 Tank. Well #B is rated for 2100 gpm @ 320' TDH and is equipped with a 250 hp motor. Energy use data from the electric bills is shown below.

Table 5.12: Piihonua #3 Well B/Booster B 2014 Energy Use and Costs

Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill	Power Factor Penalty	Rider M Discount
1/22/14	57,920	325	326	$3,337	$14,366	$3,235	$20,938	-$18	$2,481
2/20/14	33,920	151	325	$3,334	$8,413	$1,011	$12,759	-$24	$2,478
3/21/14	77,120	325	326	$3,343	$19,128	$5,029	$27,500	-$45	$2,484
4/22/14	115,840	325	326	$3,346	$28,732	$8,468	$40,546	-$32	$4,290
5/21/14	63,040	325	326	$3,346	$15,636	$3,764	$22,746	-$19	$2,486
6/20/14	63,680	325	326	$3,343	$15,795	$4,474	$23,611	-$38	$2,355
7/22/14	115,840	325	326	$3,343	$28,732	$11,002	$43,077	-$32	$2,153
8/21/14	109,440	325	326	$3,339	$27,145	$10,798	$41,282	-$30	$1,956
9/22/14	86,080	325	326	$3,340	$21,351	$7,473	$32,164	-$25	$1,916
10/22/14	82,560	325	326	$3,340	$20,478	$6,924	$30,742	-$24	$1,511
11/20/14	72,640	325	326	$3,343	$18,017	$4,669	$26,028	$0	$2,244
11/20/14	72,640	325	326	$3,343	$18,017	$4,669	$26,028	$0	$2,244
Total/Avg	**950,720**	**311**	**326**	**$40,096**	**$235,810**	**$71,515**	**$347,421**	**-$287**	**$28,597**

A summary of 2014 well and booster pump hours and flow data is shown below in Table 5.13.

Table 5.13: Piihonua #3 Well B/Booster B Hours and Pumpage

Month	Monthly Billed Energy Use (kWh)	Well B Hours	Well B Pumpage (kgal)	Average Well GPM	Estimated Well Energy kWh Using Measured kW	Bstr B Hours	Bstr B Pumpage (kgal)	Average Booster GPM	Estimated Bstr Energy kWh Using Measured kW
14-Jan	57,920	76	10,210	2,236	13,241	98	8,278	1,405	14,534
14-Feb	33,920	5	693	2,139	940	251	21,230	1,408	37,192
14-Mar	77,120	355	49,500	2,323	61,787	255	21,522	1,405	37,784
14-Apr	115,840	407	56,962	2,330	70,888	264	22,253	1,403	39,116
14-May	63,040	149	20,916	2,333	25,996	125	10,486	1,397	18,515
14-Jun	63,680	367	51,363	2,334	63,823	293	24,601	1,399	43,379
14-Jul	115,840	379	53,050	2,330	66,016	240	20,171	1,401	35,520
14-Aug	109,440	382	52,843	2,306	66,468	217	18,060	1,385	32,175
14-Sep	86,080	397	55,759	2,339	69,130	0	0	--	--
14-Oct	82,560	441	61,608	2,328	76,751	82	6,874	1,392	12,180
14-Nov	72,640	400	55,200	2,300	69,600	80	6,672	1,390	11,840
14-Dec	72,640	400	55,200	2,300	69,600	80	6,672	1,390	11,840
Totals/Avg	**950,720**	**3,760**	**523,304**	**2,300**	**654,240**	**1,987**	**166,819**	**1,398**	**294,076**

This station is on the Rider M rate, which resulted in an annual credit for the DWS of $28,596 in 2014. A credit of $287 was also received for having a power factor higher than 0.85.

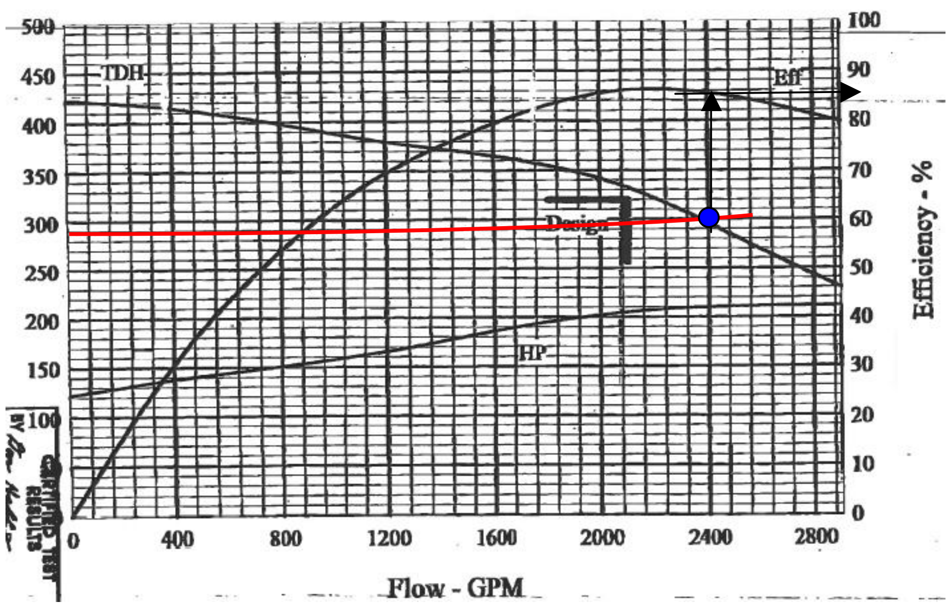
Pump Testing

To evaluate existing pump performance, we collected instantaneous flow using the existing flow meters. Power was measured with a Fluke 43B kW meter, and discharge pressure was determined using a Fluke PV-350 pressure transducer. The data for Well B is shown below.

Table 5.14: Well B Test Data

Pump Measurements / Calculations	Data
Total Flow (gpm)	2400
Discharge Pressure (psi)	8.6
Baseline Ground Elevation (ft)	280
Tank Water Level Elevation (ft)	300
Well Depth to Baseline (ft)	278
Static Head (ft)	298
Gauge Height from Baseline (ft)	2
Estimated Column/Velocity Losses (ft) 1ft/100ft	2.78
Estimated Total Head (ft): P * 2.31 + well depth + losses)	303
Total Measured Power (kW)	174.5
Estimated Motor Efficiency (%)	94%
Calculated Pump Efficiency	**83%**
Original Pump Efficiency at Flowrate	**84%**

Figure 5.4: Piihonua #3 Well B Pump Curve



Booster Pump B test data is shown below.

Table 5.15: Booster B Test Data

Pump Measurements / Calculations	Bstr B Data
Total Flow (gpm)	1429
Discharge Pressure (psi)	168
Suction Pressure (psi)	6
Estimated Total Head (ft): P * 2.31 + well depth + losses)	374
Total Measured Power (kW)	148
Estimated Motor Efficiency (%)	94%
Calculated Pump Efficiency	**72%**
Original Pump Efficiency at Flowrate	**82%**

We did not have a pump curve for the booster pump but have estimated the original efficiency to be 82% based on old specification data.

Observations and Proposed Recommendations

- As discussed, Rider M has been applied at this station using the full demand value of both the booster pump and well (325 kW). This saving opportunity has already been fully optimized by the DWS.
- The DWS has benefited from an average power factor of 0.88 (slightly higher than the required 0.85 value), which has provided a credit of $287 in 2014. If this can be improved to 0.95 by increasing the capacitance, an additional $2,483 in annual savings would be provided. These savings are included in ESM #1.
- The well pump efficiency was right on the curve. The booster pump efficiency was lower, but with the low operating hours it was not a high priority project.
- During our review, we were able to measure the pressure loss across Booster Pump B Cla-Valve and found the loss to be 10 psi or 23.1'of head. The DWS has replaced many of the old globe type Cla-Valves with Masoneilan and Pratt ball type valves, which have a pressure drop of less than 2 psi or 4.6' of head. Even though this project has been done at several stations, there are still many pump systems that have not been improved (including Booster Pump #2). The savings for this project is reviewed in ECM #3.

As discussed for Well A/Booster A, an additional measure that will require more investigation is to combine the Well A/Booster A electric account with the Well B/Booster B account. This improvement would require electrical system changes and discussions with HELCO to evaluate the most cost effective approach and has been included as a future energy measure in FEM #3.

5.1.5 Saddle Road Well

The Saddle Road Well serves the Kaumana and upper Kaumana communities. The well pump is rated for 700 gpm @ 1000' TDH and is equipped with a 250 hp motor. Energy use data is shown in Table 5.16.

Table 5.16: Saddle Well 2014 Energy Use and Costs

Billing Date	Monthly Billed Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill	Power Factor $	Rider M Discount	Net Bill
12/23/13	50,000	187	188	$1,928	$12,402	$5,336	$19,665	$0	-$8	$19,673
1/23/14	50,600	188	188	$1,930	$12,550	$4,490	$18,970	$0	$485	$18,485
2/21/14	44,000	188	189	$1,932	$10,913	$4,069	$16,914	$0	$485	$16,429
3/24/14	47,000	188	189	$1,932	$11,658	$4,120	$17,710	$0	$485	$17,224
4/23/14	45,000	187	199	$2,036	$11,161	$3,824	$17,021	$0	$485	$16,536
5/22/14	43,200	187	193	$1,977	$10,715	$3,840	$16,532	$0	$485	$16,047
6/23/14	46,800	187	193	$1,978	$11,608	$4,604	$18,190	$0	$485	$17,704
7/23/14	48,800	187	193	$1,978	$12,104	$5,124	$19,206	$0	$485	$18,721
8/22/14	49,800	187	193	$1,978	$12,352	$5,371	$19,701	$0	$485	$19,216
9/23/14	52,600	187	193	$1,976	$13,047	$5,272	$20,295	$0	$485	$19,809
10/23/14	48,200	187	193	$1,978	$11,955	$4,635	$18,568	$0	$323	$18,244
11/21/14	46,800	187	193	$1,977	$11,608	$3,977	$17,562	$0	$485	$17,071
Totals/Avg	**572,800**	**187**	**192**	**$23,602**	**$142,073**	**$54,661**	**$220,336**	**$0**	**$5,166**	**$215,170**

A summary of 2014 pump hours and flow data is shown below in Table 5.17.

Table 5.17: Saddle Well 2014 Hours and Pumpage

Month	Monthly Billed Energy Use (kWh)	Monthly Net Bill	Total Well Hours	Total Pumpage (kgal)	Average GPM	kWh/ kgal	Cost/ kgal
Jan-14	50,000	$19,673	268	10,224	636	4.9	$1.92
Feb-14	50,600	$18,485	227	8,622	634	5.9	$2.14
Mar-14	44,000	$16,429	251	9,537	632	4.6	$1.72
Apr-14	47,000	$17,224	230	7,484	542	6.3	$2.30
May-14	45,000	$16,536	250	9,180	613	4.9	$1.80
Jun-14	43,200	$16,047	243	8,923	612	4.8	$1.80
Jul-14	46,800	$17,704	300	11,064	615	4.2	$1.60
Aug-14	48,800	$18,721	257	9,452	613	5.2	$1.98
Sep-14	49,800	$19,216	262	9,594	611	5.2	$2.00
Oct-14	52,600	$19,809	285	11,979	701	4.4	$1.65
Nov-14	48,200	$18,244	*257*	*9,252*	*600*	*5.2*	*$1.97*
Dec-14	46,800	$17,071	*250*	*9,000*	*600*	*5.2*	*$1.90*
Totals/Avg	**572,800**	**$215,170**	**3,080**	**114,311**	**617**	**5.1**	**$1.90**

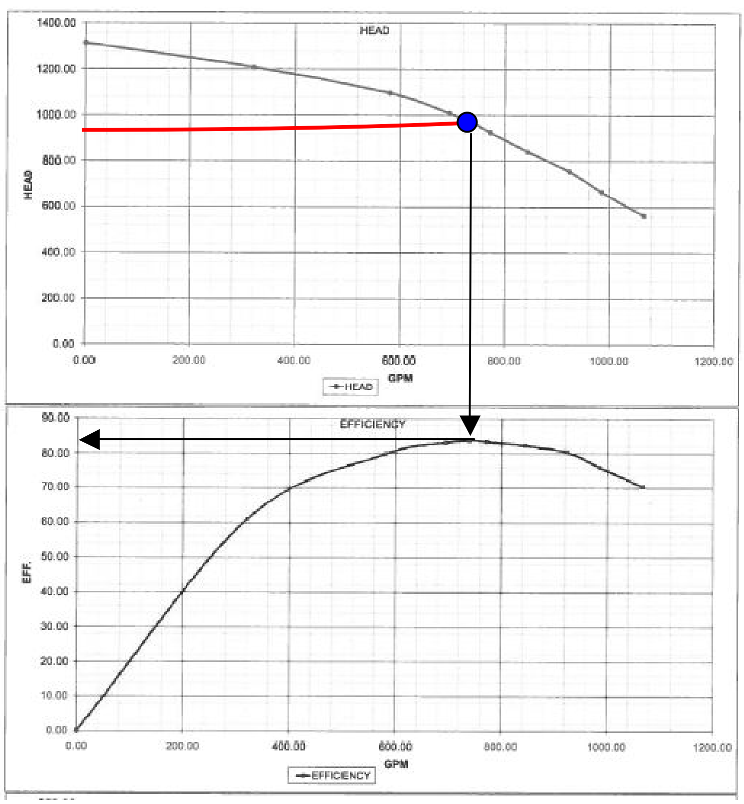
Pump Testing

To evaluate existing well performance, we collected instantaneous flow using the existing flow meter (out of the tank since the well discharge pipe meter was out of service). Power was measured with a Fluke 43B kW meter, and discharge pressure was determined using a Fluke PV-350 pressure transducer. The data for the Saddle Road Well summarized in Table 5.18.

Table 5.18: Saddle Well Test Data

Pump Measurements / Calculations	Data
Total Flow (gpm)	730
Discharge Pressure (psi)	6
Baseline Ground Elevation (ft)	1909
Tank Water Level Elevation (ft)	1924
Well Depth to Baseline (ft)	952
Static Head (ft)	967
Gauge Height from Baseline (ft)	2
Estimated Column/Velocity Losses (ft) 1ft/100ft	9.52
Estimated Total Head (ft): P * 2.31 + well depth + losses)	977
Total Measured Power (kW)	178
Estimated Motor Efficiency (%)	88%
Calculated Pump Efficiency	**86%**
Original Pump Efficiency at Flowrate	**85%**

Figure 5.5: Saddle Rd Pump Curve



Observations and Proposed Recommendations

Based on reviewing the energy billing data and the flow/pump hours, we developed the following cost saving recommendations:

- As discussed a 2-hour Rider M curtailment has been applied at this station and resulted in a credit of $5,166 in 2014. The monthly value is based on 118 kW * .40 * 10.25 = $484/month. We are unsure of why the value is 118 kW instead of the full 178 kW (178 kW measured during the site visit) that occurs when the pump is shut off. If the contract were adjusted to 178 kW, annual savings would increase by $3,592. This adjustment is included in ESM #3.

- The DWS has been able to maintain a 0.85 power factor required by HELCO to avoid a penalty. If this can be improved to 0.95 by adding additional power factor correction capacitors, $1,657 in annual savings would be realized. These savings are included in ESM #1.

- Well efficiency appears to be right on the original curve value. However the flow data collected was based on what was coming out of the tank since the well flow meter was out of service. The flow data should be verified when possible.

5.1.6 Piihonua #1 Well C

The Piihonua #1 Well C energy account is billed on the Rider J Rate Schedule. The well is rated for 2100 gpm @ 800' TDH and is equipped with a 600 hp motor. Energy use data from the electric bills is shown below in Table 5.19.

Table 5.19: Piihonua #1 Well C 2014 Energy Use and Costs

Billing Date	Total kWh	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill	Power Factor Penalty	Rider M Discount	Net Bill
1/22/14	80,600	477	478	$4,897	$19,991	$4,448	$29,337	$174	$3,680	$25,657
2/20/14	70,200	477	478	$4,902	$17,412	$3,671	$25,984	$156	$3,686	$22,298
3/21/14	71,800	477	478	$4,900	$17,809	$3,523	$26,231	$159	$3,677	$22,554
4/22/14	77,400	478	478	$4,901	$19,198	$3,849	$27,947	$169	$3,684	$24,263
5/21/14	74,000	478	478	$4,900	$18,354	$3,828	$27,082	$163	$3,683	$23,399
6/20/14	79,000	478	478	$4,900	$19,595	$4,992	$29,486	$171	$3,683	$25,803
7/22/14	79,400	477	479	$4,910	$19,694	$5,517	$30,120	$148	$3,690	$26,430
8/21/14	78,600	478	478	$4,904	$19,495	$5,670	$30,069	$146	$3,676	$26,393
9/22/14	81,200	477	479	$4,905	$20,140	$5,373	$30,418	$175	$3,686	$26,731
10/22/14	76,400	477	479	$4,908	$18,950	$4,288	$28,146	$143	$3,687	$24,459
11/20/14	72,200	477	478	$4,902	$17,908	$3,350	$26,159	$160	$3,681	$22,478
11/20/14	72,200	477	478	$4,902	$17,908	$3,350	$26,159	$160	$3,681	$22,478
Total/Avg	***913,000***	**477**	**478**	**$58,827**	**$226,454**	**$51,858**	**$337,139**	**$1,924**	**$44,195**	**$292,945**

A summary of 2014 pump hours and flow data is shown below in Table 5.20.

Table 5.20: Piihonua #1 Well C 2014 Hours and Pumpage

Month	Total kWh	Monthly Net Bill	Well Hours	Total Pumpage (kgal)	Average Flow GPM	kWh/ kgal	Cost/ kgal
Jan-14	80,600	$25,657	165	18,445	1863	4.4	$1.39
Feb-14	70,200	$22,298	143	15,745	1839	4.5	$1.42
Mar-14	71,800	$22,554	150	17,107	1900	4.2	$1.32
Apr-14	77,400	$24,263	152	5,779	634	13.4	$4.20
May-14	74,000	$23,399	183	23,976	2180	3.1	$0.98
Jun-14	79,000	$25,803	183	21,974	1998	3.6	$1.17
Jul-14	79,400	$26,430	152	19,089	2100	4.2	$1.38
Aug-14	78,600	$26,393	152	19,114	2100	4.1	$1.38
Sep-14	81,200	$26,731	158	20,666	2180	3.9	$1.29
Oct-14	76,400	$24,459	174	20,621	1977	3.7	$1.19
Nov-14	72,200	$22,478	160	19,200	2000	3.8	$1.17
Dec-14	72,200	$22,478	160	19,200	2000	3.8	$1.17
Totals/Avg	***913,000***	**$292,945**	**1,931**	**220,916**	**1898**	**4.1**	**$1.51**

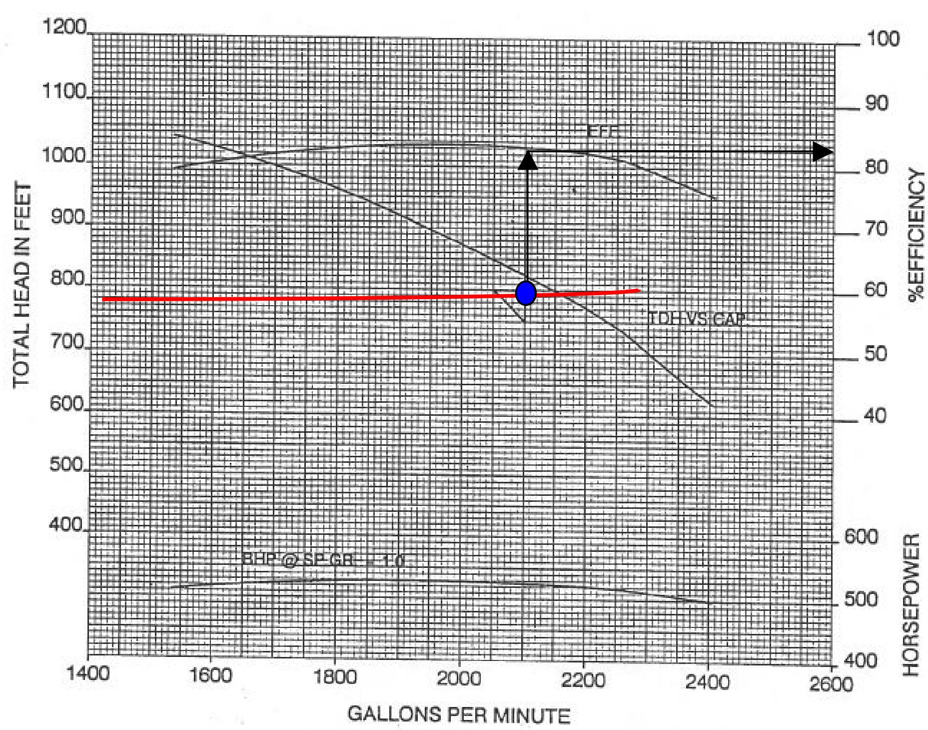
Pump Testing

To evaluate existing well performance, we collected instantaneous flow using the existing meter. Power was measured with a Fluke 43B kW meter, and discharge pressure was estimated based on tank level. The data for Piihonua #1 Well C is summarized below.

Table 5.21: Well C Pump Testing

Pump Measurements / Calculations	Data
Total Flow (gpm)	2095
Discharge Pressure (psi)	7
Baseline Ground Elevation (ft)	977
Tank Water Level Elevation (ft)	994
Well Depth to Baseline (ft)	770
Static Head (ft)	790
Gauge Height from Baseline (ft)	2
Estimated Column/Velocity Losses (ft) 1ft/100ft	7.7
Estimated Total Head (ft): P * 2.31 + well depth + losses)	796
Total Measured Power (kW)	474
Estimated Motor Efficiency (%)	89%
Calculated Pump Efficiency	**74%**
Original Pump Efficiency at Flowrate	**82%**

Figure 5.6: Piihonua #1 Well C Pump Curve



Observations and Proposed Recommendations

Based on reviewing the energy billing data and the flow/pump hours, we recommend the following cost saving measures:

- The 4-hour Rider M curtailment has been applied at this station and resulted in a credit of $44,195 in 2014. The DWS has been able to realize the maximum benefit with this agreement.
- The station average power factor was only 0.78 which has resulted in an extra charge of $1924 in 2014. If power factor can be improved to 0.95 by adding power factor correction capacitors, a $2,853 credit (plus annual savings of $1,924) would be realized. These savings are included in ESM #1.
- Well efficiency appears to be lower than the original curve value. However, we were not able to get original field test data to determine if it ever achieved this efficiency when the unit was installed. Given that the pump operates less than 2000 hours/year we have not recommended pursuing potential efficiency improvements at this time.

Although there may be potential net savings for having this station on Rate Schedule P, the low operating hours would not provide enough kWh savings to overcome the higher demand costs.

5.1.7 Haihai Booster Pump Station

The Haihai Pump Station has three pumps (Nos. 1, 2, and 3). The TDH and capacity of pumps Nos. 1 and 2 are 210 feet and 500 gpm. The TDH and capacity of pump No. 3 is 275 feet and 1,000 gpm. The Haihai pump station pumps from the Haihai Tank up to the Waiakea Uka Camp 6 Tank. 2014 energy usage and costs are shown below.

Table 5.22: Haihai Booster Pump 2014 Energy Use and Cost

Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill
1/29/14	22,880	111	111	$1,135	$5,675	$2,201	$9,011
2/28/14	18,720	85	98	$1,006	$4,643	$1,991	$7,639
3/28/14	19,520	108	109	$1,118	$4,842	$1,876	$7,836
4/29/14	23,200	103	107	$1,096	$5,754	$2,227	$9,077
5/29/14	21,600	102	107	$1,093	$5,358	$2,194	$8,644
6/27/14	21,920	103	95	$1,056	$5,437	$2,439	$8,932
7/29/14	25,920	91	101	$1,032	$6,429	$2,999	$10,460
8/28/14	23,040	94	102	$1,050	$5,715	$2,728	$9,492
9/29/14	23,520	91	101	$1,034	$5,834	$2,531	$9,399
10/29/14	22,080	91	101	$1,034	$5,477	$2,261	$8,772
11/26/14	20,160	91	101	$1,034	$5,000	$1,895	$7,930
11/26/14	20,160	91	101	$1,034	$5,000	$1,895	$7,930
Total/Avg	**262,720**	**97**	**103**	**$12,721**	**$65,163**	**$27,237**	**$105,122**

A summary of 2014 booster pump hours and flow data from the DWS Pumpage Report is shown below.

Table 5.23: Haihai Booster 2014 Hours and Pumpage

Month	Bstr A Hours	Bstr B Hours	Bstr C Hours	Total Hours	Bstr A Pumpage (kgal)	Bstr B Pumpage (kgal)	Bstr C Pumpage (kgal)	Total Pumpage (kgal)	Bstr A Flow (gpm)	Bstr B Flow (gpm)	Bstr c Flow (gpm)
Jan-14	112	171	164	447	0	10,524	11,239	21,763	0	1,024	1,144
Feb-14	4	439	0	443	0	19,187	0	19,187	0	729	
Mar-14	171	122	147	440	0	10,338	9,953	20,291	0	1,410	1,131
Apr-14	105	164	141	410	0	10,181	8,910	19,091	0	1,035	1,052
May-14	239	215	117	570	0	15,610	6,496	22,106	0	1,213	925
Jun-14	0	0	407	407	0	23	23,407	23,430	--	--	958
Jul-14	28	9	317	354	0	1,162	18,199	19,361	0	2,152	956
Aug-14	223	233	88	543	0	16,038	4,977	21,015	0	1,149	948
Sep-14	117	211	152	479	0	12,562	8,495	21,057	0	991	935
Oct-14	122	220	167	508	0	13,178	9,440	22,618	0	1,000	943
Nov-14	227	117	146	490	0	11,742	8,083	19,825	0	1,668	921
Dec-14	2	135	334	471	0	5,920	19,126	25,046	0	731	954
Totals/Avg	**1,347**	**2,036**	**2,179**	**5,562**	**0**	**126,465**	**128,325**	**254,790**	**0**	**1,191**	**988**

* Booster A pumpage may be mislabeled on pumpage report

Pump Testing

To evaluate existing booster performance, we collected flow data using the existing flow meter. Power was measured with a Fluke 43B kW meter, and discharge pressure was measured with a Fluke PV-350 pressure transducer. The data is summarized below.

Table 5.24: Haihai Pump Testing

Pump Measurements / Calculations	A	B	C
Total Flow (gpm)	510	725	959
Discharge Pressure (psi)	88	88	103
Suction Pressure (estimated from tank level)	7	7	7
Estimated Total Head (ft)	187.11	187.11	221.76
Static Head (650-473)	177	177	177
Total Measured Power (kW)	28.1	34.2	59.7
Estimated Motor Efficiency (%)	90%	90%	90%
Estimated VFD Efficiency (%)	--	--	95%
Calculated Pump Efficiency	71%	83%	78%

Observations and Proposed Recommendations

Based on the energy use data, pump hours and efficiency testing we noted the following:

- The energy data reveals that Pumps B & C are operated in parallel at least once each month. If the tank setpoints could be adjusted, it would give Booster Pump C additional time to catch up with demand before a second pump is brought on line to reduce demand charges. This improvement is reviewed in ESM #2
- Average pump efficiency was good for the station (although Pump #2 pressure was estimated since it did not have a pressure tap).
- The difference between total head (187') and static head (177') for the smaller pumps most likely does not make it worthwhile to install VFDs for these pumps.

5.1.8 Waiakea Uka Camp 6 Pump Station

The Waiakea Uka Camp 6 Booster Pump Station pumps water from the Waiakea Uka Tank up to the Hoaka Camp 7 Tank. The pump station has three pumps that operate at a TDH between 340 feet and 425 feet. The rated capacity of each of the three pumps is approximately 500 gpm. 2014 energy use and costs is shown below.

Table 5.25: Waiakea Uka Camp 6 Booster Pump 2014 Energy Use and Costs

Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill
1/29/14	27,520	110	111	$1,140	$6,826	$2,665	$10,631
2/28/14	26,240	59	86	$877	$6,508	$2,801	$10,187
3/28/14	24,960	106	109	$1,115	$6,191	$2,415	$9,721
4/29/14	28,640	114	114	$1,164	$7,104	$2,767	$11,035
5/29/14	28,000	62	88	$902	$6,945	$2,858	$10,705
6/27/14	25,280	114	114	$1,164	$6,270	$2,833	$10,268
7/29/14	30,240	110	112	$1,148	$7,501	$3,519	$12,167
8/28/14	28,960	114	114	$1,164	$7,183	$3,445	$11,793
9/29/14	30,880	62	88	$902	$7,659	$3,337	$11,898
10/29/14	27,840	115	115	$1,181	$6,905	$2,867	$10,953
11/26/14	26,240	62	89	$910	$6,508	$2,481	$9,900
11/26/14	26,240	62	89	$910	$6,508	$2,481	$9,900
Total/Avg	**331,040**	**91**	**102**	**$12,579**	**$82,109**	**$34,469**	**$129,157**

A summary of 2014 booster pump hours and flow data is shown in Table 5.26.

Table 5.26: Waiakea Uka Camp 6 Booster Pump Run Time and Pumpage

Month	Bstr A Hours	Bstr B Hours	Bstr C Hours	Total Hours	Bstr A Pumpage	Bstr B Pumpage	Bstr C Pumpage	Total Pumpage (kgal)	Bstr A Flow (gpm)	Bstr B Flow (gpm)	Bstr c Flow (gpm)
Jan-14	168	114	207	488	5,540	3,414	7,132	16,086	550	500	575
Feb-14	0	469	0	469	0	14,105	0	14,105		502	
Mar-14	146	116	204	465	4,806	3,473	6,956	15,235	549	501	569
Apr-14	166	177	101	445	5,481	5,335	3,465	14,281	549	502	571
May-14	1	172	329	501	23	5,170	11,296	16,489	548	502	572
Jun-14	106	223	207	536	3,511	6,693	7,076	17,280			570
Jul-14	111	113	209	433	3,716	3,411	7,177	14,304	560	501	573
Aug-14	243	125	109	477	8,114	3,739	3,749	15,602	557	500	573
Sep-14	209	125	142	476	6,963	3,761	4,891	15,615	554	501	574
Oct-14	216	114	182	511	7,101	3,402	6,210	16,713	548	499	570
Nov-14	114	240	107	461	3,755	7,224	3,670	14,649	548	501	573
Dec-14	133	1	414	548	4,379	27	14,210	18,616	547	409	572
Totals/Avg	**1,613**	**1,988**	**2,209**	**5,811**	**53,389**	**59,754**	**75,832**	**188,975**	**551**	**492**	**572**

Pump Testing

To evaluate existing well performance, we collected flow data using the existing flow meter. Power was measured with a Fluke 43B kW meter, and discharge pressure was measured with a Fluke PV-350 pressure transducer. The data is summarized below.

Table 5.27: Waiakea Uka Camp 6 Pump Testing

Pump Measurements / Calculations	A	B	C
Total Flow (gpm)	502	485	569
Discharge Pressure (psi)	165	165	165
Suction Pressure (estimated based on tank level)	6.5	6.5	6.5
Estimated Total Head (ft)	366	366	366
Static Head (1020-654)	366	366	366
Total Measured Power (kW)	57.5	50.1	61
Estimated Motor Efficiency (%)	90%	90%	90%
Calculated Pump Efficiency	**67%**	**74%**	**71%**

Observations and Proposed Recommendations

Based on the energy use data, pump hours and efficiency testing we noted the following:

- All the pumps are operating at a reduced efficiency. However, based on the low operating hours, we have not recommended pump efficiency improvements at this time.
- The monthly demand shows that DWS staff is making the effort to operate one pump by having tank setpoints far enough apart. However, it looks like occasionally two pumps are needed.
- Static and total head are the same indicating that frictional head is minimal.

We have no energy savings recommendation for this station.

5.1.9 Waiakea Uka Camp 7 (Hoaka) Booster Pump Station

The Waiakea Uka Camp 7 Booster Pump station has two pumps (Nos. 1 and 2) that operate at a TDH of 324 feet and have a capacity of 300 gpm. The Waiakea Uka Camp 7 pump station pumps water from the Camp 7 Tank to the Delima Tank.

Table 5.28: Waiakea Uka Camp 7 Booster Pump 2014 Energy Use and Costs

Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill
1/29/14	4,826	42	48	$492	$1,197	$520	$2,209
2/27/14	4,969	28	41	$421	$1,232	$582	$2,236
3/28/14	4,620	28	41	$421	$1,146	$501	$2,068
4/29/14	5,113	28	41	$421	$1,268	$546	$2,236
5/29/14	5,006	28	41	$421	$1,242	$564	$2,227
6/27/14	4,450	28	41	$420	$1,104	$551	$2,075
7/29/14	5,171	52	53	$545	$1,283	$655	$2,483
8/28/14	5,693	37	45	$465	$1,412	$729	$2,606
9/29/14	6,038	28	41	$420	$1,498	$704	$2,622
10/29/14	5,372	54	54	$552	$1,332	$605	$2,490
11/26/14	4,700	28	41	$418	$1,166	$497	$2,081
11/26/14	4,700	28	41	$418	$1,166	$497	$2,081
Total/Avg	**60,658**	**34**	**44**	**$5,417**	**$15,045**	**$6,951**	**$27,413**

A summary of 2014 booster pump hours and flow data is shown below.

Table 5.29: Waiakea Uka Camp 7 Booster Pump 2014 Hours and Pumpage

Month	Bstr A Hours	Bstr B Hours	Total Hours	Bstr A Pumpage (kgal)	Bstr B Pumpage (kgal)	Total Pumpage (kgal)	Bstr A Flow (gpm)	Bstr B Flow (gpm)
Jan-14	69	92	161	1,211	0	1,211	292	0
Feb-14*	0	151	151	0	0	0		0
Mar-14	83	70	153	1,123	0	1,123	225	0
Apr-14	74	70	143	1,295	0	1,295	292	0
May-14	52	114	166	918	0	918	293	0
Jun-14	69	97	166	1,210	0	1,210	292	0
Jul-14	38	105	142	6	0	6	3	0
Aug-14	87	96	183	1,111	0	1,111	214	0
Sep-14	43	130	173	746	0	746	293	0
Oct-14	81	105	186	1,378	0	1,378	284	0
Nov-14	76	75	151	1,332	0	1,332	293	0
Dec-14	145	46	191	2,551	0	2,551	292	0
Totals/Avg	**816**	**1,151**	**1,967**	**12,881**	**0**	**12,881**	**252**	**0**

*February data has missing pumpage data

Pump Testing

To evaluate existing well performance, we collected flow data using the existing flow meter. Power was measured with a Fluke 43B kW meter, and discharge pressure was measured with a Fluke PV-350 pressure transducer. The data is summarized below.

Table 5.30: Waiakea Uka Camp 7 Pump Testing

Pump Measurements / Calculations	A	B
Total Flow (gpm)	295	296
Discharge Pressure (psi)	144	144
Suction Pressure (estimated from tank level)	5.5	6.5
Estimated Total Head (ft)	320	318
Static Head (1320-1020)	300	300
Total Measured Power (kW)	25.5	26.3
Estimated Motor Efficiency (%)	93%	89%
Calculated Pump Efficiency	75%	76%

Observations and Proposed Recommendations

Based on the energy use data, pump hours and efficiency testing we noted the following:

- Pump efficiencies are good for this station
- The monthly demand is fairly steady showing that DWS staff has made the effort to minimize two-pump operation by having tank setpoints far enough apart.
- Static and total head are close indicating that frictional head is minimal.

We have no energy savings recommendation for this station.

5.2 Hakalau System

The Hakalau water system is located along the Hawaii Belt Road along Chin Chuck Road. This water system serves Zone 2970 with elevations ranging from 160 to 1,325 feet. The system is supplied by the Hakalau Well and the Hakalau Iki Spring and has two storage tanks. The Hakalau Well has a capacity of 50 gpm at 460' TDH. The Hakalau Iki Spring has a rated capacity of 180 gpm. Improvements were made to the spring intake box several years ago to prevent surface water influence. A summary of 2014 energy usage and cost for the Hakalau Well is shown below.

Table 5.31: Hakalau Well 2014 Energy Use and Costs

Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill
1/4/14	2,463	11	0	$0	$778	$324	$1,102
2/3/14	2,014	11	0	$0	$636	$258	$894
3/4/14	2,034	11	0	$0	$642	$274	$916
4/2/14	2,085	11	0	$0	$659	$260	$918
5/2/14	2,081	11	0	$0	$657	$260	$918
6/3/14	2,774	11	0	$0	$876	$344	$1,220
7/2/14	2,338	11	0	$0	$738	$321	$1,059
7/31/14	2,309	11	0	$0	$729	$327	$1,056
9/2/14	3,275	11	0	$0	$1,034	$447	$1,482
10/2/14	2,874	11	0	$0	$908	$366	$1,274
11/1/14	2,769	11	0	$0	$875	$342	$1,217
12/2/14	2,263	11	0	$0	$715	$265	$980
Total/Avg	**29,279**	**11**	**0**	**$0**	**$9,248**	**$3,789**	**$13,037**

A summary of 2014 pump hours and flow data from the DWS Pumpage Report is shown below in Table 5.32.

Table 5.32: Hakalau Well 2014 Run Time and Pumpage

Month	Monthly Energy Use (kWh)	Monthly Bill	Well Hours	Well Pumpage (kgal)	Spring Flow (kgal)	Total Pumpage (kgal)	Average System GPM	kWh/ kgal	Cost/ kgal
Jan-14	2,463	$1,102	191	595	417	1,012	23	4.1	$1.85
Feb-14	2,014	$894	175	546	439	985	22	3.7	$1.64
Mar-14	2,034	$916	206	645	467	1,112	25	3.2	$1.42
Apr-14	2,085	$918	192	598	517	1,116	25	3.5	$1.53
May-14	2,081	$918	258	774	568	1,342	31	2.7	$1.19
Jun-14	2,774	$1,220	222	694	492	1,187	27	4.0	$1.76
Jul-14	2,338	$1,059	231	722	697	1,419	32	3.2	$1.47
Aug-14	2,309	$1,056	286	896	424	1,320	30	2.6	$1.18
Sep-14	3,275	$1,482	269	844	492	1,337	31	3.9	$1.75
Oct-14	2,874	$1,274	267	808	467	1,276	29	3.6	$1.58
Nov-14	2,769	$1,217	199	645	419	1,065	24	4.3	$1.88
Dec-14	2,263	$980	188	389	420	809	18	5.8	$2.52
Totals/Avg	**29,279**	**$13,037**	**2,684**	**8,161**	**5,819**	**13,980**	**27.3**	**3.5**	**$1.57**

In 2014, the Hakalau Iki Spring flow was 480,000/month and the rest was supplemented with the Hakalau Well (approximately ~680,000/month). Given that the spring has a rated capacity of 180 gpm and is only providing an average flow of 11 gpm, it appears that the well setpoints may need to be adjusted to use as much spring water as possible. Savings for this adjustment would be $9,782 annually and is reviewed in OM #4.

5.3 Honomu System

The Honomu water system is located along Hawaii Belt Road at Akaka Falls Road. Elevations within the Honomu water system range from 149 to 391 feet. The system obtains its water supply from Honomu Spring near Akaka Falls. The Honomu Well is also available to supplement the spring with a capacity of 250 gpm @ 540' TDH. The pump is equipped with a 75 hp motor. Old flow data indicates that Akaka Falls has capacity of 0.14 mgd. Based on the pumpage report, the spring is used for the primary water source and provides a wide range of flows. A summary of 2014 well energy usage and cost is shown below.

Table 5.33: Honomu Well 2014 Energy Use and Costs

Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill
1/4/14	640	1	25	$256	$159	$131	$546
2/3/14	640	39	42	$425	$159	$125	$709
3/4/14	640	44	44	$449	$159	$130	$738
4/2/14	600	44	44	$449	$149	$121	$718
5/2/14	600	2	25	$256	$149	$121	$526
6/3/14	680	33	38	$392	$169	$133	$693
7/2/14	5,400	44	44	$450	$1,339	$661	$2,450
7/31/14	600	31	37	$382	$149	$133	$664
9/2/14	720	34	39	$397	$179	$148	$723
10/2/14	600	27	35	$363	$149	$127	$638
11/1/14	600	20	32	$328	$149	$124	$601
12/2/14	680	21	32	$331	$169	$127	$627
Total/Avg	**12,400**	**28**	**36**	**$4,478**	**$3,076**	**$2,079**	**$9,633**

A summary of 2014 pump hours and flow data from the DWS Pumpage Report is shown below in Table 5.34.

Table 5.34: Honomu Well 2014 Pumpage and Spring Flow

Month	Well Pumpage	Spring Flow	Total Flow	Average System GPM
Jan-14	0	1,368	1,368	31
Feb-14	0	12,655	12,655	289
Mar-14	0	1,406	1,406	32
Apr-14	0	1,395	1,395	32
May-14	0	15,794	15,794	361
Jun-14	1875	9,241	11,116	254
Jul-14	2	1,576	1,578	36
Aug-14	0	1,510	1,510	34
Sep-14	0	1,430	1,430	33
Oct-14	2	1,331	1,333	30
Nov-14	1	1,667	1,668	38
Dec-14	0	1,424	1,424	33
Totals/Avg	**1,880**	**50,796**	**52,676**	**106.4**

The system has wide swings in flow, which doesn’t appear to be a problem most of the time (with the exception of June when the well was required). DWS staff indicated that the well is exercised once/month.

Observations and Proposed Recommendations

We recommend installing a VFD for the well and limiting the VFD to a minimal value to just pump enough flow to exercise the pump and purge the well each month. With a maximum speed set below 25 kW, the well would be downsized enough to allow the station to qualify for Rate Schedule G (if it can maintain less than 5,000 kWh/month and less than 25 kW for demand). Although the energy cost/kWh would increase, the 125 hours of annual well operation would have a minimal impact on energy costs. Annual demand savings would be $4478. This project is reviewed as part of ESM #5.

5.4 Papaikou System

The Paukaa-Papaikou water system serves Papaikou Village, Puueopaku, Paukaa, and Kalaoa. This system serves eight zones with elevations ranging from 95 to 1,224 feet. This system is supplied by two wells and two springs, Kaieie Mauka Spring and Kaieie Medeiros Spring (also known as Kaieie Spring).

The Kaieie Mauka (Papaikou) Spring is at an elevation of 1,253 feet and has an estimated capacity of approximately 20 gpm. The spring was not used in 2014 due to corrosion control issues. This problem is currently being addressed to get the spring back on line

The Kaieie Medeiros Spring is at an elevation of 695 feet and has an estimated capacity of 14 gpm. The Kaieie Medeiros is the most dependable surface source, while the Papaikou intake source is less dependable, often running dry. In 2014 the spring was used each month except for March and June. DWS staff is currently checking with the operator to see why the well was not used these months.

The Papaikou Well has a rated capacity of 375 gpm @ 460 feet and the Kaieie Mauka Well is rated to pump 100 gpm @1140' TDH. The system has two booster pump stations, Kaieie Mauka Pump Station and Medeiros Pump Station and five storage tanks. The energy use and cost for the two well accounts is summarized in Table 5.35 and 5.36.

Table 5.35: Kaieie Mauka Well 2014 Energy Use, Costs, Hours and Pumpage

Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill	Well Hours	Total Pumpage (kgal)	Average Flow GPM
1/2/14	3,520	43	43	$443	$873	$453	$1,769	71	416	98
1/31/14	3,280	43	43	$443	$814	$440	$1,696	61	359	98
3/3/14	4,160	42	43	$439	$1,032	$547	$2,018	74	434	98
4/1/14	4,000	43	43	$443	$992	$483	$1,918	65	383	98
5/1/14	3,440	43	43	$443	$853	$410	$1,706	76	472	104
6/2/14	3,920	43	43	$443	$972	$458	$1,874	73	434	99
7/1/14	3,520	43	43	$443	$873	$453	$1,769	69	401	97
7/31/14	3,280	43	43	$443	$814	$440	$1,696	81	476	98
9/2/14	4,160	42	43	$439	$1,032	$547	$2,018	88	517	98
10/1/14	4,000	43	43	$443	$992	$483	$1,918	70	411	98
10/31/14	3,440	43	43	$443	$853	$410	$1,706	69	406	98
12/1/14	3,360	43	43	$443	$833	$370	$1,647	75	440	98
Total/Avg	**44,080**	**43**	**43**	**$5,305**	**$10,933**	**$5,494**	**$21,733**	**872**	**5,149**	**98**

Table 5.36: Papaikou Well 2014 Energy Use, Costs, Hours and Pumpage

Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill	Well Hours	Total Pumpage (kgal)	Average Flow GPM
1/2/14	8,320	48	48	$492	$2,064	$935	$3,490	181	4540	418
1/31/14	8,960	48	48	$492	$2,222	$908	$3,622	158	3964	418
3/3/14	9,920	48	48	$492	$2,460	$1,096	$4,048	211	3798	300
4/1/14	9,920	48	48	$492	$2,460	$998	$3,951	203	5118	420
5/1/14	10,560	48	48	$492	$2,619	$1,063	$4,174	199	4995	418
6/2/14	10,560	48	48	$492	$2,619	$1,127	$4,238	192	4838	420
7/1/14	9,600	48	48	$492	$2,381	$1,124	$3,997	182	4557	417
7/31/14	8,640	48	48	$492	$2,143	$1,055	$3,690	184	4631	419
9/2/14	10,240	48	48	$492	$2,540	$1,254	$4,286	186	4678	419
10/1/14	9,280	48	48	$492	$2,302	$1,036	$3,829	189	4744	418
10/31/14	9,600	48	48	$492	$2,381	$1,029	$3,902	182	4575	419
12/1/14	9,600	48	48	$492	$2,381	$938	$3,811	188	4731	419
Total/Avg	**115,200**	**48**	**48**	**$5,904**	**$28,573**	**$12,560**	**$47,038**	**2,255**	**55,169**	**419**

Observations and Proposed Recommendations

After reviewing the energy billing data and the flow/pump hours, we developed the following cost saving recommendations:

- Initially it looked like Rider M could be applied to both wells based on DWS staff input and the low operating hours. However, the requirements for Rider M are that the initial demand must be at least 100 kW to qualify for the rate. Both wells are well below this value.

- Both wells were not available for testing during our site visit so efficiency was not evaluated. However even if efficiency was lower than the original curve value, the operating hours are low enough to not justify improvements.

- DWS staff indicated that after the current issues are resolved for the Kaieie Mauka (Papaikou) Spring, this water source will again be used on a regular basis. When that happens, both wells will still need to be exercised periodically, which will create high demand charges without significant energy use. To minimize these charges, we recommend installing VFDs on both wells to allow staff to run the wells periodically at a very low flow rate to minimize demand charges. We estimate that approximately 20 kW for both wells could be saved with the installation of VFDs. This would reduce demand charges by $5,500 for both stations and has been included as part of ESM #5.

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5.5 Pepeekeo System

The Pepeekeo water system is located along the Hawaii Belt Road between Kulaimano Road and Kaapeka Street. The system elevations range from 337 to 934 feet and is supplied by the Maukaloa Spring (also called the Makea Spring) and Kulaimano Well #1 and Well #2. Two storage tanks currently provide storage for the Pepeekeo system.

Kulaimano Well #1 is rated for 300 gpm @ 750' TDH and Kulaimano Well #2 is rated for 300 gpm @ 935' TDH. Well #1 did not run in 2014 due to repairs (although there were still significant demand charges). DWS staff expects that this well will be used primarily as a back up well in the future.

Table 5.37: Kulaimano Well #1 2014 Energy Use, Costs, Hours and Pumpage

Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill	Well Hours	Total Pumpage (kgal)	Average Flow GPM
1/3/14	160	0	65	$730	$0	$0	$730	0	0	0
2/3/14	160	0	65	$730	$0	$0	$730	0	0	0
3/4/14	0	0	65	$730	$0	$0	$730	0	0	0
4/2/14	160	0	65	$730	$0	$0	$730	0	0	0
5/2/14	160	0	65	$730	$0	$0	$730	0	0	0
6/3/14	160	0	65	$730	$0	$0	$730	0	0	0
7/2/14	160	0	65	$730	$0	$0	$730	0	0	0
8/1/14	160	0	65	$730	$0	$0	$730	0	0	0
9/3/14	160	2	65	$730	$0	$0	$730	0	0	0
10/2/14	0	0	65	$730	$0	$0	$730	0	0	0
11/1/14	160	0	25	$256	$40	$80	$376	0	0	0
12/2/14	160	0	25	$256	$40	$80	$376	0	0	0
Total/Avg	**1,600**	**0**	**65**	**$7815**	**$80**	**$160**	**$8,054**	**0**	**0**	**0**

Table 5.38: Kulaimano Well #2 2014 Energy Use, Costs, Hours and Pumpage

Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill	Well Hours	Total Pumpage (kgal)	Average Flow GPM
1/3/14	20,480	80	80	$815	$5,080	$2,200	$8,094	*230*	4,402	319
2/3/14	18,160	79	79	$813	$4,504	$1,793	$7,110	*195*	3,753	321
3/4/14	16,520	79	79	$814	$4,098	$1,774	$6,686	217	4,195	322
4/2/14	16,480	79	79	$814	$4,088	$1,616	$6,518	223	4,328	323
5/2/14	17,040	79	79	$814	$4,226	$1,679	$6,719	249	4,824	323
6/3/14	20,760	80	80	$820	$5,149	$2,160	$8,129	224	4,317	321
7/2/14	17,400	80	80	$818	$4,316	$1,988	$7,121	250	4,838	323
8/1/14	18,800	80	80	$818	$4,663	$2,221	$7,702	243	4,708	323
9/3/14	20,680	79	80	$816	$5,129	$2,459	$8,404	246	4,779	324
10/2/14	18,400	79	80	$816	$4,564	$1,988	$7,367	228	4,398	321
11/1/14	17,760	79	80	$816	$4,405	$1,844	$7,065	231	4,476	323
12/2/14	18,560	79	80	$815	$4,603	$1,744	$7,162	247	4,751	321
Total/Avg	**221,040**	**79**	**80**	**$9,788**	**$54,825**	**$23,465**	**$88,078**	**2,783**	**53,769**	**3,864**

Observations and Proposed Recommendations

After reviewing the energy billing data and the flow/pump hours, we developed the following cost saving recommendations:

- Both wells were not available for testing during our site visit so efficiency was not evaluated.

- Based on 1994 data, Mauka Loa (Makea) Spring had a capacity of 0.40 mgd. The operator indicated that a few years ago the source went dry and may have been diverted at a higher elevation. The spring was only used one month in 2012 and one month in 2013. If it can be corrected, the average flow of 0.40 mgd (277 gpm) would take care of system flow requirements and would only require periodic well exercising. Savings for this improvement would be over $60,000 and has been included in OM #2

- DWS staff indicated that after the current issues are resolved for the Kaieie Mauka (Papaikou) Spring, the water source will again be used on a regular basis. When that happens, both wells will still need to be exercised periodically, which will create high demand charges without significant energy use. To minimize these charges, we recommend installing VFDs on both wells to allow staff to run the wells periodically at a very low flow rate to minimize demand charges. This improvement should be included in ESM #5 after the spring issue is resolved.

SECTION 6. NORTH HILO

A summary of energy use and cost for the system electric accounts is shown in Table 6.1. The two high-energy well accounts were reviewed in this section.

Table 6.1: North Hilo Electric Accounts

Service Account	2013 kWh	2013 Cost	2014 kWh	2014 Cost
Laupahoehoe Wells	186,700	$78,960	188,700	79,970
Ookala Well	48,456	$24,959	51,243	$26,032
Ninole Boosters	7,050	$3,605	8,713	4,334
Total	**242,206**	**$107,524**	**248,656**	**$110,336**

6.1 Laupahoehoe System

The Laupahoehoe water system is located along the Hawaii Belt Road between Stevens Road and Kapehu Road. This system uses two deep wells. Well #1 is rated for 283 gpm @ 803' TDH and Well #2 is rated for 300 gpm @ 740' TDH. The system has one booster station and three storage tanks. The 500,000 Manowaiopae Tank is in the process of being replaced with a larger one million gallon tank.

The Kihalani Spring with 0.10 mgd capacity and the Manowaiopae Spring with a 0.02 mgd capacity originally supplied this system. Both of these water sources have not been used in 20 years. DWS staff indicated that if the wells are down, water is transported to the tank sites instead of using the springs.

A summary of 2014 energy use data from facility spreadsheets is shown below in Table 6.2.

Table 6.2: Laupahoehoe Well 2014 Energy Use and Costs

Billing Date	Total kWh	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill
1/3/14	18,100	123	124	$1,271	$4,489	$1,951	$7,712
2/3/14	16,900	57	91	$933	$4,192	$1,673	$6,798
3/4/14	17,100	57	91	$933	$4,241	$1,835	$7,009
4/2/14	15,300	57	91	$933	$3,795	$1,505	$6,233
5/2/14	14,700	99	111	$1,138	$3,646	$1,457	$6,241
6/3/14	15,300	123	123	$1,261	$3,795	$1,609	$6,664
7/1/14	16,400	123	123	$1,261	$4,068	$1,875	$7,203
8/1/14	15,000	93	108	$1,106	$3,721	$1,785	$6,611
9/3/14	15,200	123	123	$1,265	$3,770	$1,824	$6,859
10/2/14	14,500	93	108	$1,110	$3,596	$1,580	$6,287
11/1/14	15,000	57	90	$927	$3,721	$1,567	$6,214
12/2/14	15,200	58	91	$927	$3,770	$1,442	$6,139
Total/Avg	**188,700**	**89**	**106**	**$13,063**	**$46,804**	**$20,103**	**$79,970**

As shown in Table 6.2, in 2014 two wells were operated together occasionally which increased the peak demand. DWS staff indicated that Hurricane Iselle caused one of these situations when the power lines were down for a full day and the tank went empty. When the power was restored, both pumps were activated. Staff indicated that there also might have been other outages during the year when the operators ran both wells to catch up.

A summary of 2014 pump hours and flow data from the DWS Pumpage Report is shown in Table 6.3.

Table 6.3: Laupahoehoe Well 2014 Pumpage & Hours

Month	Total kWh	Monthly Net Bill	Well #1 Hours	Well #2 Hours	Well #1 Pumpage	Well #2 Pumpage	Well 1 Average GPM	Well 2 Average GPM
Jan-14	18,100	$7,712	294	0	4,339	0	246	
Feb-14	16,900	$6,798	321	0	4,765	0	247	
Mar-14	17,100	$7,009	247	0	3,611	0	244	
Apr-14	15,300	$6,233	260	0	3,859	7	247	292
May-14	14,700	$6,241	232	5	3,536	58	254	
Jun-14	15,300	$6,664	286	16	4,544	321	265	336
Jul-14	16,400	$7,203	259	1	4,029	12	259	286
Aug-14	15,000	$6,611	236	4	3,642	71	257	338
Sep-14	15,200	$6,859	257	0	3,930	0	255	
Oct-14	14,500	$6,287	267	0	4,081	0	255	
Nov-14	15,000	$6,214	253	0	3,856	0	254	
Dec-14	15,200	$6,139	254	1	4,316	23	283	348
Totals/Avg	**188,700**	**$79,970**	**3,166**	**26**	**48,508**	**492**	**256**	**320**

<u>Pump Testing</u>

To evaluate existing well performance, we collected instantaneous flow using the existing flow meters. Power was measured with a Fluke 43B kW meter, and discharge pressure was determined using a Fluke PV-350 pressure transducer.

Table 6.4: Laupahoehoe Well Test Data

Pump Measurements / Calculations	Well 1	Well 2
Total Flow (gpm)	280	341
Discharge Pressure (psi)	8	26
Baseline Ground Elevation (ft)	659	665
Tank Water Level Elevation (ft)	655	655
Well Depth to Baseline (ft)	657	685
Static Head (ft)	653	675
Gauge Height from Baseline (ft)	2	2
Estimated Column/Velocity Losses (ft) 1ft/100ft	6.57	6.85
Estimated Total Head (ft): P * 2.31 + well depth + losses)	684	754
Total Measured Power (kW)	53.5	66
Estimated Motor Efficiency (%)	92%	90%
Calculated Pump Efficiency	**73%**	**82%**
Original Pump Efficiency at Flowrate	**75%**	**82%**

As shown in Table 6.4, the calculated pump efficiency from the test data is very close to the original efficiency determined from each pump curve below.

Figure 6.1: Laupahoehoe Well #1 Pump Curve

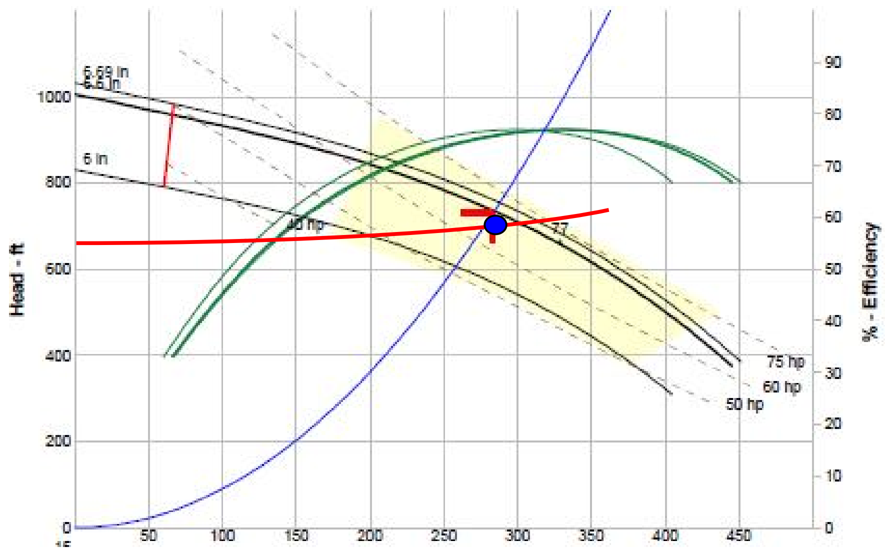
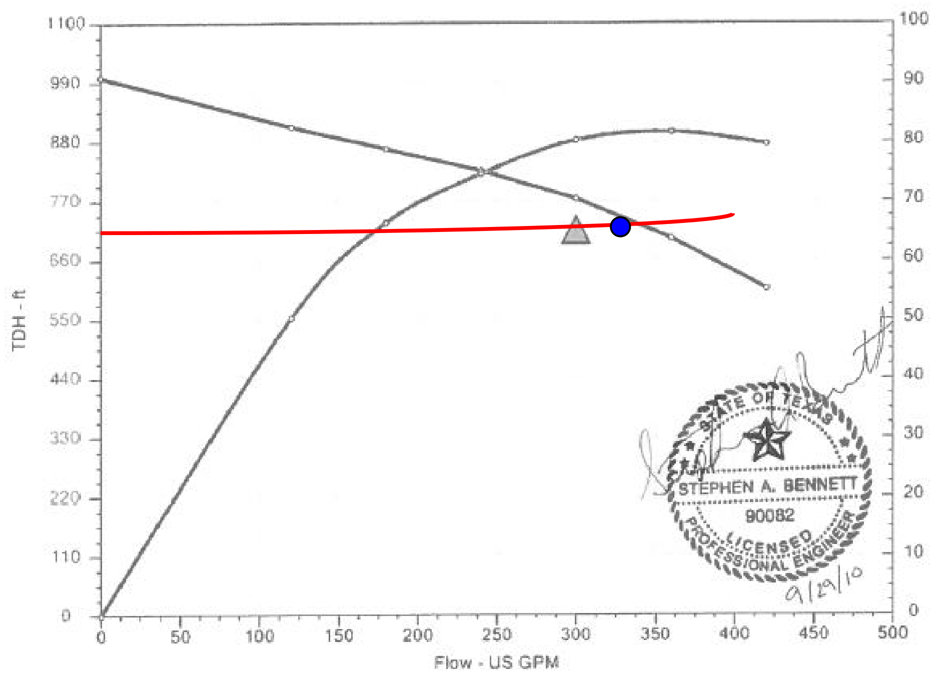


Figure 6.2: Laupahoehoe Well #2 Pump Curve



Observations and Proposed Recommendations

Potential savings measures include the following:

- As discussed, two wells were operated together occasionally after several power outages during the year. Currently the lead well is activated at 11' and shuts off at 13' and the lag well is activated at 6.5' and shuts off at 10.5' indicating that the tank level setpoints are spaced appropriately. Another option is to have the second pump deactivated and rely on a low level alarm to have the operator manually turn on a second pump if needed after investigating. With $4,900 in annual savings, this may be worthwhile considering and has been included in ESM #2.

Both springs are out of service and would require a more detailed study to determine if water treatment systems would be cost effective. With the expectation that the wells would still be required periodically if the spring sources were available, annual energy savings would be approximately $50,000 per year.

6.2 Ninole System

The Ninole water system is supplied by the Chaves Spring, which has a rated capacity of 40 gpm. Flow from the spring is directed into the Ninole Tank before it is pumped to the distribution system by the Ninole Booster Pump Station. The pump station has two pumps rated for 40 gpm at 230 feet TDH.

The station is billed on HELCO Rate G, which does not have a demand charge. The total 2014 energy cost for the station in 2014 was less than $4500.

6.3 Ookala System

The Ookala water system serves the Ookala House lot Subdivision. This system is supplied by the Ookala Well with a capacity of 250 gpm @ 700' TDH. The system has one 300,000-gallon tank and no booster stations. The well is activated at a tank level of 11' and shuts off at 13'. A summary of 2014 energy use data from facility spreadsheets is shown below in Table 6.5. The average cost/kgal in 2014 was $2.40/kgal.

Table 6.5: Ookala Well 2014 Energy Use and Costs

Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill	Well Hours	Total Pumpage (kgal)	Average Flow GPM
1/29/14	3,026	59	60	$610	$751	$350	$1,710	43	583	224
2/27/14	3,427	59	59	$609	$850	$421	$1,880	*50*	700	233
3/28/14	3,469	59	60	$610	$860	$392	$1,862	58	757	219
4/29/14	3,714	59	60	$610	$921	$414	$1,946	52	683	220
5/29/14	3,685	59	60	$611	$914	$432	$1,957	57	758	220
6/27/14	4,324	60	60	$611	$1,072	$538	$2,221	75	991	219
7/29/14	4,024	60	60	$611	$998	$524	$2,133	61	808	220
8/28/14	3,888	60	60	$611	$964	$518	$2,093	56	724	217
9/29/14	5,917	60	60	$612	$1,468	$691	$2,771	97	1,273	219
10/29/14	6,435	60	60	$616	$1,596	$712	$2,924	107	1,424	222
11/26/14	4,667	60	60	$616	$1,158	$494	$2,268	79	1,065	224
11/26/14	4,667	60	60	$616	$1,158	$494	$2,268	83	1,109	223
Total/Avg	**51,243**	**60**	**60**	**$7,342**	**$12,710**	**$5,980**	**$26,032**	**818**	**10,875**	**222**

Well Pump Testing

To evaluate existing well performance, we collected flow using the existing meter, power was measured with a Fluke 43B kW meter, and discharge pressure was estimated based on tank level. The results are summarized below.

Table 6.6: Ookala Well Test Data

Pump Measurements / Calculations	Data
Total Flow (gpm)	230
Discharge Pressure (psi)	20
Baseline Ground Elevation (ft)	641
Tank Water Level Elevation (ft)	655
Well Depth to Baseline (ft)	631
Static Head (ft)	645
Gauge Height from Baseline (ft)	2
Estimated Column/Velocity Losses (ft) 1ft/100ft	6.31
Estimated Total Head (ft): P * 2.31 + well depth + losses)	686
Total Measured Power (kW)	59
Estimated Motor Efficiency (%)	90%
Calculated Pump Efficiency	**56%**

Observations and Proposed Recommendations

Based on the test data, the pump efficiency was 56%. We did not have a pump curve for the Ookala Well to determine what the original efficiency value was, but we would expect it to be at least 75%. Instead of replacing or refurbishing the well with the same size unit, we recommend installing a VFD to minimize demand charges. This may improve efficiency if the pump is operating to the right of the best efficiency point but we have only taken credit for a lower demand cost in ESM #5.

SECTION 7. HAMAKUA SYSTEM

The Hamakua System is located in District II and consists of the Haina System (which includes the Puukapu-Niene Pump Stations), and the Paauilo and Kukuihaele System. A summary of energy use and costs for the system electric accounts is shown in Table 7.1.

Table 7.1: Hamakua 2013/2014 Energy Use Accounts

Tank or Pump Station	2013 kWh	2013 Cost	2014 kWh	2014 Cost
Plumeria St	26,000	$26,072	552,120	$211,632
Old Mamalahoa Hwy Ahualoa DW	719,200	$299,032	490,400	$227,412
Haina Boosters	213,896	$82,715	73,347	$33,801
Haina Deep Well	452,960	$173,302	159,360	$70,646
Paauilo Well	137,000	$52,356	130,600	$50,883
Ookala Well	48,456	$24,959	51,243	$26,032
Puukapu Niene #1 Boosters	72,631	$29,225	71,179	$29,077
Puukapu CC Camp Boosters	116,170	$45,895	124,500	$49,319
Ahualoa Boosters	153	$705	0	$0
Costa Tank	0	$0	0	$0
Desilva Boosters	8,455	$4,195	8,411	$4,202
Desilva Tank	5,387	$2,661	9,558	$4,685
Honokaa (Hospital) Boosters	11,583	$8,315	8,611	$6,856
Kapulena Boosters	21,591	$9,692	17,471	$8,022
Kukuihaele Boosters	0	$0	0	$0
Kalopa Mauka Boosters	0	$0	0	$0
Saw Mill Boosters	6,594	$3,416	6,598	$3,436
Waipo Valley	0	$0	0	$0
Pohakea Mauka Rd (Bstr Downside)	0	$0	0	$0
Pohakea Mauka Rd (Bstr Upside)	0	$0	0	$0
Old Mamalahoa Hwy Telemetry	2,131	$1,270	2,006	$1,225
Ahualoa Pump Bstr Plt	0	$0	69	$301
Puukapu Niene #2 Boosters	40,367	$17,779	37,673	$16,552
Honokaa Hospital Deep Well	0	$0	0	$0
Total	**1,882,574**	**$781,589**	**1,743,146**	**$744,081**

The pump system high-energy accounts (above $25,000) are reviewed in this section.

The energy use of the Hamakua System decreased by 9% between 2013 and 2014. The use of more water from the South Kohala system (and the Waimea Treatment Plant) contributed to 2014 system savings of $37,000 compared to 2013.

7.1 Haina System

The service area of the Haina water system extends from Ahualoa to Pohakea. It serves 24 zones (between 4060 and 4950) with elevations ranging from 855 to 2,690 feet. Except for the towns of Honokaa and Haina, the major portion of the system serves a scattered population in the Ahualoa, Kalopa, Kaapahu, Pohakea, Paauhau, and Paauilo Homesteads.

The Haina system obtains its water from the Waimea Treatment Plant, the Haina Deep Well, the Honokaa Well and the Ahualoa Well. The Honokaa Well is only used for back up when the Haina Well is down. The Waimea Treatment Plant serves both the Waimea and Haina water systems and is described more in the South Kohala Section. The Haina water system has 12 booster pump stations and 24 storage tanks in service.

7.1.1 Haina Well Energy Use

At the time of our evaluation, the Haina Well was down for repairs. Normally this well is operated as the primary supply for the Honokaa / Haina area and is rated to pump 400 gpm @ 960’ TDH. DWS staff has had issues starting the well and so far has been able to rule out MCC equipment problems. The consensus is that the problem resides with the pump and line shaft assembly. The Haina Well is activated at a tank level of 5.85’ and deactivated at 7.85’

A summary of 2014 energy use data from facility spreadsheets is shown below in Table 7.2.

Table 7.2: Haina Well 2014 Energy Use and Cost

Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill	Rider M Discount	Total
1/13/14	33,280	123	123	$1,265	$8,255	$3,282	$12,801	$0	$12,801
2/11/14	35,200	123	123	$1,262	$8,731	$3,675	$13,667	$0	$13,667
3/12/14	31,520	123	123	$1,262	$7,818	$3,080	$12,159	$0	$12,159
4/10/14	35,040	123	123	$1,261	$8,691	$3,370	$13,322	$0	$13,322
5/12/14	23,360	122	123	$1,257	$5,794	$2,373	$9,423	$0	$9,423
6/11/14	0	0	123	$1,325	$0	$0	$1,325	$0	$1,325
7/11/14	0	0	123	$1,325	$0	$0	$1,325	$0	$1,325
8/11/14	320	4	123	$1,325	$0	$0	$1,325	$0	$1,325
9/11/14	160	2	123	$1,325	$0	$0	$1,325	$0	$1,325
10/11/14	160	0	123	$1,325	$0	$0	$1,325	$0	$1,325
11/10/14	160	0	123	$1,325	$0	$0	$1,325	$0	$1,325
12/10/14	160	0	123	$1,325	$0	$0	$1,325	$0	$1,325
Totals/Avg	**159,360**	**52**	**123**	**$15,579**	**$39,288**	**$15,779**	**$70,646**	**$0**	**$70,646**

As shown in Table 2, although the DWS did not use the well for 7 months in 2014, the monthly peak demand charge of $1,325 was still billed each month. Without the well on line, the booster pumps were also off line but that account was still billed $800/month for demand charges.

While the well has been down, the DWS has been able to supply the system by bringing water down from the Waimea treatment plant transmission line. Although the best long-term solution to reduce energy costs is to use the Waimea WTP water all the time, DWS staff indicated that the flow needed from the plant would be difficult to maintain on a regular basis. However, this is expected to change after the plant micro filtration upgrade is complete.

A summary of 2014 pump hours and flow data from the DWS Pumpage Report is shown below in Table 7.3. As noted, average flow for the well has been slightly below 400 gpm.

Table 7.3: Haina Well 2014 Hours and Pumpage

Month	Monthly Energy Use (kWh)	Monthly Net Bill	Well Hours	Well Pumpage (kgal)	Average GPM	kWh/ kgal	Cost/ kgal	Pump kW from hours and billed usage	Calculated Pump Efficiency
Jan-14	33,280	$12,801	279	6,330	378	5.3	2.0	119	62%
Feb-14	35,200	$13,667	265	5,963	375	5.9	2.3	133	56%
Mar-14	31,520	$12,159	283	6,310	372	5.0	1.9	111	66%
Apr-14	35,040	$13,322	294	6,558	372	5.3	2.0	119	61%
May-14	23,360	$9,423	133	2,928	368	8.0	3.2	--	41%
Jun-14	0	$1,325	0	0					
Jul-14	0	$1,325	0	0					
Aug-14	320	$1,325	0	0					
Sep-14	160	$1,325	0	0					
Oct-14	160	$1,325	0	0					
Nov-14	160	$1,325	0	0					
Dec-14	160	$1,325	0	0					
Totals/Avg	**159,360**	**$70,646**	**1,252**	**28,089**	**373**	**5.9**	**2.3**	**131.9**	**57%**

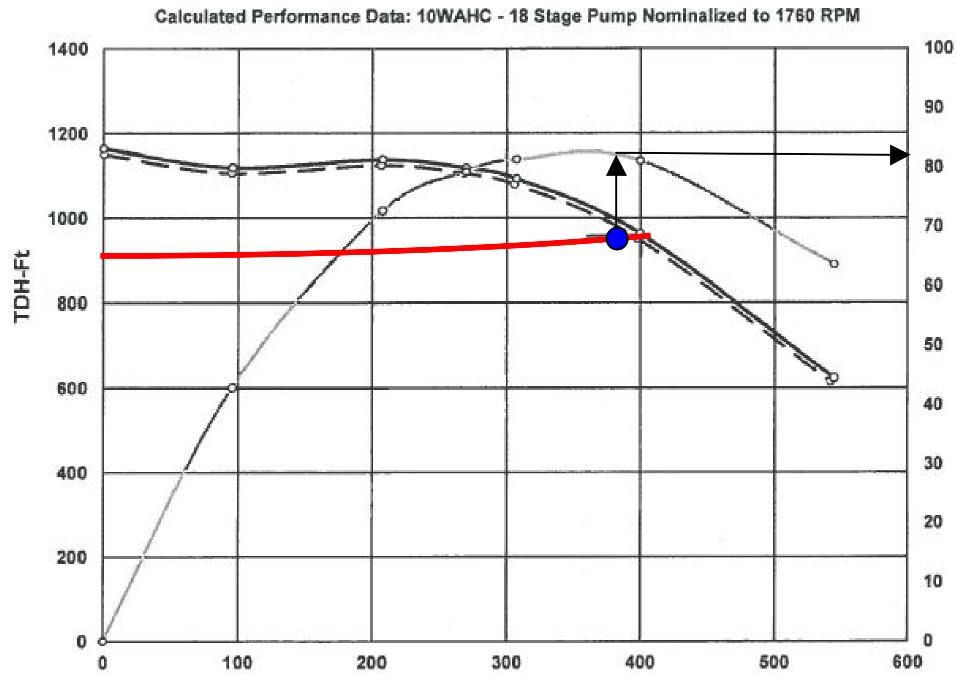
With the pump out of service, we used the total monthly pumpage and equipment hours to determine average flow and a 123 kW value from the electric bills and used these values to calculate an average pump efficiency of 57% (based on a 950' TDH and 92% motor efficiency).

Table 7.4: Haina Well Test Data

Pump Measurements / Calculations	Data
Total Flow (gpm)	373
Discharge Pressure (psi)	24
Baseline Ground Elevation (ft)	856
Tank Water Level Elevation (ft)	912
Well Depth to Baseline (ft)	910
Static Head (ft)	966
Gauge Height from Baseline (ft)	2
Estimated Column/Velocity Losses (ft) 1ft/100ft	9.1
Estimated Total Head (ft): P * 2.31 + well depth + losses)	977
Total Measured Power (kW)	121
Estimated Motor Efficiency (%)	92%
Calculated Pump Efficiency	**62%**
Original Pump Efficiency at Flowrate	**82%**

The estimated value is significantly lower than the original pump efficiency of approximately 82% shown on the pump curve in Figure 7.1 and could be one of the reasons that the pump failed in June. Savings for improving pump efficiency is reviewed in ECM #2.

Figure 7.1: Haina DW Pump Curve



<u>Observations and Proposed Recommendations</u>

Recommendations are provided for all three wells at the end of Section 7.1.3

7.1.2 Honokaa Well Energy Use

The Honokaa Well (referred to as Plumeria Street Station on the electric bill) is rated for approximately 300 gpm and has been used as the lead well since the Haina Well went offline in June 2014. The well is currently operated in hand continuously and appears to be supplemented by the Waimea Treatment Plant flow. DWS staff indicated that once the Haina Well is repaired, it will be run as the primary well for the one year warranty period. After the one-year period, the Honokaa Well will most likely be used as the primary well.

The operator indicated that the Honokaa Well is currently run continuously to avoid a turbidity issue that occurs if the well is allowed to be inactive for too long. If the well is brought on line after being off line, the system must be purged for hours before it can be used. Once the Haina Well is repaired, system improvements and SCADA controls will be evaluated to resolve this issue.

A summary of 2014 energy use data from facility spreadsheets is shown below in Table 7.5. The station energy use includes the two wells and the two booster pumps at the station.

Table 7.5: Honokaa Well 2014 Energy Use and Costs

Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill	Rider M Discount	Net Cost/ kWh
1/13/14	560	131	132	$1,357	$139	$118	$1,614	$0	$2.88
2/11/14	880	132	133	$1,361	$218	$154	$1,734	$0	$1.97
3/12/14	960	132	133	$1,361	$238	$156	$1,755	$0	$1.83
4/10/14	1,040	132	133	$1,359	$258	$162	$1,779	$0	$1.71
5/12/14	840	134	134	$1,369	$208	$147	$1,725	$0	$2.05
6/11/14	960	132	133	$1,363	$238	$167	$1,769	$0	$1.84
7/11/14	83,800	131	132	$1,357	$20,785	$9,599	$31,741	$0	$0.38
8/11/14	97,360	132	133	$1,361	$24,148	$11,398	$36,908	$0	$0.38
9/11/14	93,000	132	133	$1,359	$23,067	$10,039	$34,465	$0	$0.37
10/11/14	93,280	130	132	$1,349	$23,137	$9,521	$34,007	$0	$0.36
11/10/14	89,720	129	131	$1,347	$22,254	$8,467	$32,067	$0	$0.36
12/10/14	89,720	129	131	$1,347	$22,254	$8,467	$32,067	$0	$0.36
Totals/Avg	**552,120**	**131**	**132**	**$16,291**	**$136,944**	**$58,396**	**$211,632**	**$0**	**$1.21**

A summary of 2014 pump hours and flow data is shown below in Table 7.6.

Table 7.6: Honokaa Well 2014 Run Time and Pumpage

Month	Monthly Energy Use (kWh)	Monthly Net Bill	Well Hours	Well Pumpage (kgal)	Average GPM	kWh/kgal	Cost/kgal	Pump kW from hours and billed usage	Calculated Pump Efficiency
Jan-14	560	$1,614	0	0					
Feb-14	880	$1,734	0	0					
Mar-14	960	$1,755	0	0					
Apr-14	1,040	$1,779	0	0					
May-14	840	$1,725	0	0					
Jun-14	960	$1,769	0	0					
Jul-14	83,800	$31,741	0	0					
Aug-14	97,360	$36,908	0	0					
Sep-14	93,000	$34,465	0	0					
Oct-14	93,280	$34,007	743	13,917	312	6.7	2.4	126	74%
Nov-14	89,720	$32,067	719	12,960	300	6.9	2.5	125	71%
Dec-14	89,720	$32,067	719	12,960	300	6.9	2.5	125	71%
Totals/Avg	**552,120**	**$211,632**	**2181**	**39,837**	**304**	**6.8**	**2.5**	**125**	**72%**

The three months of data collected for 2014 was used to estimate the average well efficiency to be 72%. This coincided with the testing performed at the well site. Even though the well has a higher efficiency than the Haina Well, the cost/kgallon pumped was similar. $2.30 for the Haina Well and $2.50 for the Honokaa Well. However this does not include the extra ~$5,000/month for the Haina Boosters which drives the total cost up to $2.80 /kgal for the Haina System.

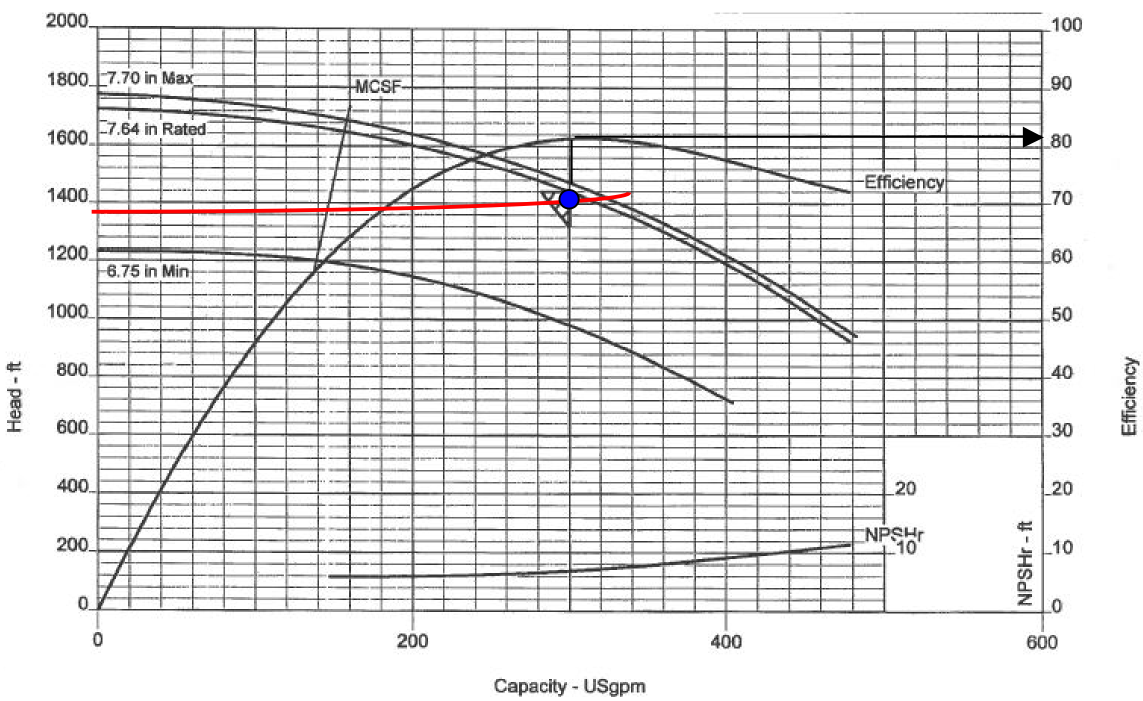
Pump Testing

To evaluate existing well performance, we collected flow data using the existing flow meter. Power was measured with a Fluke 43B kW meter, and discharge pressure was determined using a Fluke PV-350 pressure transducer. The data is summarized below in Table 7.7

Table 7.7: Honokaa Well Test Data

Pump Measurements / Calculations	Data
Total Flow (gpm)	300
Discharge Pressure (psi)	7.8
Baseline Ground Elevation (ft)	1334
Tank Water Level Elevation (ft)	1350
Well Depth to Baseline (ft)	1400
Static Head (ft)	1416
Gauge Height from Baseline (ft)	2
Estimated Column/Velocity Losses (ft) 1ft/100ft	14
Estimated Total Head (ft): P * 2.31 + well depth + losses)	1434
Total Measured Power (kW)	128.2
Estimated Motor Efficiency (%)	89%
Calculated Pump Efficiency	**71%**
Original Pump Efficiency at Flowrate	**81%**

Figure 7.2: Honokaa Pump Curve



Observations and Proposed Recommendations

Recommendations are provided for all three wells at the end of Section 7.1.3

7.1.3 Ahualoa Well

The Ahualoa Well is rated for approximately 775 gpm @ 1370' TDH and is equipped with a 2300V, 400 hp submersible motor. The well pumps to the one million gallon Ahualoa Tank and is activated at a tank level of 16' and shuts off at 20'.

DWS staff indicated that the well's usage has not been firmly defined. The Microlab's preferred operation is to use the well on a regular basis to minimize the problems with disinfection by-products. The Operations Department indicated that they prefer to use the Waimea Water Treatment Plant water to reduce system energy costs with the well only used in drought conditions. If the treatment plant water was used as the primary water source (and Ahualoa Well as the backup), an ammonia injection system would be needed for the well since the treatment plant uses chloramines as the primary disinfectant.

A summary of 2014 energy use data from facility spreadsheets is shown below in Table 7.8.

Table 7.8: Ahualoa Well 2014 Energy Use and Costs

Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill	Rider M Discount	Power Factor Penalty	Net Cost/ kWh
1/13/14	73,200	297	298	$5,803	$15,971	$7,105	$28,879	$0	TBD	$0.39
2/11/14	63,200	297	297	$5,799	$13,789	$6,485	$26,073	$0	TBD	$0.41
3/12/14	79,200	297	297	$5,799	$17,280	$7,601	$30,681	$0	TBD	$0.39
4/10/14	61,200	287	297	$5,799	$13,353	$5,812	$24,964	$0	TBD	$0.41
5/12/14	72,400	297	297	$5,799	$15,797	$7,036	$28,632	$0	TBD	$0.40
6/11/14	116,800	297	297	$5,795	$25,484	$12,113	$43,392	$0	TBD	$0.37
7/11/14	23,600	296	297	$5,792	$5,149	$2,858	$13,798	$0	TBD	$0.58
8/11/14	800	2	298	$6,203	$0	$0	$6,203	$0	TBD	
9/11/14	0	0	298	$6,203	$0	$0	$6,203	$0	TBD	
10/11/14	0	0	297	$6,195	$0	$0	$6,195	$0	TBD	
11/10/14	0	0	297	$6,195	$0	$0	$6,195	$0	TBD	
12/10/14	0	0	297	$6,195	$0	$0	$6,195	$0	TBD	
Totals/Avg	**490,400**	**172**	**297**	**$71,580**	**$106,823**	**$49,009**	**$227,412**	**$0**	**TBD**	**$1.34**

A summary of 2014 pump hours and flow data is shown below in Table 7.9.

Table 7.9: Ahualoa Well 2014 Hours and Pumpage

Month	Monthly Energy Use (kWh)	Monthly Bill	Well Hours	Well Pumpage (kgal)	Average GPM	kWh/kgal	Cost/kgal
Jan-14	73,200	$28,879	230	10,459	758	7.0	2.8
Feb-14	63,200	$26,073	212	9,631	757	6.6	2.7
Mar-14	79,200	$30,681	263	11,913	755	6.6	2.6
Apr-14	61,200	$24,964	202	9,000	743	6.8	2.8
May-14	72,400	$28,632	0	0			
Jun-14	116,800	$43,392	0	0			
Jul-14	23,600	$13,798	0	0			
Aug-14	800	$6,203	0	0			
Sep-14	0	$6,203	0	0			
Oct-14	0	$6,195	0	0			
Nov-14	0	$6,195	0	0			
Dec-14	0	$6,195	0	0			
Totals/Avg	**490,400**	**$227,412**	**907**	**41,003**	**753**	**6.8**	**2.7**

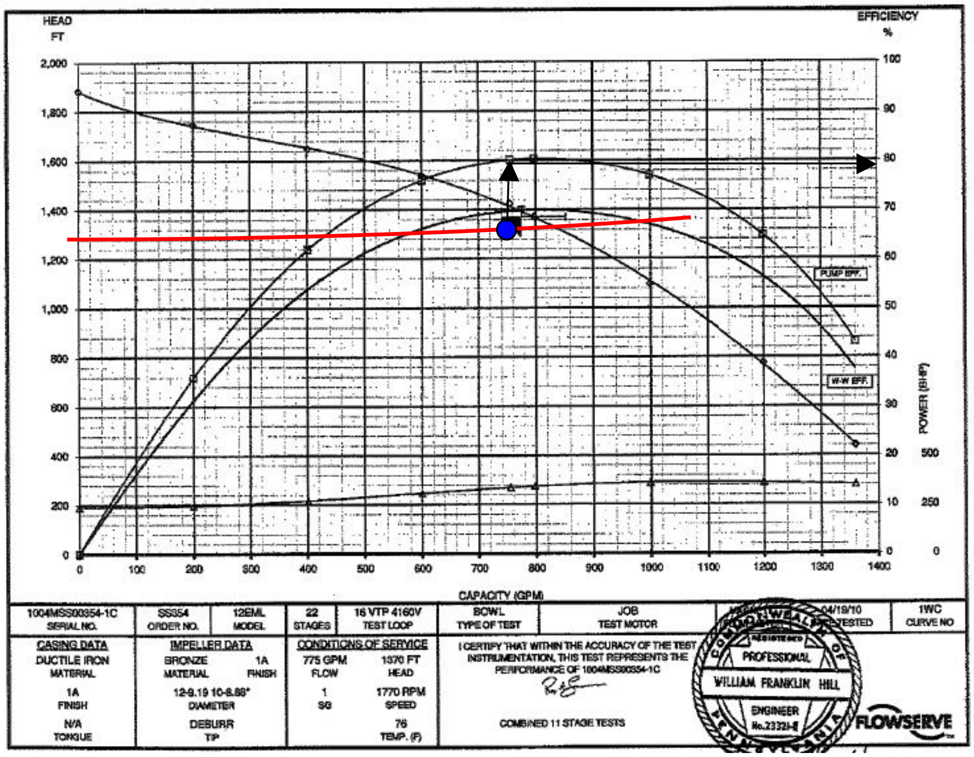
Well Pump Testing

The well was not available during the site visit (air bound issues). To estimate efficiency we used the average kW value from the power bills, calculated head based on well/tank elevations and used average flow from the pumpage reports.

Table 7.10: Ahualoa Well Test Data

Pump Measurements / Calculations	Data
Total Flow (gpm)	753
Discharge Pressure (psi)	13
Baseline Ground Elevation (ft)	2599
Tank Water Level Elevation (ft)	2630
Well Depth to Baseline (ft)	1281
Static Head (ft)	1312
Gauge Height from Baseline (ft)	2
Estimated Column/Velocity Losses (ft) 1ft/100ft	12.81
Estimated Total Head (ft): P * 2.31 + well depth + losses)	1326
Total Measured Power (kW)	301
Estimated Motor Efficiency (%)	87%
Calculated Pump Efficiency	**72%**
Original Pump Efficiency at Flowrate	**79%**

Figure 7.3: Ahualoa Well Pump Curve



As shown in Figure 7.3, the 72% calculated efficiency is not too far off the original pump efficiency of 79% determined from the pump curve.

Observations and Proposed Recommendations for the Three Wells

DWS staff indicated that once the Haina Well is repaired, it would be run as the primary well for the one-year warranty period. After the one-year period, the Honokaa Well would most likely be used as the primary well. As discussed, the Ahualoa Well operation has not been firmly defined based on the issue of disinfection by-products if the well was used as a backup to the Waimea Plant.

Based on the above considerations, we have recommended the following improvements:

- The use of flow from the Waimea Treatment Plant provides significant savings. Although droughts will affect the water supply during certain times of the year, the availability of higher flows after the treatment plant upgrades are completed should be fully utilized. The potential savings for using treatment plant water to minimize use of the three wells and the booster pumps 80% of the time would be approximately $320,000 annually. This does not include demand charges for each station, which would still be charged by HELCO since the wells would be exercised on a regular basis. We believe the savings justify the cost of ammonia injection systems at the wells and have provided a cost/benefit review in OM #3.

- As part of the above effort, we also recommend installing VFDs for the wells. This will allow the wells to be exercised on a regular basis (at lower flows) without getting penalized for higher demand based on only operating the pump for a few hours/month. Even during droughts the VFD maximum speed could be adjusted to maintain the wells at a lower demand level. This will not save kWh since the wells would be operating at a reduced efficiency, but this will have a minimal effect on overall cost if the wells are primarily used as back up to the treatment plant water source. This improvement would also allow the DWS to switch the Ahualoa Well from Rate Schedule P to Rate Schedule J to reduce demand charges from $19.50/kW to $10.25/kW. This measure is reviewed as part of ESM #5.

- If the wells are used intermittently only during droughts and for exercising, the hours will be low enough to not qualify for Rider M. However, if OM #3 is not pursued, we would expect that two of the wells would qualify for a four hour Rider M. Savings for this alternative option would be as follows (assuming the Ahualoa Well would still be on Rate Schedule P):

  Ahualoa Well: 296 kW * 19.50/kW * 75% * 12 months = $51,900
  Haina or Honokaa Well: 120 kW * 10.50/kW * 75% * 12 months = $11,340

  ESM #4 would need to be modified to include the above stations.

- Power factor (and credit/cost penalties) were not included on the DWS energy reports (most likely just needs to have a column added). If we assume the existing well power factor of 0.85, installing capacitors to improve to the power factor to 0.95 would provide the following savings:

  Ahualoa Well: $1,784 (this was only for 6 months usage in 2014)
  Haina Well: $549
  Honokaa Well: $1,532

  These savings are not as high as some of the high-energy wells and would be even lower if OM #3 is implemented. Based on this, this is not a high priority project to pursue at this time.

- Well efficiency is more than 10% lower than the original curve values for the Haina and Honokaa Wells. Based on the expectation that OM #3 (using more Waimea water) will be pursued and the current repairs being done for the Haina Well will improve efficiency, we have not recommended pursuing additional efficiency improvements at this time.

7.2 Kukuihaele System

The Kukuihaele water system is located along the Honokaa-Waipio Road at Mud Lane. This water system serves Zones 4700 and 4750 and includes two booster pump stations and two tanks. The system was served by the Waiulili spring until an earthquake disrupted the water source. To provide service to the system, the DWS installed 30,000’ of 3” line from the Mudlane (Puukapu/Ahualoa) Tank to the Kukuihaele Tank. The water is supplied from the Waimea Water Treatment Plant. The new system configuration will not require the use of the Kukuihaele (Mastranado) Boosters.

7.3 Paauilo System

The Paauilo water system is located along Mamalahoa Highway at Pohakea Road. The service area extends from Paauilo Village to Kaao with elevations ranging from 281 to 1,055 feet and is served by the Paauilo Deep Well. The Well is rated for 300 gpm at 1100' TDH and is equipped with a 125 hp motor. The Paauilo system is connected by a one-way intertie with the Haina water system. When needed, this connection allows water to flow from Haina to Paauilo.

A summary of 2014 energy use data from facility spreadsheets is shown below in Table 7.12.

Table 7.12: Paauilo Well 2014 Energy Use and Costs

Billing Date	Total kWh	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill	Rider M Discount	Net Bill	Net Cost/ kWh
1/28/14	11,800	105	106	$1,082	$2,927	$394	$4,403	$798	$3,605	$0.31
2/26/14	10,200	104	106	$1,081	$2,530	$341	$3,952	$783	$3,169	$0.31
3/27/14	9,200	104	106	$1,081	$2,282	$167	$3,531	$770	$2,761	$0.30
4/28/14	10,600	103	105	$1,080	$2,629	$313	$4,022	$752	$3,271	$0.31
5/28/14	11,000	104	105	$1,078	$2,728	$460	$4,267	$699	$3,568	$0.32
6/26/14	11,600	104	105	$1,076	$2,877	$618	$4,571	$713	$3,859	$0.33
7/28/14	12,800	104	105	$1,079	$3,175	$815	$5,069	$710	$4,360	$0.34
8/27/14	10,800	104	105	$1,078	$2,679	$616	$4,373	$709	$3,664	$0.34
9/26/14	11,800	104	105	$1,078	$2,927	$528	$4,533	$793	$3,740	$0.32
10/28/14	12,000	105	105	$1,078	$2,976	$1,007	$5,062	$270	$4,792	$0.40
11/25/14	9,400	104	105	$1,077	$2,332	$141	$3,550	$792	$2,759	$0.29
11/25/14	9,400	104	105	$1,077	$2,332	$141	$3,550	$792	$2,759	$0.29
Total/Avg	**130,600**	**104**	**105**	**$12,949**	**$32,393**	**$5,541**	**$50,883**	**$8,578**	**$42,305**	**$0.32**

A summary of 2014 pump hours and flow data from the DWS Pumpage Report is shown in Table 7.13.

Table 7.13: Paauilo Well 2014 Hours and Pumpage

Month	Total kWh	Monthly Net Bill	Well Hours	Well Pumpage	Average Well GPM
Jan-14	11,800	$3,605	109	855	130
Feb-14	10,200	$3,169	90	1,736	320
Mar-14	9,200	$2,761	94	1,657	295
Apr-14	10,600	$3,271	94	1,689	299
May-14	11,000	$3,568	109	1,958	301
Jun-14	11,600	$3,859	112	2,042	303
Jul-14	12,800	$4,360	119	2,181	305
Aug-14	10,800	$3,664	98	1,782	303
Sep-14	11,800	$3,740	122	2,218	302
Oct-14	12,000	$4,792	106	1,927	302
Nov-14	9,400	$2,759	97	1,751	301
Dec-14	9,400	$2,759	99	1,792	303
Totals/Avg	**130,600**	**$42,305**	**104**	**1,799**	**289**

Well Testing

To evaluate existing well performance, we collected flow using the existing meter, power was measured with a Fluke 43B kW meter, and discharge pressure was measured with a pressure transducer. The results are summarized below.

Table 7.14: Paauilo Well Test Data

Pump Measurements / Calculations	Data
Total Flow (gpm)	335
Discharge Pressure (psi)	7.1
Baseline Ground Elevation (ft)	1054
Tank Water Level Elevation (ft)	1070
Well Depth to Baseline (ft)	1098
Static Head (ft)	1114
Gauge Height from Baseline (ft)	2
Estimated Column/Velocity Losses (ft) 1ft/100ft	10.98
Estimated Total Head (ft): P * 2.31 + well depth + losses)	1127
Total Measured Power (kW)	101.2
Estimated Motor Efficiency (%)	92%
Calculated Pump Efficiency	**76%**

Observations and Proposed Recommendations

Based on the energy and runtime/pumpage data, the following was noted:

- The well is operated approximately 100 hours/month. The DWS is fortunate that even with low operating hours, the well qualified for 4-hour Rider M rate resulting in over $8500 saved in 2014.

- The tested pump efficiency was 76%, which is reasonable for a pump this size. We did not have a pump curve to determine how close this was to the original pump efficiency but even if it exceeds 80% the low operating hours would not justify improvements.

- Although the best opportunity for savings is to simply use more water from the Waimea Treatment Plant (after the upgrade work is completed), the low operating hours does not make this a high priority area since Rider M reduces demand charge considerably.

We have no energy saving recommendations for this pump system.

SECTION 8. NORTH KOHALA SYSTEM

The North Kohala system is part of District II and includes the Makapala, Hawi and Halaula systems. Table 8.1 is a summary of the electric accounts and energy usage and costs.

Table 8.1: North Kohala Energy Accounts

Tank or Pump Station	2013 kWh	2013 Cost	2014 kWh	2014 Cost
Kapaau	0	$378	0	$378
Makapala Well	36,820	$16,047	34,463	$15,211
Medeiros Boosters	142,840	$55,455	111,040	$44,692
Karpovich Boosters	109,560	$42,637	95,680	$38,968
Kaauhuhu Hstd Res #1	0	$378	0	$378
Hawi Well #B and Boosters	927,400	$334,216	892,400	$324,308
Hawi Well #A	252,200	$110,596	212,700	$97,602
Halaula Chlor Station	0	$0	0	$0
Kaauhuhu Homestead Tank	0	$0	0	$0
Total	**1,468,820**	**$559,707**	**1,346,283**	**$521,537**

The pump system high-energy accounts (above $25,000) are reviewed in this section.

8.1 North Kohala Spring/Surface Water Sources

In the past the North Kohala water system was supplied with multiple surface water sources shown in Table 8.2.

Table 8.2: North Kohala Spring/Surface Sources

Water Source	Status on Drawing	Type	1994 Flow Data (MGD)	80% of Rated Flow (annual flow)	DWS Notes
Lindsey	Line cut	Tunnel	.093	27.2 mg	
Watt #1	Line cut	Tunnel	.175	51.1 mg	Turned back over to private land owner
Hapahapai	Line cut	Spring	.045	13.4 mg	Turned back over to private land owner
Kohala #5	Line cut	Unknown	No Data	--	
Bond #1	Line cut	Tunnel	.200	58.4 mg	
Murphy Tunnel	Line cut	Tunnel	.07	20.4 mg	
Maulua	Unkown	Tunnel	No Data	--	

In the 1990s, more stringent federal surface water regulations were adopted as part of the Surface Water Treatment Rule (SWTR). Over time, the DWS made the decision to abandon the surface water sources that would have required water treatment systems and install more deep wells to satisfy water demands.

Although it may be a significant effort to bring the tunnel/spring sources back on line, having more detailed task and cost data specific to each source would provide the DWS with the information needed to make an informed decision. As a first step in this process, we have provided approximate energy savings that could potentially be realized. This is only for reducing well energy use and does not include annual O&M costs that may be required if any of the site requires a packaged water treatment plant.

Based on 80% of the Lindsey, Watt, Hapahapai, and Bond water source capacity, the potential exits to contribute 150 million gallons annually to the system. Using the Hawi Well energy cost of $1500/million gallons, the following energy savings could be realized:

<u>Hawi Deep Wells:</u>

Annual tunnel/spring flow: 150 MG
Energy pumping cost: $1,500/MG
North Kohala well pumpage: 240 MG
Potential annual energy savings: $225,000

The 1500/MG was based on data in Tables 8.6 and 8.9. Based on the above potential savings, we have recommended a more detailed review of these sources as part of EMP #4.

<u>Makapala Deep Well:</u>

Annual tunnel/spring flow: 20.4 MG
Well energy pumping cost: $1,700/MG
Makapala annual pumpage: 7.5 MG
Potential annual energy savings: $15,211

Based on the above review, the energy saved by using the Murphy Tunnel would not make it worthwhile to pursue the use of this water source.

8.2 Makapala-Niulii System

The Makapala-Niulii water system is located along the Akoni Pule Highway. The system includes one tank, one spring and a deepwell. The Murphy Tunnel was the original source of supply for this system at elevation 1300 ft and had rated capacity of 60 gpm but was determined to be under surface influence by the DoH and could not be used without treatment. Based on this, the line was cut and the source was turned over to the landowner. In 2005, the DWS developed the Makapala Well to provide a regular source of supply. A summary of the well energy use in 2014 is shown in Table 8.3.

Table 8.3: Makapala Well 2014 Energy and Cost Data

Billing Date	Total kWh	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill	Net Cost/ kWh
1/13/14	3,250	13.3	0.0	$0	$1,027	$412	$1,438	$0.44
2/11/14	2,401	13.4	0.0	$0	$758	$296	$1,055	$0.44
3/12/14	2,541	13.2	0.0	$0	$803	$329	$1,131	$0.45
4/10/14	2,759	13.5	0.0	$0	$871	$326	$1,197	$0.43
5/12/14	2,816	13.8	0.0	$0	$889	$333	$1,223	$0.43
6/11/14	3,430	13.7	0.0	$0	$1,083	$412	$1,496	$0.44
7/11/14	3,035	13.3	0.0	$0	$959	$400	$1,359	$0.45
8/11/14	2,489	13.2	0.0	$0	$786	$349	$1,135	$0.46
9/11/14	2,926	13.3	0.0	$0	$924	$404	$1,329	$0.45
10/11/14	3,069	13.4	0.0	$0	$969	$387	$1,357	$0.44
11/10/14	2,906	13.2	0.0	$0	$918	$358	$1,275	$0.44
12/10/14	2,841	13.7	0.0	$0	$897	$319	$1,216	$0.43
Totals/Avg	**34,463**	**13.4**	**0.0**	**$0**	**$10,885**	**$4,325**	**$15,211**	**$0.44**

A summary of 2014 pump hours and flow data is shown below in Table 8.4.

Table 8.4: Makapala Well 2014 Run Time and Pumpage

Month	Total kWh	Monthly Bill	Well #1 Hours	Well #1 Pumpage (kgal)	Spring Pumpage (kgal)	Average GPM	kWh/ kgal	Cost/ kgal
Jan-14	3,250	$1,438	165	658	0	66	16.0	2.2
Feb-14	2,401	$1,055	166	665	0	67	13.0	1.6
Mar-14	2,541	$1,131	202	806	0	67	13.1	1.4
Apr-14	2,759	$1,197	0	0	796	18	0.0	
May-14	2,816	$1,223	224	891	0	66	12.2	1.4
Jun-14	3,430	$1,496	229	913	0	67	12.3	1.6
Jul-14	3,035	$1,359	178	708	0	66	15.4	1.9
Aug-14	2,489	$1,135	169	673	0	66	11.9	1.7
Sep-14	2,926	$1,329	0	0	1038	24	0.0	0.0
Oct-14	3,069	$1,357	217	826	0	64	10.8	1.6
Nov-14	2,906	$1,275	181	712	0	66	10.3	1.8
Dec-14*	2,841	$1,216	*181*	*712*	*0*	*66*	*14.8*	*1.7*
Totals/Avg	**34,463**	**$15,211**	**1912**	**7564**	**1834**	**58**	**11**	**$1.7**

* December hours/pumpage data estimated

Although there was flow recorded for the Murphy Tunnel on the pumpage report (as shown in Table 8.4), staff indicated that this was an error and no flow was used from this spring source.

Observations and Proposed Recommendations

We did not identify any energy saving recommendations for this system.

8.3 Hawi and Halaula System

The Hawi water system extends from Puakea Bay to the west, Hoea Makai Road to the north, Kaauhuhu Homesteads to the south, and the connection with the Halaula water system to the east. All water is supplied from the two Hawi deep wells, and approximately 70 percent of customers require no further pumping.

The Halaula water system is connected to the Hawi water system and receives all of its water supply from Hawi. The water system serves the Ainakea Village subdivision, the community of Halawa, and customers along Akoni Pule Highway, Mill Road, and Maulili Road. There is no additional pumping in this water system, and only one operational zone.

8.3.1 Hawi Well A

The Hawi Well A account is billed on HELCO Rate Schedule J. The well is equipped with a 200 hp submersible motor and is rated to pump 700 gpm @ 900’ TDH. Energy use data from the electric bills is shown below in Table 8.5. This well is typically used as a backup to Hawi Well B and is activated at 10.5’ and shuts off at 13.5’ (Hawi Well B comes on at 11.5’ and shuts off at 13.5’).

Table 8.5: Hawi Well A 2014 Energy Use and Costs

Billing Date	Total kWh	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Rider M Discount	Power Factor Adjustment	Total Bill	Net Cost/ kWh
1/13/14	18,300	182	182	$1,866	$4,539	$1,955	$0	$0	$8,359	0.46
2/11/14	15,200	182	182	$1,866	$3,770	$1,518	$0	$0	$7,153	0.47
3/12/14	17,800	182	182	$1,866	$4,415	$1,900	$0	$0	$8,180	0.46
4/10/14	14,500	182	182	$1,866	$3,596	$1,430	$0	$0	$6,891	0.48
5/12/14	17,100	182	182	$1,866	$4,241	$1,693	$0	$0	$7,799	0.46
6/11/14	17,100	182	182	$1,866	$4,241	$1,797	$0	$0	$7,904	0.46
7/11/14	17,300	182	182	$1,866	$4,291	$1,979	*$0*	$0	$8,135	0.47
8/11/14	17,400	182	182	$1,866	$4,316	$2,064	$0	$0	$8,245	0.47
9/11/14	17,500	182	182	$1,866	$4,341	$2,083	$0	$0	$8,288	0.47
10/11/14	18,100	182	182	$1,866	$4,489	$1,954	$0	$0	$8,308	0.46
11/10/14	14,900	182	182	$1,866	$3,696	$1,549	$0	$0	$7,109	0.48
12/10/14	27,500	182	182	$1,866	$6,821	$2,538	$0	$0	$11,224	0.41
Totals/Avg	**212,700**	**182.0**	**182**	**$22,386**	**$52,757**	**$22,459**	**$0**	**$0**	**$97,602**	**0.46**

A summary of 2014 pump hours and flow data is shown below in Table 8.6.

Table 8.6: Hawi Well A 2014 Hours and Pumpage

Month	Total kWh	Monthly Bill	Well #1 Hours	Well #1 Pumpage (kgal)	Average GPM	kWh/ kgal	Cost/ kgal
Jan-14	18,300	$8,359	90.5	4277	788	4.3	2.0
Feb-14	15,200	$7,154	90.6	4282	788	3.5	1.7
Mar-14	17,800	$8,181	81	3824	787	4.7	2.1
Apr-14	14,500	$6,892	93.5	4325	771	3.4	1.6
May-14	17,100	$7,800	91.8	4332	786	3.9	1.8
Jun-14	17,100	$7,904	92.9	4386	787	3.9	1.8
Jul-14	17,300	$8,136	99	4672	787	3.7	1.7
Aug-14	17,400	$8,245	87.8	4143	786	4.2	2.0
Sep-14	17,500	$8,289	100.1	4718	786	3.7	1.8
Oct-14	18,100	$8,309	89.5	4223	786	4.3	2.0
Nov-14	14,900	$7,110	144.9	6814	784	2.2	1.0
Dec-14	27,500	$11,224	144.9	6814	784	4.0	1.6
Totals/Avg	**212,700**	**$97,602**	**1062**	**49,996**	**785**	**4.3**	**2.0**

<u>Well Pump Testing</u>

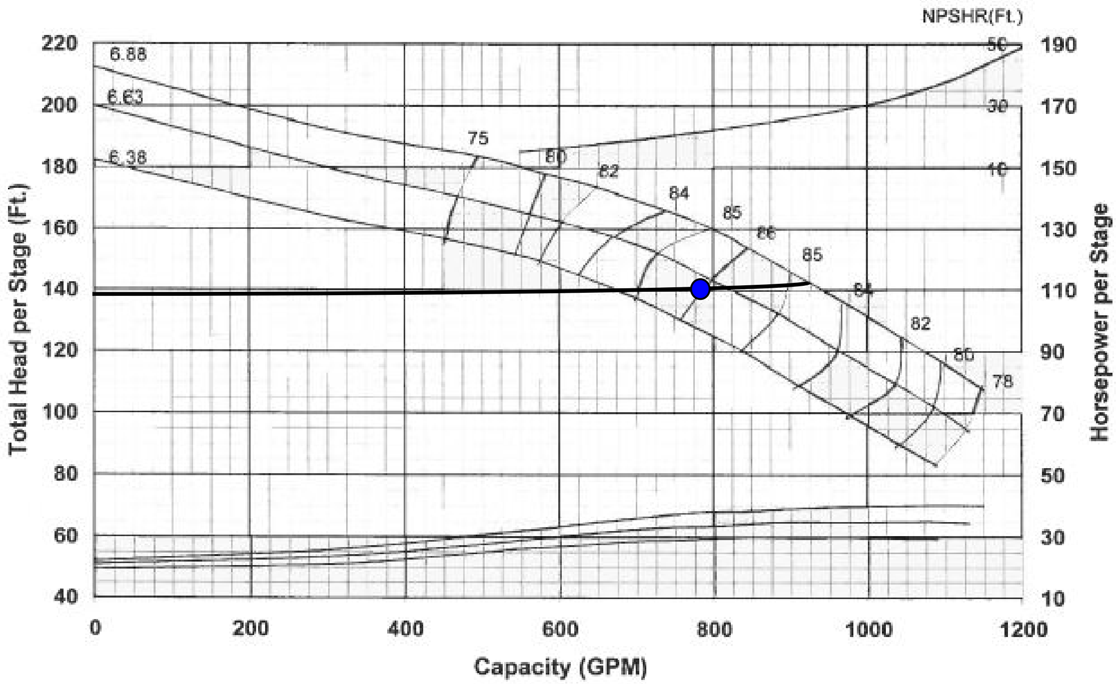
To evaluate existing well performance, we collected instantaneous flow using the existing flow meter. Power was measured with a Fluke 43B kW meter, and discharge pressure was determined using a Fluke PV-350 pressure transducer.

Table 8.7: Hawi Well A Test Data

Pump Measurements / Calculations	Data
Total Flow (gpm)	790
Discharge Pressure (psi)	117
Baseline Ground Elevation (ft)	542
Tank Water Level Elevation During Test (ft)	808
Well Depth to Baseline (ft)	566
Static Head (ft)	832
Gauge Height from Baseline (ft)	2
Estimated Column/Velocity Losses (ft) 1ft/100ft	5.66
Estimated Total Head (ft): P * 2.31 + well depth + losses)	844
Total Measured Power (kW)	179
Estimated Motor Efficiency (%)	91%
Calculated Pump Efficiency	**77%**
Curve Pump Efficiency	**86%**

The data indicated that Hawi Well A was operating close to the original pump curve efficiency.

Figure 8.1: Hawi Well A Pump Curve



Observations and Proposed Recommendations for Hawi Well A

- Based on input from DWS staff, this well is typically used during the peak Rider M curtailment while Hawi #2 is turned off which results in low operating hours (less than 100 hours/month).
- The pump station has a lower kWh/kgal value than Hawi #2, but has a higher cost/kgal.
- There was no penalty for poor power factor since 85% was maintained, but the DWS could benefit with a discount of $750 if power factor was improved to 95% using power factor correction capacitors or with the application of a VFD.
- If a VFD is applied and used to operate Hawi Well A at a lower capacity, demand costs could be reduced if the hours are also reduced more by adjusting the tank setpoint values to not activate the pump until the level was lower. This improvement is included in ESM #5.

8.3.2 Hawi Well B & Boosters

The Hawi Well B account is also billed on HELCO Rate Schedule J. The well is equipped with a 200 hp motor and is rated to pump 700 gpm @ 875’ TDH. This station also includes three 40 hp booster pumps rated for 300 gpm @ 350’ TDH. Energy use data from the electric bills is shown below in Table 8.8.

Table 8.8: Hawi Well B 2014 Energy Use and Costs

Billing Date	Total kWh	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Rider M Discount	Power Factor Adjustment	Total Bill	Net Cost/ kWh
1/13/14	83,800	194	200	$2,051	$20,785	$7,671	$1,253	$91	$30,508	0.36
2/11/14	73,400	195	199	$2,041	$18,206	$5,844	$1,213	$81	$26,090	0.36
3/12/14	83,600	195	198	$2,026	$20,736	$7,597	$1,252	$91	$30,359	0.36
4/10/14	74,000	194	196	$2,005	$18,354	$5,900	$1,215	$81	$26,259	0.35
5/12/14	65,800	195	195	$2,001	$16,321	$5,165	$1,214	$92	$23,486	0.36
6/11/14	80,000	192	195	$1,999	$19,843	$6,953	$1,249	$87	$28,795	0.36
7/11/14	79,400	192	194	$1,989	$19,694	$7,684	$1,233	$87	$29,366	0.37
8/11/14	79,000	191	194	$1,984	$19,595	$7,981	$1,227	$86	$29,560	0.37
9/11/14	76,000	192	194	$1,985	$18,851	$7,768	$1,229	$104	$28,604	0.38
10/11/14	72,400	192	194	$1,987	$17,958	$6,493	$1,231	$80	$26,438	0.37
11/10/14	67,200	192	194	$1,987	$16,668	$5,681	$1,231	$93	$24,336	0.36
12/10/14	57,800	192	195	$2,000	$14,336	$4,170	$1,251	$82	$20,506	0.35
Totals/Avg	**892,400**	**193**	**196**	**$24,056**	**$221,345**	**$78,907**	**$14,797**	**$1,056**	**$324,308**	**0.36**

A summary of 2014 pump hours and flow data from the DWS Pumpage Report is shown below.

Table 8.9: Hawi Well B Hours & Pumpage

Month	Total kWh	Monthly Net Bill	Well Hours	Well Pumpage	Average GPM	kWh/ kgal	Cost/ kgal
Jan-14	83,800	$30,508	420	17,511	694	4.8	1.7
Feb-14	73,400	$26,090	406	16,838	692	4.4	1.5
Mar-14	83,600	$30,359	438	18,136	691	4.6	1.7
Apr-14	74,000	$26,259	363	14,956	686	4.9	1.8
May-14	65,800	$23,486	452	18,652	688	3.5	1.3
Jun-14	80,000	$28,795	420	17,457	693	4.6	1.6
Jul-14	79,400	$29,366	447	18,520	690	4.3	1.6
Aug-14	79,000	$29,560	360	14,840	687	5.3	2.0
Sep-14	76,000	$28,604	463	19,147	689	4.0	1.5
Oct-14	72,400	$26,438	380	14,832	650	4.9	1.8
Nov-14	67,200	$24,336	298	27,812	1555	2.4	0.9
Dec-14	57,800	$20,506	*400*	*17,000*	708	3.4	1.2
Totals/Avg	**892,400**	**$324,308**	**4,447**	**198,701**	**760**	**4.3**	**1.5**

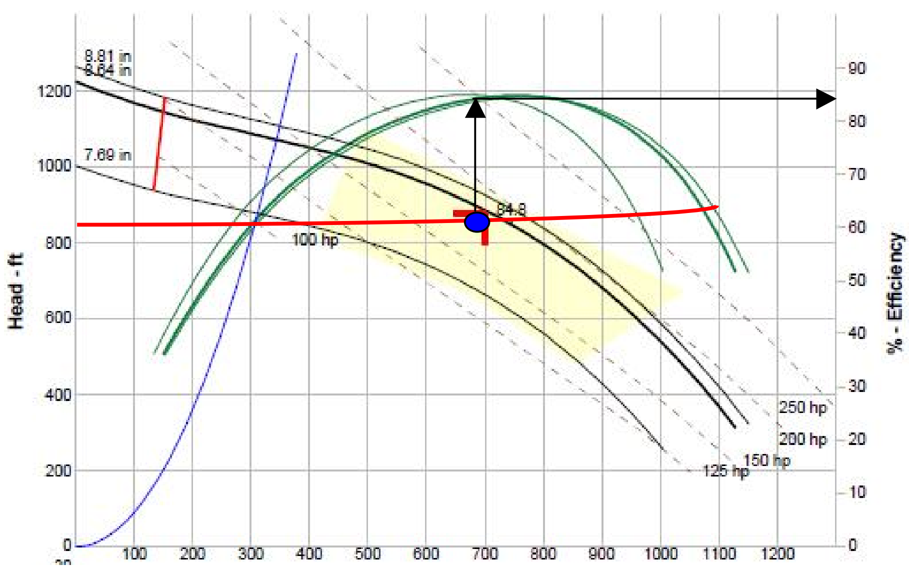
Well Pump Testing

To evaluate existing well performance, we collected instantaneous flow using the existing flow meter. Power was measured with a Fluke 43B kW meter, and discharge pressure was determined using a Fluke PV-350 pressure transducer.

Table 8.10: Hawi Well B Test Data

Pump Measurements / Calculations	Data
Total Flow (gpm)	690
Discharge Pressure (psi)	5
Baseline Ground Elevation (ft)	795
Tank Water Level Elevation During Test (ft)	808
Well Depth to Baseline (ft)	818
Static Head (ft)	831
Gauge Height from Baseline (ft)	2
Estimated Column/Velocity Losses (ft) 1ft/100ft	8.18
Estimated Total Head (ft): P * 2.31 + well depth + losses)	840
Total Measured Power (kW)	156
Estimated Motor Efficiency (%)	91%
Calculated Pump Efficiency	**77%**
Curve Pump Efficiency	**86%**

Figure 8.2: Hawi Well B Pump Curve



<u>Observations and Proposed Recommendations for Hawi Well B</u>

- The DWS saved $14,800 in 2014 by successfully applying the Rider M (4 hour) agreement to this account.
- The power factor was 81%, which is lower than the minimum 85% required by HELCO. This resulted in $1,056 in extra charges. The DWS could eliminate these charges and obtain an extra credit of $2,454 if power factor was improved to 95% using power factor correction capacitors or with the application of a VFD. For this station, we believe power factor capacitors would be a better choice since it is operated as the primary well. This improvement is included in ESM #1.

8.3.3 Hawi Well B Boosters

Booster Pumps A, B and C at the Hawi Pump Station have 40 hp motors and are each rated to pump 300 gpm @ 350' TDH. The energy use for the boosters is included in the Hawi Well B energy use in Table 8.8. A summary of 2014 pump hours and flow data is shown below in Table 8.11.

Table 8.11: Booster Energy Use Breakdown

Month	Bstr A Hours	Bstr B Hours	Bstr C Hours	Bstr A Pumpage	Bstr B Pumpage	Bstr C Pumpage	Average GPM	Estimated Monthly Energy Use (kWh)	Estimated Energy Cost for Boosters
Jan-14	32	0	332	0	0	5,949	299	9,456	$3,404
Feb-14	0	0	327	0	0	6,876	300	9,317	$3,354
Mar-14	1	0	334	0	0	5,979	299	9,508	$3,423
Apr-14	0	0	230	0	0	4,110	298	6,544	$2,356
May-14	1	0	302	6	0	5,438	300	8,618	$3,103
Jun-14	0	0	319	0	0	5,716	298	9,100	$3,276
Jul-14	1	0	307	8	0	5,490	298	8,738	$3,146
Aug-14	0	0	239	0	0	4,267	298	6,806	$2,450
Sep-14	0	0	290	0	0	*5,200*	299	8,259	$2,973
Oct-14	0	0	250	2	0	4,466	297	7,131	$2,567
Nov-14	0	0	226	0	0	4,029	297	6,438	$2,318
Dec-14	0	0	221	0	0	3,939	297	6,293	$2,265
Totals/Avg	**35**	**0**	**3,376**	**16**	**0**	**56,259**	**298**	**96,207**	**$34,635**

Only one pump was available for testing during the site visit. The remaining two boosters had maintenance issues. The data collected is summarized below.

Table 8.12: Booster Test Data

Pump Measurements / Calculations	Bstr C
Total Flow (gpm)	300
Discharge Pressure (psi)	152
Suction Pressure	5
Estimated Total Head (ft)	340
Static Head: El 1075 - 806	269
Total Measured Power (kW)	28.5
Estimated Motor Efficiency (%)	93%
Calculated Pump Efficiency	**72%**
Original Pump Efficiency at Flowrate	**N/A**

<u>Observations and Proposed Recommendations</u>

A pump curve was not available to compare the testing efficiency with the rated efficiency. However this was one of the few pump systems tested that had a significant amount of frictional head (71'). Based on this data, a VFD may be cost effective for Booster C. This will need to be reviewed in more detail to determine if the frictional losses are due to a local issue (Cla-valve) or if it is due to frictional head in the piping system. The original pump curve will also provide the data needed to evaluate the potential pump efficiency loss at lower flow rates.

8.3.4 Medeiros Booster

The Pump Station is billed on the HELCO Rate Schedule J. Pumps A and B have 20 hp motors and are rated for 150 gpm @ 361 feet TDH. Pump C has a rated capacity of 300 gpm and is equipped with a 50 hp motor. Energy use data from the HELCO electric bills is shown below in Table 8.13.

Table 8.13: Medeiros Booster Pumps 2014 Energy Use and Costs

Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill
1/2/14	12,600	33	39	$400	$3,125	$1,382	$4,907
1/31/14	9,760	46	46	$470	$2,421	$983	$3,874
3/3/14	11,360	46	46	$470	$2,818	$1,245	$4,533
4/1/14	9,640	33	39	$403	$2,391	$972	$3,766
5/1/14	7,480	33	39	$404	$1,855	$771	$3,031
6/2/14	9,320	33	39	$404	$2,312	$1,002	$3,717
7/1/14	10,320	33	40	$405	$2,560	$1,203	$4,168
7/31/14	8,720	33	39	$403	$2,163	$1,064	$3,630
9/2/14	8,640	33	39	$403	$2,143	$1,068	$3,614
10/1/14	8,040	33	39	$403	$1,994	$906	$3,303
10/30/14	7,680	33	39	$403	$1,905	$836	$3,144
12/1/14	7,480	33	39	$403	$1,855	$747	$3,005
Total/Avg	**111,040**	**35**	**40**	**$4,970**	**$27,542**	**$12,180**	**$44,692**

A summary of 2014 pump hours and flow data is shown below in Table 8.14.

Table 8.14: Medeiros 2014 Pump Hours and Flow

Month	Monthly Energy Use (kWh)	Monthly Net Bill	Bstr A	Bstr B	Bstr C	Total Pumpage	Average GPM
Jan-14	12,600	$4,907	10	0	316	5,620	296
Feb-14	9,760	$3,874	0	0	305	5,391	295
Mar-14	11,360	$4,533	2	0	313	5,521	294
Apr-14	9,640	$3,766	0	0	22	3,749	284
May-14	7,480	$3,031	0	0	256	4,512	294
Jun-14	9,320	$3,717	0	0	338	5,956	294
Jul-14	10,320	$4,168	0	0	237	4,160	293
Aug-14	8,720	$3,630	0	0	288	4,005	232
Sep-14	8,640	$3,614	0	0	249	4,370	293
Oct-14	8,040	$3,303	0	0	243	4,264	293
Nov-14	7,680	$3,144	0	0	198	3,476	293
Dec-14	7,480	$3,005	0	13	208	3,755	301
Totals/Avg	**111,040**	**$44,692**	**12**	**13**	**2,972**	**54,779**	**288**

Table 8.15: Medeiros Test Data

Pump Measurements / Calculations	Bstr C
Total Flow (gpm)	293
Discharge Pressure (psi)	167
Suction Pressure	2
Estimated Total Head (ft)	381
Static Head: El 1417-1075	342
Total Measured Power (kW)	30.6
Estimated Motor Efficiency (%)	93%
Calculated Pump Efficiency	**74%**
Original Pump Efficiency at Flowrate	**N/A**

Observations and Proposed Recommendations

We have no recommendations for this pump system

8.3.5 Karpovich Booster

The Karpovich Booster Pump Station is billed on the HELCO Rate Schedule J. Pumps A and B have 20 hp motors and are rated for 150 gpm @ 369 feet TDH. Pump C has a rated capacity of 300 gpm @ 406' TDH and is equipped with a 50 hp motor. Energy use data from the HELCO electric bills is shown below in Table 8.16.

Table 8.16: Karpovich Booster Pumps 2014 Energy Use and Costs

Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill
1/2/14	8,800	32	32	$327	$2,183	$985	$3,495
1/31/14	7,400	32	32	$327	$1,835	$761	$2,923
3/3/14	8,400	32	32	$329	$2,083	$937	$3,350
4/1/14	9,080	32	32	$328	$2,252	$919	$3,499
5/1/14	6,800	32	32	$330	$1,687	$707	$2,724
6/2/14	8,800	30	31	$320	$2,183	$950	$3,452
7/1/14	10,240	31	31	$322	$2,540	$1,195	$4,056
7/31/14	8,040	32	32	$327	$1,994	$986	$3,307
9/2/14	7,800	45	45	$462	$1,935	$970	$3,367
10/1/14	7,000	31	38	$388	$1,736	$797	$2,922
10/30/14	6,960	57	57	$581	$1,726	$764	$3,071
12/1/14	6,360	56	57	$579	$1,577	$645	$2,802
Total/Avg	**95,680**	**37**	**38**	**$4,621**	**$23,732**	**$10,615**	**$38,968**

A summary of 2014 pump hours and flow data is shown below in Table 8.17.

Table 8.17: Karpovich 2014 Pump Hours and Flow

Month	Monthly Energy Use (kWh)	Monthly Net Bill	Bstr A	Bstr B	Bstr C	Total Pumpage	Average GPM	kWh/1000 gallons
Jan-14	8,800	$3,495	0	0	248	4,045	272	2.2
Feb-14	7,400	$2,923	0	1	228	3,741	273	2.0
Mar-14	8,400	$3,350	0	210	91	4,160	230	2.0
Apr-14	9,080	$3,499	0	0	1	25	321	
May-14	6,800	$2,724	420	549	0	6,568	113	
Jun-14	8,800	$3,452	602	50	0	4,187	107	2.1
Jul-14	10,240	$4,056	437	9	3	2,928	109	3.5
Aug-14	8,040	$3,307	425	0	0	2,763	108	2.9
Sep-14	7,800	$3,367	407	0	0	2,947	121	2.6
Oct-14	7,000	$2,922	437	3	7	2,911	109	2.4
Nov-14	6,960	$3,071	349	0	0	2,232	106	3.1
Dec-14	6,360	$2,802	385	17	0	2,550	106	2.5
Totals/Avg	**95,680**	**$38,968**	**3,463**	**838**	**577**	**39,057**	**165**	**2.4**

Table 8.18: Karpovich Booster Test Data

Pump Measurements / Calculations	Bstr A
Total Flow (gpm)	115
Discharge Pressure (psi)	172
Suction Pressure	4
Estimated Total Head (ft)	388
Static Head: El 1765-1417	348
Total Measured Power (kW)	15
Estimated Motor Efficiency (%)	90%
Calculated Pump Efficiency	**62%**
Original Pump Efficiency at Flowrate	**N/A**

Observations and Proposed Recommendations

A pump curve was not available to compare the testing efficiency with the rated efficiency, but the calculated efficiency value was lower than expected. The system had 40' of frictional head, which may be worthwhile for a future VFD application. However, as discussed for the Hawi Well B Boosters, the potential measure needs to be reviewed in more detail to determine if the frictional losses are due to a local issue (Cla-valve) or if it is due to frictional head in the piping system. The original pump curve will also provide the data needed to evaluate the potential pump efficiency loss at lower flow rates.

The kWh/gallon value increased when Booster A was put on line. When this was compared with Booster C energy use (for the same pumpage), approximately 22,000 kWh could be saved annually. This measure is reviewed in OM #5.

SECTION 9. SOUTH KOHALA SYSTEM

The South Kohala system is part of District II and includes the Waimea and Lalamilo systems. Table 9.1 is a summary of the South Kohala electric accounts and 2013/2014 energy usage and costs.

Table 9.1: Parker Ranch Well Energy Use Breakdown

Service Account	2013 kWh	2013 Cost	2014 kWh	2014 Cost
Lalamilo Wells A,B,C,D	3,316,800	$1,273,871	3,302,400	$1,259,894
Parker Well #2	1,889,000	$652,829	3,005,000	$1,005,030
Parker Well #1	2,321,000	$832,166	956,000	$412,629
Lalamilo Parker Well #4	2,080,800	$772,742	2,141,200	$801,842
Lalamilo Parker Well #3	1,418,000	$548,415	1,745,200	$663,458
Kapiolani Rd	2,917,040	$1,065,162	2,630,880	$985,294
Parker Ranch Well	349,400	$189,130	1,152,600	$440,931
Uplands 404 Boosters	52,200	$25,290	54,000	$29,253
New Waimea Baseyard	41,960	$18,231	43,560	$19,001
Radio Base Station	957	$778	952	$780
Waimea WTP	42,960	$19,148	93,600	$37,681
Waimea WTP Sludge Pump	101,754	$39,065	93,584	$36,577
Lalamilo Parker Well 3&4 #319	276	$493	275	$494
Lalamilo Parker Well #3 Control	406	$548	390	$543
Lalamilo Parker Well #4 Control	545	$606	589	$626
Lalamilo Parker Well 3&4 #1103	425	$556	420	$555
Lalamilo Parker Well Resv #610	801	$713	812	$721
Total	**14,534,324**	**$5,439,743**	**15,221,462**	**$5,695,309**

The pump system high-energy accounts (above $25,000) are reviewed in this section.

9.1 Waimea System

The Waimea water system has seven tanks, one booster pump and is supplied by the Waimea Water Plant, the Parker Ranch Well and the Waimea Well.

The distribution system extends from the treatment plant down Kawaihae Road nearly to Kawaihae, and east to the Pukkapu Nienie, Kukuihaele system and Haina water systems in the Hamakua system. There are two effluent flow meters at the plant. The Kawaihae flow meter is typically 415 gpm and the Hamakua flow is approximately 1,100 gpm. There are also flow meters for the Kukuihaele system, Puukapu CCC station pumps to the Puukapu system, and Ahualoa meter for the Hamakua system.

9.1.1 Water Treatment Plant

The treatment plant surface water sources include the Waikoloa and Kohakohau streams. Marine Dam and Kohakohau Dam**,** which diverts water from the streams to the Waimea Treatment Plant. The rated capacity of the outlet structures for these two dams is 3,000 gpm.

Flow from the streams varies greatly with the weather. During extended drought periods, the supply is not sufficient to meet demands and large reservoirs are required to store water for use during drought periods.

The system has four reservoirs to store untreated water, with a total capacity of 158.5 MG (million gallons). Waikoloa Reservoir Nos. 1, 2, and 3 are concrete structures that have a capacity of 50 MG each. The fourth raw water storage reservoir, Reservoir No. 3**,** is a concrete reservoir with a capacity of 8.5 MG.

Treatment at the Waimea Water Treatment Plant consists of flocculation, settling, and sand filtration. The water is also disinfected and treated for corrosion control. There is one in-ground, 4 mg reservoir for treated water, Reservoir No. 2 (also called the clearwell) before it flows to the distribution system. Water supplied from the Parker Ranch and Waimea Well is blended with treated surface water in the treatment plant clearwell prior to distribution to the water system.

The DWS is currently upgrading the sand filter to a microfilter system that will use membrane filters to remove contaminants from water. The microfiltration system forces water through membrane pores to improve the removal of crystal salts and microorganisms from the surface water. The new plant is designed to handle an average flow of 4.0 MGD, but DWS staff indicated they expect to be limited by the available intake water and that an average of 3.0 MGD is a more realistic expectation of additional flow.

The pretreatment system will remain in place (coagulation and flocculation) even though the system is not needed for the new treatment process. It will be maintained to reduce maintenance and improve the life of the new filter system. There will be an increase in plant power consumption with the equipment, but this will be minimal compared to the significant savings that is expected by reducing the operating hours of the Waimea and Parker Ranch Wells. These pumps will most likely only be needed during drought conditions.

After the last reservoir, the raw water piping elevation drops over 230 feet as it is directed to the treatment process. In 1989, the DWS recognized that this was a suitable location for a hydro turbine and installed a Byron Jackson "VKW" three-stage turbine with 50 hp generator. The unit was originally designed to produce 32.7 kW of power based on a net head of 231'. After years of service, the Francis unit was replaced with a Pelton type turbine that improved peak generator production from 18 kW to 40 kW. The hydro turbine power generation feeds directly into the plant electrical system and offsets any plant energy consumption. Last year, the unit was turned off due to problems it was creating for the coagulation/flocculation system. The plant operators were having difficulty getting good floc and keeping the turbidity numbers down when while the hydro unit was online. Based on this issue, the unit will not be reactivated until the plant upgrade is completed. DWS staff expects the new filters to take care of the turbidity issues.

The secondary well sources for the Waimea Treatment Plant include the Parker Ranch Well and the Waimea Well. Water from both wells is blended with treated surface water in the treatment plant clearwell prior to distribution to the water system. DWS staff indicated that the practice of blending well water with the treatment plant water produces better quality water prior to distribution. In the future, chloramination equipment will be installed at the pump stations to allow the wells to pump directly into the distribution line.

9.1.2 Parker Ranch Well

The Parker Ranch Well (also known as the Puukapu Well) is rated for 500 gpm at 1,870 feet TDH. The pump is equipped with a 350 hp motor for 2300-volt service. A summary of 2014 energy use data from facility spreadsheets is shown below in Table 9.2.

Table 9.2: Parker Ranch Well 2014 Energy Use and Costs

Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill	Power Factor Charge	Rider M
1/13/14	204,600	304	315	$6,143	$44,640	$20,162	$70,945	$102	$0
2/11/14	211,200	304	315	$6,143	$46,080	$21,261	$73,484	$104	$0
3/12/14	211,600	304	315	$6,143	$46,168	$20,636	$72,947	$105	$0
4/10/14	210,800	304	315	$6,143	$45,993	$19,796	$71,932	$104	$0
5/12/14	233,600	304	315	$6,143	$50,968	$22,469	$79,579	$114	$0
6/11/14	78,600	304	315	$6,143	$17,149	$8,444	$31,735	$47	$0
7/11/14	200	304	315	$6,143	$44	$824	$7,010	$402	$0
8/11/14	400	304	315	$6,143	$87	$744	$6,974	$299	$0
9/11/14	400	64	326	$6,757	$0	$0	$6,757	$0	$0
10/11/14	400	64	326	$6,757	$0	$0	$6,757	$0	$0
11/10/14	400	118	308	$6,406	$0	$0	$6,406	$0	$0
12/10/14	400	118	308	$6,406	$0	$0	$6,406	$0	$0
Totals/Avg	**1,152,600**	**233**	**316**	**$75,466**	**$251,130**	**$114,335**	**$440,931**	**$1,277**	**$0**

The energy data shows that the pump operation was very consistent when it was on-line. A summary of 2014 pump hours and flow data from the DWS Pumpage Report is shown below in Table 9.3.

Table 9.3: Parker Ranch Well 2014 Hours and Pumpage

Month	Monthly Energy Use (kWh)	Monthly Net Bill	Well Hours	Well Pumpage	Average GPM	kWh/ kgal	Cost/ kgal
Jan-14	204,600	$70,945	720.9	23825	551	8.6	3.0
Feb-14	211,200	$73,484	671.1	22155	550	9.5	3.3
Mar-14	211,600	$72,947	739.7	24395	550	8.7	3.0
Apr-14	210,800	$71,932	724.5	23815	548	8.9	3.0
May-14	233,600	$79,579	717.7	23508	546	9.9	3.4
Jun-14	78,600	$31,735	0	0			
Jul-14	200	$7,010	0.6	712			
Aug-14	400	$6,974	0	0			
Sep-14	400	$6,757	0	0			
Oct-14	400	$6,757	0	0			
Nov-14	400	$6,406	0	0			
Dec-14	400	$6,406	0	0			
Totals/Avg	**1,152,600**	**$440,931**	**3,575**	**118,410**	**549**	**9.1**	**3.7**

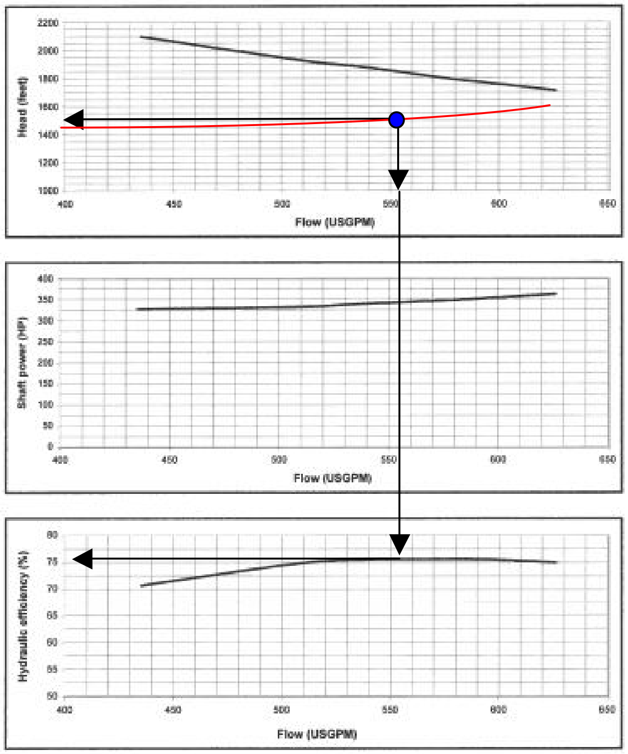
Parker Ranch Pump Testing

To evaluate existing pump performance, we worked with DWS staff to collect instantaneous flow data using the existing well flow meter. Power was measured with a Fluke 43B kW meter, and discharge pressure was determined using a Fluke PV-350 pressure transducer. The data collected is summarized in Table 9.4.

Table 9.4: Parker Ranch Field Measurements

Pump Measurements / Calculations	Data
Total Flow (gpm)	554
Discharge Pressure (psi)	101.3
Baseline Ground Elevation (ft)	2828
Tank Water Level Elevation (ft)	3052
Well Depth to Baseline (ft)	1243
Static Head (ft)	1467
Gauge Height from Baseline (ft)	2
Estimated Column/Velocity Losses (ft) 1ft/100ft	12.43
Estimated Total Head (ft): P * 2.31 + well depth + losses)	1491
Total Measured Power (kW)	302
Estimated Motor Efficiency (%)	94%
Calculated Pump Efficiency	**55%**
Original Pump Efficiency at Flowrate	**75%**

Figure 9.1: Parker Ranch Field Measurements



Observations and Proposed Recommendations

This pump station is on the HELCO "P" Rate Schedule, which provides a lower kWh charge, but a higher demand charge compared to the "J" Rate Schedule.

- The pump station was charged $1,277 for low power factor, which could be corrected with power factor capacitors as recommended for other stations in ESM #1. Even though these savings would be reduced in the future with lower operating hours, the long-term benefits make the project cost effective.

- Based on the field data in Table 9.4, the pump efficiency is approximately 20% less than the rated efficiency shown on the original curve in Figure 9.1. If the efficiency was improved to 75%, and the pump was operated the same number of hours as 2014, approximately $109,000 in annual savings would be realized. However, since the well hours will be reduced significantly after the treatment plant upgrades, improving the pump efficiency should be re-evaluated next year with updated operating hours.

- At this time, the DWS operates either the Waimea or Parker Ranch Well to supplement the flow from the Treatment Plant. In ESM #4, we have recommended operating both wells on a regular schedule to qualify for Rider M (which requires that pump stations normally operate between 5:00 pm and 9:00 pm). Since the DWS is charged for peak demand at both stations every month, operating them together periodically will not change the energy costs significantly.

9.1.3 Waimea Well

The Waimea Well is a Centrilift submersible pump with an 800 hp, 4000 V Byron Jackson motor. The pump is rated for 1000 gpm @ 1800' TDH and is equipped with a Siemens VFD. Flow is maintained between 800 and 1000 gpm using the VFD depending on flow available from the water treatment plant. A summary of 2014 energy use data from facility spreadsheets is shown below.

Table 9.5: Waimea Well 2014 Energy Use and Cost

Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc Charges	Total Bill	Power Factor Charge	Rider M
1/13/14	128,240	478	509	$5,215	$31,808	$12,269	$49,292	-$518	$0
2/11/14	0	0	539	$5,591	$0	$0	$5,591	$0	$0
3/12/14	0	0	539	$5,591	$0	$0	$5,591	$0	$0
4/10/14	0	0	539	$5,591	$0	$0	$5,591	$0	$0
5/12/14	0	0	539	$5,591	$0	$0	$5,591	$0	$0
6/11/14	200,400	462	499	$5,113	$49,706	$20,427	$75,246	-$767	$0
7/11/14	349,520	526	531	$5,441	$86,692	$38,183	$130,316	-$1,290	$0
8/11/14	390,400	541	541	$5,543	$96,832	$43,888	$146,263	-$1,433	$0
9/11/14	385,200	542	542	$5,560	$95,542	$41,049	$142,151	-$1,415	$0
10/11/14	382,400	546	546	$5,592	$94,848	$37,814	$138,254	-$1,406	$0
11/10/14	397,360	541	543	$5,568	$98,558	$36,578	$140,704	-$1,458	$0
12/10/14	397,360	541	543	$5,568	$98,558	$36,578	$140,704	-$1,458	$0
Totals/Avg	**2,630,880**	**348**	**534**	**$65,963**	**$652,545**	**$266,786**	**$985,294**	**-$9,746**	**$0**

The billing data in Table 9.5 implies that the pump was operated at approximately 800 gpm in January (no pumpage data was available). A summary of 2014 pump hours is shown below in Table 9.6. Since there was no flow data shown in the Pumpage Report, monthly flow was estimated using an 800 gpm flow when HELCO measured demand was low, and 1000 gpm for higher demands.

Table 9.6: Waimea Well Hours and Pumpage

Month	Monthly Energy Use (kWh)	Monthly Bill	Well Hours	Estimated Well Pumpage (kgal)	Flow (GPM)	kWh/ kgal	Cost/ kgal
Jan-14	128,240	$49,292	268	12,867	800	10.0	3.8
Feb-14	0	$5,591	0	0			
Mar-14	0	$5,591	0	0			
Apr-14	0	$5,591	0	0			
May-14	0	$5,591	0	0			
Jun-14	200,400	$75,246	434	20,839	800	9.6	3.6
Jul-14	349,520	$130,316	665	35,910	900	9.7	3.6
Aug-14	390,400	$146,263	722	43,314	1000	9.0	3.4
Sep-14	385,200	$142,151	710	42,611	1000	9.0	3.3
Oct-14	382,400	$138,254	701	42,053	1000	9.1	3.3
Nov-14	397,360	$140,704	735	44,086	1000	9.0	3.2
Dec-14			25	802	1000		
Totals/Avg	**2,630,880**	**$985,294**	**4,970**	***238,544***	**800.00**	**10.9**	**4.1**

Waimea Pump Testing

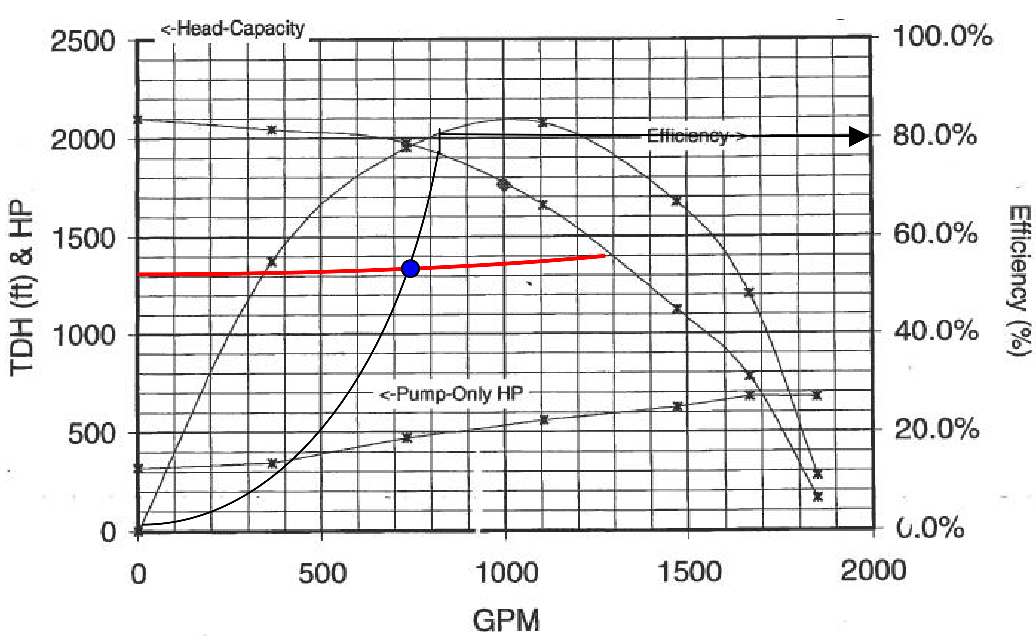
To evaluate existing pump performance, we worked with DWS staff to collect instantaneous flow data using the existing well flow meter. Power was measured with a Fluke 43B kW meter, and discharge pressure was determined using a Fluke PV-350 pressure transducer.

To calculate pump efficiency, we used the original nameplate motor efficiency of 78% (submersible motor) and a VFD and transformer efficiency of 95%. These losses could be higher (which would improve pump efficiency) but could not be measured directly. A summary of the data and the original pump curve with the measured operating point and estimated system curve is shown below.

Table 9.7: Waimea Field Measurements

Pump Measurements / Calculations	Waimea
VFD Speed	58.5 Hz
Total Flow (gpm)	782
Discharge Pressure (psi)	36.4
Baseline Ground Elevation (ft)	2972
Tank Water Level Elevation (ft)	3050
Well Depth to Baseline (ft)	1255
Static Head (ft)	1333
Gauge Height from Baseline (ft)	2
Estimated Column/Velocity Losses (ft) 1ft/100ft	12.55
Estimated Total Head (ft): P * 2.31 + well depth + losses)	1354
Total Measured Power (kW)	494
Estimated VFD Efficiency (%)	95%
Transformer Efficiency (%)	95%
Estimated Motor Efficiency (%)	78%
Calculated Pump Efficiency	**57%**
Original Pump Efficiency at Flowrate	**80%**

Figure 9.2: Waimea Pump Curve



Observations and Proposed Recommendations

- At this time, the DWS operates either the Waimea or Parker Ranch Well to supplement the flow from the Treatment Plant. In ESM #4, we have recommended operating both wells on a regular basis to qualify for Rider M (which requires that pump stations normally operate between 5:00 pm and 9:00 pm). Since the DWS is charged for peak demand at both stations every month, operating them together periodically will not change the energy costs significantly.

  The advantages of having a VFD installed, is that the well could be turned down to a lower level without deactivating the well completely if needed to benefit from the Rider M savings.

- Having a VFD at the station has also provided the DWS with a power factor credit of $9,746 in 2014 by maintaining the power factor at 0.99.

- Based on the field data in Table 9.7, the pump efficiency appears to be significantly lower than the rated efficiency shown on the original curve in Figure 9.2. If the efficiency could be improved to 70%, by upgrading or replacing the pump, approximately $92,000 annually could be saved (based on 2014 pump run time) as shown in Table 9.8.

Table 9.8: Waimea Field Measurements

Pump Energy Use Calculations	Data
Total Flow (gpm)	554
Estimated Total Head (ft): P * 2.31 + well depth + losses)	1491
Estimated VFD Efficiency (%)	95%
Transformer Efficiency (%)	95%
Estimated Motor Efficiency (%)	94%
Improved Pump Efficiency	70%
New Power (kW)	236
2014 Hours of Operation	3,575
New Energy Use	845,437
2014 Energy Use	1,152,600
Annual kWh Savings	307,163
Annual Potential Cost Savings	**$92,148**

At this time, the well has not been included in ECM #2 since the operating hours will be decreased significantly after the plant upgrades are completed. This station should be re-evaluated next year with updated data.

9.2 Lalamilo System

The Lalamilo water system includes eight wells, two booster pump stations and nine tanks. The system has approximately 640 connections and an average daily flow of 3.7 million gallons. The system serves customers from the Kaei Hana II industrial development to Mauna Lani. Nearly half of this system's water demands are in the Mauna Lani area. The system serves high water use customers in the resort areas of the water system. The annual energy use for the eight wells in 2013/2014 is shown below in Table 9.9.

Table 9.9: Lalamilo & Parker Well 2013 and 2014 Energy Use & Cost

Well	2013 kWh	2013 Cost	2014 kWh	2014 Cost
Lalamilo Wells A,B,C,D	3,316,800	$1,273,871	3,302,400	$1,259,894
Parker Well #2	1,889,000	$652,829	3,005,000	$1,005,030
Parker Well #1	2,321,000	$832,166	956,000	$412,629
Lalamilo Parker Well #4	2,080,800	$772,742	2,141,200	$801,842
Lalamilo Parker Well #3	1,418,000	$548,415	1,745,200	$663,458
Total	**11,025,600**	**$4,080,023**	**11,149,800**	**$4,142,853**

To reduce energy costs, the DWS began exploring the potential of re-establishing part of the old wind turbine site adjacent to the pump stations to provide power to the well sites. In 2011, the DWS and the National Renewable Energy Laboratory established a partnership arranged by the County of Hawaii's Department of Research and Development to model the energy output potential at the wind farm site and evaluate the most cost effective approach for the DWS. The evaluation found that five new units could be installed at the site to provide enough power for the deep well pump stations. The project would also contribute to the State's Clean Energy Initiative's goal of 70 percent renewable energy by 2030.

In April 2013, the DWS awarded the project to the Lalamilo Wind Company LLC and executed a Power Purchase Agreement in October 2013. An Environmental Assessment for the project was completed and accepted by the State of Hawaii Office of Environmental Quality Control (OEQC). Currently, an Interconnect Agreement with HELCO is being finalized. The construction phase of the Wind Farm Re-powering Project is scheduled to begin in May 2015, with the commercial operation scheduled to occur in the first half of 2016.

The cost of energy for the first five years will be $0.24/kWh plus $0.03/kWh required by the state for HCP/ITP costs. Compared to the 2014 rate of $0.31 for the Lalamilo Wells and Parker Wells #1 and #2 and the $0.35/kWh unit cost for the Parker #3 and #4 Wells, the DWS will save $600,349 annually.

The four Parker Wells are the primary source for the Lalamilo System. Wells #2 and #4 typically operated 24 hours per day during 2014 and Wells #1 and #3 were alternated to maintain a consistent flow. The wells pump into the Lalamilo Tanks.

9.2.1 Lalamilo Wells

The Lalamilo Deep Wells include four wells (A, B, C, and D), which operate at TDH of 1,174 feet, 1,089 feet, 1,140 feet, and 1,085 feet, respectively. The rated capacity of wells B, C, and D is 1,000 gpm and the rated capacity of Well A is 700 gpm.

Electric service for all four wells is provided through one electric account on the HELCO Schedule P Rate. A summary of 2014 energy use for the station is shown below.

Table 9.10: Lalamilo Well 2014 Energy Use & Cost

Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill	Power Factor Charge	Rider M
1/9/14	225,600	631	879	$17,141	$49,222	$22,211	$88,574	-$664	$0
2/7/14	152,400	629	878	$17,117	$33,251	$14,562	$64,930	-$201	$0
3/10/14	195,600	848	988	$19,258	$42,677	$19,040	$80,975	-$681	$0
4/8/14	176,400	848	988	$19,258	$38,488	$16,414	$74,160	-$115	$0
5/8/14	298,800	924	1025	$19,995	$65,193	$27,071	$112,260	-$1,022	$0
6/9/14	310,800	619	873	$17,024	$67,812	$29,904	$114,739	-$1,103	$0
7/9/14	324,000	916	920	$17,936	$70,692	$34,060	$122,688	-$1,064	$0
8/8/14	315,600	911	917	$17,889	$68,859	$34,412	$121,160	-$1,041	$0
9/9/14	362,400	916	920	$17,936	$79,070	$39,032	$136,038	-$1,164	$0
10/8/14	296,400	916	920	$17,936	$64,670	$29,103	$111,709	-$909	$0
11/7/14	304,800	920	922	$17,983	$66,502	$28,246	$112,731	-$1,014	$0
12/8/14	339,600	919	922	$17,971	$74,095	$27,862	$119,929	-$1,105	$0
Totals/Avg	**3,302,400**	**833**	**929**	**$217,445**	**$720,531**	**$321,918**	**$1,259,894**	**-$10,083**	**$0**

As discussed previously, the new wind power purchase agreement will help reduce the annual 1.2 million dollar energy cost at this pump station by approximately 11.6% (146,000 annually). However, if the station is maintained on Rate Schedule P as part of the HELCO back-up power agreement, the ~$18,000 monthly demand cost will most likely still occur during periods of low wind when the load is transferred to HELCO.

Table 9.11: Lalamilo Well 2014 Run Time and Pumpage

Month	Monthly Energy Use (kWh)	Monthly Bill	Well A Hours	Well B Hours	Well C Hours	Well D Hours	Total Hours	Total Pumpage	Average GPM	kWh/ kgal	Cost/ kgal
Jan-14	225,600	$88,574	726	0	0	0	726	27,865	640	8.1	3.2
Feb-14	152,400	$64,930	70	0	19	478	567	29,583	869	5.2	2.2
Mar-14	195,600	$80,975	502	0	26	165	693	28,597	688	6.8	2.8
Apr-14	176,400	$74,160	224	228	25	431	907	44,302	814	4.0	1.7
May-14	298,800	$112,260	0	199	0	743	942	49,526	877	6.0	2.3
Jun-14	310,800	$114,739	0	173	123	744	1040	55,414	888	5.6	2.1
Jul-14	324,000	$122,688	0	12	268	714	994	46,911	786	6.9	2.6
Aug-14	315,600	$121,160	0	46	0	709	755	56,695	1252	5.6	2.1
Sep-14	362,400	$136,038	0	12	241	719	972	52,370	898	6.9	2.6
Oct-14	296,400	$111,709	0	186	252	508	946	51,244	903	5.8	2.2
Nov-14	304,800	$112,731	0	282	53	740	1074	57,744	896	5.3	2.0
Dec-14	339,600	$119,929	0	76	274	748	1098	58,965	895	5.8	2.0
Totals/Avg	**3,302,400**	**$1,259,894**	**1,523**	**1,213**	**1,280**	**6,699**	**10,714**	**559,216**	**867.1**	**6.0**	**2.3**

Testing was performed on Lalamilo Wells B, C and D (Well A was out of service during the site visit). The data collected and calculated pump efficiency is shown in Table 9.12. Rated pump efficiency was determined from the original pump curves.

Table 9.12: Lalamilo Well Test Data

Pump Measurements / Calculations	A	B	C	D
Total Flow (gpm)	N/A	900	952	907
Discharge Pressure (psi)	3	3.3	17.4	17
Baseline Ground Elevation (ft)	1105	1088	1086	1085
Tank Water Level Elevation (ft)	1103	1103	1103	1101
Well Depth to Baseline (ft)	*1150*	1100	1130	1131
Static Head (ft)	1148	1115	1147	1147
Gauge Height from Baseline (ft)	2	2	2	2
Estimated Column/Velocity Losses (ft) 1ft/100ft	11.5	11	11.3	11.31
Estimated Total Head (ft): P * 2.31 + well depth + losses)	1170	1121	1183	1184
Total Measured Power (kW)	200	281	294	321
Estimated Motor Efficiency (%)	94%	94%	94%	91%
Calculated Pump Efficiency	**N/A**	**72%**	**77%**	**69%**
Original Pump Efficiency at Flowrate	**80%**	**78%**	**80%**	**68%**

<u>Opportunities for Reducing Lalamilo Pump Station Energy Costs</u>

- As shown in Table 9.12, the existing Lalamilo well efficiencies are close enough to the original values to not justify the cost of pulling pumps with the hope of gaining a few more efficiency points.

- During our review we noticed the use of strainers just before the flow meters for Lalamilo Well A, B and C. Well D had a new flow meter recently installed and the strainer had been removed and replaced with a spool piece. For one of the wells there were taps available on the suction and discharge side of the strainer to allow us to take pressure readings. The data showed a pressure drop of approximately 3 psi across the strainer.

- Although it appears the DWS is already in the process of replacing the old flow meters and strainers, we have included this as a measure (ECM #4) to highlight the savings and encourage the DWS to replace the remaining strainer/flow meter units. Based on simple savings estimate for the Lalamilo Wells, one-psi drop is approximately equivalent to one kW of savings. Based on average run time of 1339 hours for Wells A, B and C, this amounts to $1205 in annual savings for each well.

- The station had an average 2014 power factor of 0.95 using power factor correction capacitors. This provided the DWS with a credit of $10,083 in 2014 as shown on Table 9.10.

9.2.2 Parker Well #1

Parker Well #1 is a Byron Jackson Pump with a 500 hp, 2300 V submersible motor with a rated efficiency of 89%. The pump is rated for 1250 gpm @ 1250 TDH. A summary of pump station energy use and cost is provided in Table 9.13.

Table 9.13: Parker Well #1 2014 Energy Use & Cost

Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill	Power Factor Charge	Rider M
1/9/14	600	0	421	$8,210	$131	$994	$9,334	$534	$0
2/7/14	400	0	421	$8,210	$87	$1,018	$9,315	$581	$0
3/10/14	600	0	421	$8,210	$131	$1,001	$9,342	$542	$0
4/8/14	28,000	418	420	$8,190	$6,109	$3,060	$17,360	$100	$0
5/8/14	800	418	420	$8,190	$175	$959	$9,324	$485	$0
6/9/14	600	0	420	$8,190	$131	$1,000	$9,321	$541	$0
7/9/14	11,000	418	420	$8,190	$2,400	$1,717	$12,307	$138	$0
8/8/14	195,400	422	422	$8,229	$42,633	$22,357	$73,219	$254	$0
9/9/14	209,200	420	421	$8,210	$45,644	$23,642	$77,496	$269	$0
10/8/14	206,000	422	422	$8,229	$44,946	$21,246	$74,421	$266	$0
11/7/14	162,600	422	422	$8,229	$35,477	$16,014	$59,720	$219	$0
12/8/14	140,800	422	422	$8,229	$30,720	$12,522	$51,472	$195	$0
Totals/Avg	**956,000**	**280**	**421**	**$98,514**	**$208,584**	**$105,531**	**$412,629**	**$4,123**	**$0**

Electric service for the station is provided by HELCO on the Schedule P Rate. As discussed for the Lalamilo Wells, this rate has a lower kWh cost but higher demand cost. For stations used consistently, the rate typically provides the lowest net cost. However this situation will change when power is supplied with the new wind turbines. A summary of 2014 energy use for the station is shown below.

Table 9.14: Parker Well #1 2014 Hours and Pumpage

Month	Monthly Energy Use (kWh)	Monthly Bill	Total Hours	Total Pumpage (kgal)	Average GPM	kWh/ kgal	Cost/ kgal
Jan-14	600	$9,334	0	0			
Feb-14	400	$9,315	0	0			
Mar-14	600	$9,342	66	4,685	1183		
Apr-14	28,000	$17,360	0	0			
May-14	800	$9,324	1	51	1063		
Jun-14	600	$9,321	25	1,758	1181		
Jul-14	11,000	$12,307	317	22,371	1177		
Aug-14	195,400	$73,219	479	34,379	1197	5.7	2.1
Sep-14	209,200	$77,496	533	37,531	1175	5.6	2.1
Oct-14	206,000	$74,421	443	31,156	1172	6.6	2.4
Nov-14	162,600	$59,720	314	22,049	1169	7.4	2.7
Dec-14	140,800	$51,472	*500*	35,898	1197	3.9	1.4
Totals/Avg	**956,000**	**$412,629**	**2,677**	**189,878**	**1,168**	**5.8**	**2.1**

Parker #1 Well Testing

To evaluate existing pump performance, we collected instantaneous flow data using the existing well flow meter. Power was measured with a Fluke 43B kW meter, and discharge pressure was determined using a Fluke PV-350 pressure transducer.

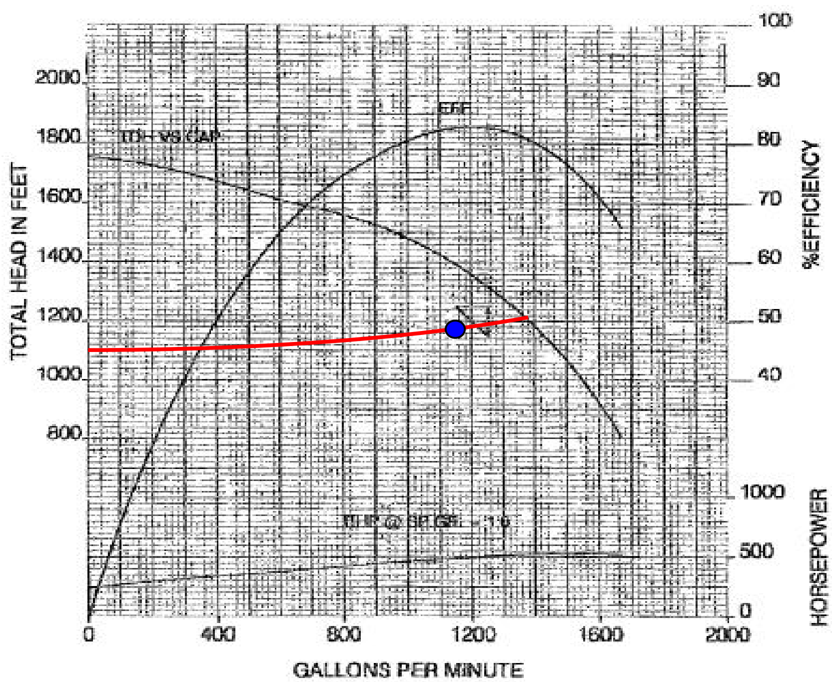
To calculate pump efficiency, we used the original motor efficiency of 89% (submersible motor) and the original well depth data shown in Table 9.15.

Table 9.15: Parker Well #1 Test Data

Pump Measurements / Calculations	Data
Total Flow (gpm)	1185
Discharge Pressure (psi)	19
Baseline Ground Elevation (ft)	1150
Tank Water Level Elevation (ft)	1103
Well Depth to Baseline (ft)	1148
Static Head (ft)	1101
Gauge Height from Baseline (ft)	2
Estimated Column/Velocity Losses (ft) 1ft/100ft	11.48
Estimated Total Head (ft): P * 2.31 + well depth + losses)	1205
Total Measured Power (kW)	411
Estimated Motor Efficiency (%)	89%
Calculated Pump Efficiency	**74%**
Original Pump Efficiency at Flowrate	**82%**

The calculated pump efficiency is approximately 6% less than the original curve efficiency.

Figure 9.3: Parker Well #1 Test Data



Observations and Proposed Recommendations

- The calculated pump efficiency was approximately 8% less than the original curve efficiency. However based on an estimated +/- 5% uncertainty calculating efficiency based on the wire to water relationship, we do not recommend investing in system improvements until repair issues justify the expense for pulling the pump.

- The pump station was charged $4,123 for low power factor, which could be corrected with power factor capacitors. However this may not be an issue with the new Wind Power Agreement and should not be pursued until after the first year of operation to see if power factor is penalized.

9.2.3 Parker Well #2

Parker Well #2 is also a Byron Jackson Pump with a 500 hp, 2300 V submersible motor and a nameplate efficiency of 89%. The pump is rated for 1250 gpm @ 1250 TDH. A summary of pump station energy use and cost is provided in Table 9.16.

Table 9.16: Parker Well #2 2014 Energy & Cost Data

Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill	Power Factor Charge	Rider M
1/9/14	264,200	415	418	$8,145	$57,644	$22,608	$88,398	$132	$4,244
2/7/14	252,000	415	417	$8,139	$54,982	$20,039	$83,160	$126	$4,238
3/10/14	244,400	415	418	$8,153	$53,324	$20,413	$81,891	$123	$4,251
4/8/14	211,400	416	419	$8,167	$46,124	$15,574	$69,864	$109	$4,265
5/8/14	233,800	417	419	$8,161	$51,011	$17,928	$77,101	$118	$4,259
6/9/14	279,800	416	418	$8,149	$61,048	$23,845	$93,042	$138	$4,248
7/9/14	242,800	417	419	$8,176	$52,975	$22,269	$83,420	$122	$4,275
8/8/14	250,200	420	420	$8,190	$54,590	$24,026	$86,806	$126	$4,289
9/9/14	264,800	418	421	$8,206	$57,775	$25,306	$91,287	$132	$4,304
10/8/14	251,800	417	421	$8,217	$54,939	$21,366	$84,522	$126	$4,316
11/7/14	240,200	417	421	$8,215	$52,408	$18,950	$79,574	$121	$4,314
12/8/14	269,600	418	421	$8,204	$58,822	$18,940	$85,966	$134	$4,302
Totals/Avg	**3,005,000**	**417**	**419**	**$98,122**	**$655,643**	**$251,265**	**$1,005,030**	**$1,508**	**$51,305**

Electric service for the station is provided by HELCO on the Schedule P Rate with a Rider M. As shown in Table 9.16, to take advantage of the Rider M, the DWS was required to deactivate the well between 5:00 and 9:00 PM. The effort made by DWS provided a credit of $51,305 in 2014 for adhering to this schedule.

A summary of 2014 pumpage and well hours for the station is shown in Table 9.17

Table 9.17: Parker Well #2 2014 Hours and Pumpage Data

Month	Monthly Energy Use (kWh)	Monthly Bill	Total Hours	Total Pumpage	Average GPM	kWh/ kgal	Cost/ kgal
Jan-14	264,200	$88,398	630	42,191	1117	6.3	2.1
Feb-14	252,000	$83,160	583	39,278	1122	6.4	2.1
Mar-14	244,400	$81,891	426	35,335	1382	6.9	2.3
Apr-14	211,400	$69,864	545	36,567	1119	5.8	1.9
May-14	233,800	$77,101	643	43,185	1120	5.4	1.8
Jun-14	279,800	$93,042	620	41,795	1123	6.7	2.2
Jul-14	242,800	$83,420	604	40,599	1121	6.0	2.1
Aug-14	250,200	$86,806	619	41,594	1120	6.0	2.1
Sep-14	264,800	$91,287	614	41,217	1119	6.4	2.2
Oct-14	251,800	$84,522	558	39,250	1172	6.4	2.2
Nov-14	240,200	$79,574	639	42,981	1120	5.6	1.9
Dec-14	269,600	$85,966	*640*	43,091	1122	6.3	2.0
Totals/Avg	**3,005,000**	**$1,005,030**	**7,121**	**487,083**	**1146**	**6.2**	**2.1**

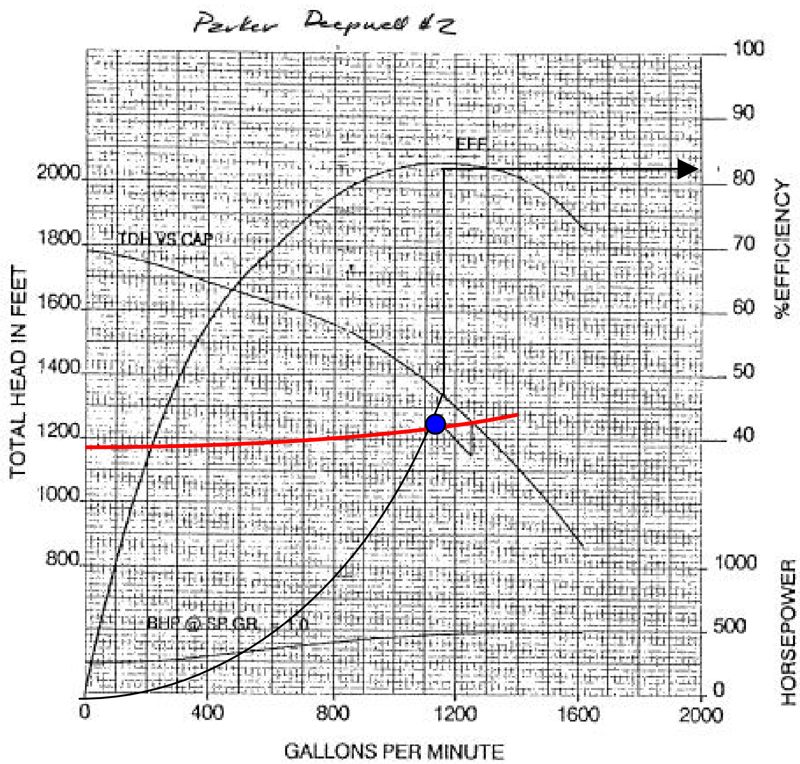
<u>Parker #2 Well Testing</u>

To evaluate existing pump performance, we collected flow data using the existing flow meters. Power was measured with a Fluke 43B kW meter, and discharge pressure was determined using a Fluke PV-350 pressure transducer. To calculate pump efficiency, we used the original motor efficiency of 89% (submersible motor) and the original well depth data shown below.

Table 9.18: Parker Well #2 Test Data

Pump Measurements / Calculations	Data
Total Flow (gpm)	1071
Discharge Pressure (psi)	2
Baseline Ground Elevation (ft)	1178
Tank Water Level Elevation (ft)	1103
Well Depth to Baseline (ft)	1275
Static Head (ft)	1200
Gauge Height from Baseline (ft)	2
Estimated Column/Velocity Losses (ft) 1ft/100ft	12.75
Estimated Total Head (ft): P * 2.31 + well depth + losses)	1294
Total Measured Power (kW)	410
Estimated Motor Efficiency (%)	89%
Calculated Pump Efficiency	**72%**
Original Pump Efficiency at Flowrate	**82%**

Figure 9.4: Parker Well #2 Pump Curve



Observations and Proposed Recommendations

- The calculated pump efficiency was approximately 10% less than the original curve efficiency. However based on an estimated +/- 5% uncertainty calculating efficiency based on the wire to water relationship, we do not recommend investing in system improvements until repair issues justify the expense for pulling the pump.

- The pump station was charged $1,508 for low power factor, which could be corrected with power factor capacitors. However this may not be an issue with the new Wind Power Agreement and should not be pursued until after the first year of operation to see if power factor is penalized.

9.2.4 Parker Well #3

Parker Well #3 is also a Byron Jackson Pump with a 500 hp, 2300 V submersible motor and a nameplate efficiency of 89%. The pump is rated for 1250 gpm @ 1270 TDH. A summary of pump station energy use and cost is provided in Table 9.19.

Table 9.19: Parker Well #3 2014 Energy Use and Cost

Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill	Power Factor Charge
1/9/14	256,400	428	428	$4,391	$63,596	$26,381	$94,368	$136
2/7/14	296,800	425	427	$4,377	$73,616	$28,945	$106,938	$156
3/10/14	178,000	429	429	$4,395	$44,150	$18,234	$66,779	$97
4/8/14	272,000	427	428	$4,387	$67,465	$25,839	$97,691	$144
5/8/14	237,600	429	429	$4,395	$58,933	$22,971	$86,299	$127
6/9/14	226,400	430	430	$4,403	$56,155	$23,476	$84,034	$121
7/9/14	239,600	430	430	$4,412	$59,429	$26,989	$90,829	$192
8/8/14	37,200	430	430	$4,410	$9,227	$4,393	$18,029	$41
9/9/14	0	140	430	$4,476	$0	$0	$4,476	$0
10/8/14	400	99	430	$4,476	$0	$0	$4,476	$0
11/7/14	400	428	429	$4,397	$99	$283	$4,780	$180
12/8/14	400	424	427	$4,377	$99	$284	$4,760	$179
Totals/Avg	**1,745,200**	**377**	**429**	**$52,895**	**$432,768**	**$177,795**	**$663,458**	**$1,372**

Electric service for the station is provided by HELCO on the Schedule J Rate. Having the well on this rate schedule has decreased the demand charge ($52,895 per year versus $98,122 for Parker #2) but increases the kWh charge ($0.35/kWh versus $0.30/kWh for Parker #2).

A summary of 2014 pumpage and well hours for the station is shown below. We have estimated the average flow for the last 5 months when pump hours were minimal.

Table 9.20: Parker Well #3 2014 Hours and Pumpage

Month	Monthly Energy Use (kWh)	Total Bill	Total Hours	Total Pumpage	Average GPM	kWh/ kgal	Cost/ kgal
Jan-14	256,400	$94,368	725	54,720	1257	4.7	1.7
Feb-14	296,800	$106,938	442	32,213	1214	9.2	3.3
Mar-14	178,000	$66,779	670	51,578	1284	3.5	1.3
Apr-14	272,000	$97,691	559	42,036	1254	6.5	2.3
May-14	237,600	$86,299	505	37,928	1251	6.3	2.3
Jun-14	226,400	$84,034	576	43,360	1254	5.2	1.9
Jul-14	239,600	$90,829	240	18,041	1255		
Aug-14	37,200	$18,029	0	32	*1250*		
Sep-14	0	$4,476	0	4	*1250*		
Oct-14	400	$4,476	1	0	*1250*		
Nov-14	400	$4,780	0	86	*1250*		
Dec-14	400	$4,760	0	14	*1250*		
Totals/Avg	**1,745,200**	**$663,458**	**3,718**	**280,012**	**1252**	**5.9**	**2.1**

Parker #3 Well Testing

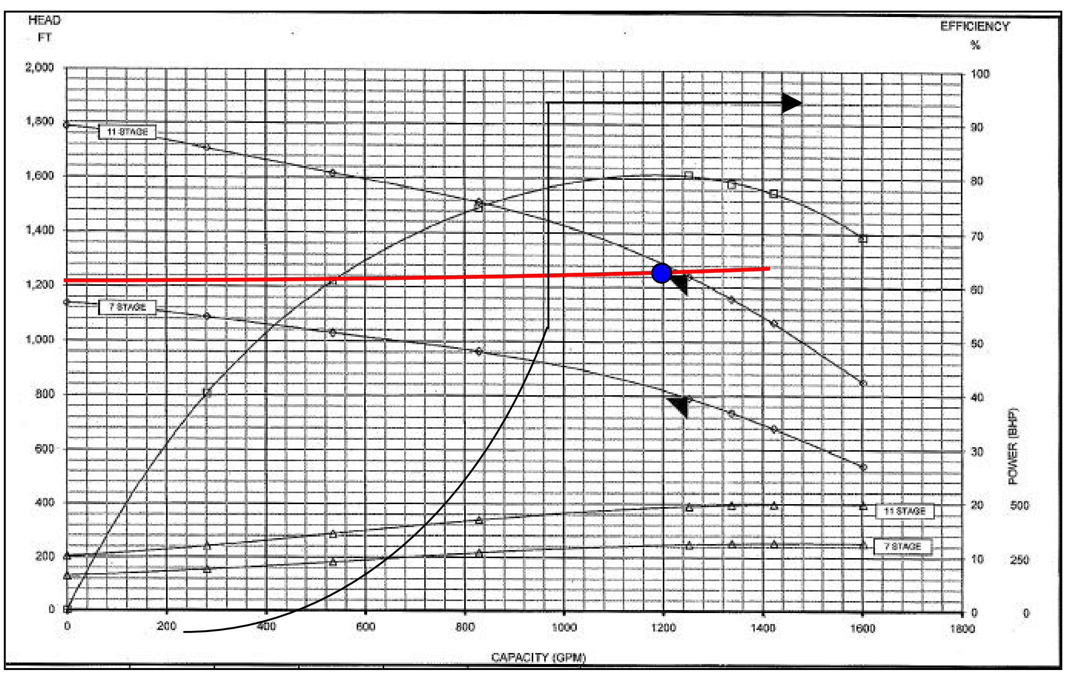
To evaluate existing pump performance, we collected flow data using the existing flow meter. Power was measured with a Fluke 43B kW meter, and discharge pressure was determined using a Fluke PV-350 pressure transducer. To calculate pump efficiency, we used the original motor efficiency of 89% (submersible motor) and the original well depth data shown below.

Table 9.21: Parker Well #3 Test Data

Pump Measurements / Calculations	Data
Total Flow (gpm)	1254
Discharge Pressure (psi)	6.6
Baseline Ground Elevation (ft)	1150
Tank Water Level Elevation (ft)	1103
Well Depth to Baseline (ft)	1275
Static Head (ft)	1228
Gauge Height from Baseline (ft)	2
Estimated Column/Velocity Losses (ft) 1ft/100ft	12.75
Estimated Total Head (ft): P * 2.31 + well depth + losses)	1305
Total Measured Power (kW)	443
Estimated Motor Efficiency (%)	89%
Calculated Pump Efficiency	**78%**
Original Pump Efficiency at Flowrate	**80%**

The original pump efficiency was determined from the manufacturer's pump curve in Figure 9.5.

Figure 9.5: Parker Well #3 Pump Curve



The calculated pump efficiency is only 2% less than the original curve efficiency. Based on the data, the pump system appears to be operating close to the original design conditions.

Observations and Proposed Recommendations

- The pump station was charged $1,372 for low power factor, which could be corrected with power factor capacitors. However this may not be an issue with the new Wind Power Agreement and should not be pursued until after the first year of operation to see if power factor is penalized.

- With HELCO still charging for peak demand at the station, we recommend delegating this well as a back-up unit and installing a VFD to provide minimal flow (and power use) for periodic testing. As long as the other Parker Wells are operating, this well will have lower demand charges and minimal usage. The cost effectiveness of installing a VFD at this station is reviewed in ESM #5.

9.2.5 Parker Well #4

Parker Well #4 is also a Byron Jackson Pump with a 500 hp, 2300 V submersible motor and a nameplate efficiency of 89%. The pump is rated for 1250 gpm @ 1270 TDH. A summary of pump station energy use and cost is provided in Table 9.22.

Table 9.22: Parker Well #4 Pump 2014 Energy Use & Cost

Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill	Power Factor Charge	Rider M
1/9/14	197,200	412	413	$4,229	$48,912	$20,306	$73,448	$106	$0
2/7/14	283,600	406	410	$4,200	$70,342	$27,661	$102,203	$149	$0
3/10/14	124,000	411	412	$4,225	$30,756	$12,724	$47,705	$70	$0
4/8/14	249,200	412	413	$4,229	$61,810	$23,679	$89,717	$132	$0
5/8/14	157,200	412	413	$4,229	$38,991	$15,223	$58,443	$86	$0
6/9/14	164,800	412	412	$4,227	$40,876	$17,108	$62,211	$90	$0
7/9/14	181,200	412	413	$4,229	$44,944	$20,380	$69,553	$98	$0
8/8/14	168,000	412	412	$4,227	$41,670	$19,519	$65,416	$92	$0
9/9/14	186,000	411	412	$4,225	$46,134	$21,279	$71,638	$101	$0
10/8/14	149,600	411	411	$4,217	$37,106	$15,653	$56,976	$83	$0
11/7/14	158,800	412	412	$4,223	$39,388	$15,779	$59,390	$87	$0
12/8/14	121,600	412	412	$4,221	$30,161	$10,761	$45,143	$69	$0
Totals/Avg	**2,141,200**	**411**	**412**	**$50,682**	**$531,088**	**$220,072**	**$801,842**	**$1,164**	**$0**

Electric service for the station is provided by HELCO on the Schedule J Rate. Having the well on this rate schedule has decreased the demand charge but increases the kWh charge. A summary of 2014 pumpage and well hours for the station is shown below.

Table 9.23: Parker Well #4 2014 Pump Hours and Pumpage

Month	Monthly Energy Use (kWh)	Monthly Net Bill	Total Hours	Total Pumpage (kgal)	Average GPM	kWh kgal	Cost/ kgal
Jan-14	197,200	$73,448	725	51,463	1183	3.8	1.4
Feb-14	283,600	$102,203	336	23,709	1175	12.0	4.3
Mar-14	124,000	$47,705	653	46,153	1179	2.7	1.0
Apr-14	249,200	$89,717	401	28,186	1170	8.8	3.2
May-14	157,200	$58,443	386	27,083	1169	5.8	2.2
Jun-14	164,800	$62,211	460	32,258	1170	5.1	1.9
Jul-14	181,200	$69,553	420	29,440	1168	6.2	2.4
Aug-14	168,000	$65,416	445	31,146	1165	5.4	2.1
Sep-14	186,000	$71,638	390	2,718	--	--	--
Oct-14	149,600	$56,976	374	26,095	1163	5.7	2.2
Nov-14	158,800	$59,390	321	22,299	1160	7.1	2.7
Dec-14	121,600	$45,143	*260*	17,943	1150	6.8	2.5
Totals/Avg	**2,141,200**	**$801,842**	**5,171**	**338,493**	**1168**	**6.3**	**2.4**

Parker #4 Well Testing

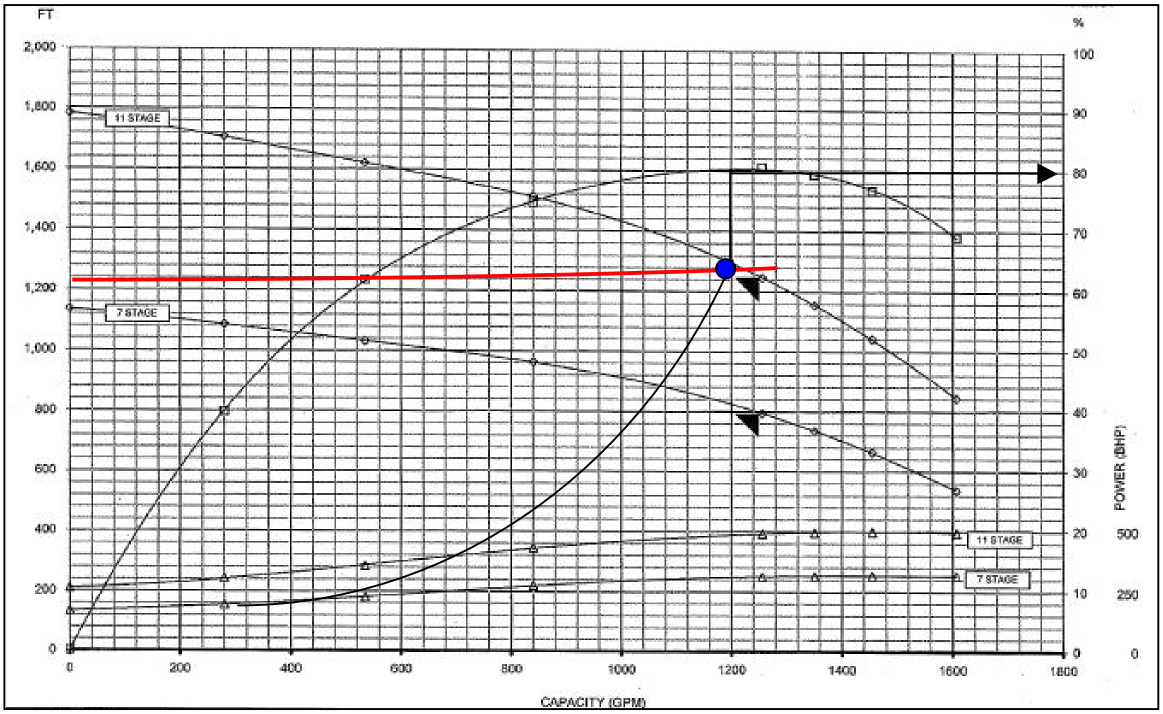
To evaluate existing pump performance, we collected flow data using the existing flow meter. Power was measured with a Fluke 43B kW meter, and discharge pressure was determined using a Fluke PV-350 pressure transducer. To calculate pump efficiency, we used the original motor efficiency of 89% (submersible motor) and the original well depth data shown below.

Table 9.24: Parker Well #4 Test Data

Pump Measurements / Calculations	Data
Total Flow (gpm)	1170
Discharge Pressure (psi)	3.8
Baseline Ground Elevation (ft)	1150
Tank Water Level Elevation (ft)	1103
Well Depth to Baseline (ft)	1275
Static Head (ft)	1228
Gauge Height from Baseline (ft)	2
Estimated Column/Velocity Losses (ft) 1ft/100ft	12.75
Estimated Total Head (ft): P * 2.31 + well depth + losses)	1299
Total Measured Power (kW)	453
Estimated Motor Efficiency (%)	89%
Calculated Pump Efficiency	**71%**
Original Pump Efficiency at Flowrate	**80%**

The original pump efficiency was determined from the manufacturer’s pump curve in Figure 9.6.

Figure 9.6: Parker Well #4 Pump Curve



Observations and Proposed Recommendations

- The pump station was charged $1,164 for low power factor, which could be corrected with power factor capacitors. However this may not be an issue with the new Wind Power Agreement and should not be pursued until after the first year of operation to see if power factor is penalized.

- The calculated pump efficiency was approximately 9% less than the original curve efficiency. However based on an estimated +/- 5% uncertainty calculating efficiency based on the wire to water relationship, we do not recommend investing in system improvements until repair issues justify the expense for pulling the pump.

- Based on our recommendation for installing a VFD for Parker Well #3, this well should be operated more hours to make up the difference for only operating Well #3 as a back-up unit.

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SECTION 10. NORTH KONA SYSTEM

The North Kona water system is the largest DWS water system in terms of both average production and number of connections. The water system contains 56 operational zones with elevations ranging from 0 to 5,013 feet. The distribution system is contained between the Mamalahoa Highway and the ocean from Keahole Airport to just beyond the intersection of Mamalahoa Highway and Kuakini Highway. The North Kona water system is connected to the South Kona water system.

Table 10.1: North Kona Energy Accounts

Tank or Pump Station	2013 kWh	2013 Cost	2014 kWh	2014 Cost
Halekii Deep Well	2,917,600	$1,033,195	2,900,640	$1,035,529
Honokohau Deep Well	4,768,000	$1,646,214	3,899,800	$1,398,704
Hualalai Deep Well & Boosters	48,800	$141,195	1,400	$116,099
Holualoa Deep Well and Boosters	560,800	$220,507	691,400	$266,028
Kahaluu Shaft Wells	4,334,400	$1,531,640	4,337,200	$1,537,494
Kahaluu Well A,C and Boosters	2,261,760	$839,174	2,226,240	$828,946
Kahaluu Well B	770,640	$286,396	486,720	$188,604
Kahaluu Well D	0	$3,577	300,780	$115,751
Kalaoa Deepwell	2,618,800	$890,229	2,838,000	$983,249
QLT Deepwell	3,638,600	$1,271,263	3,657,800	$1,303,216
Waiaha Well	1,512,880	$601,010	1,780,640	$697,709
Keopu Well	1,361,600	$512,457	1,196,400	$460,181
Kaloko Palani #5 Boosters	544,600	$209,875	482,800	$190,991
Aloha Kona (Kailua View) Boosters	172,598	$65,584	176,147	$67,040
Kuakini Hy/Pualani Bstr Stn #1	63,356	$26,965	73,627	$31,674
Kalaoa Boosters	85,234	$34,841	74,980	$32,126
Kaloko Mauka #1	157,520	$61,214	146,880	$58,056
Kaloko Mauka #2	113,760	$46,072	107,600	$44,338
Kaloko Mauka #3	74,640	$31,978	70,320	$30,744
Keauhou Boosters	70,240	$34,029	69,760	$33,879
Kaloko #1 Boosters	0	$654	0	$654
Hinalani/Kaloko #2 Boosters	400	$820	1,600	$1,323
Hawaiian Tel Boosters	2,160	$4,966	2,200	$1,582
Honalo Rubbish Boosters	39,051	$16,910	28,059	$12,472
Kuakini Hy	1,604	$1,051	1,641	$1,069
Kaloko Mauka #4	55,360	$24,861	42,320	$19,862
Kaloko Mauka #5	40,800	$19,951	34,480	$17,298
Kaloko Mauka #6	20,720	$9,308	18,640	$8,523
Kaloko Mauka #7	33,280	$14,556	28,760	$12,782
Doris Boosters	703	$2,780	710	$954
Kona Baseyard	60,385	$24,774	58,228	$24,235
Holmes Tank	436	$560	289	$500
Palani 575 #2 Boosters	8,000	$17,321	7,360	$12,209
Palani 310 #1 Boosters	4,640	$5,970	10,400	$5,787
Palani 920 #3 Boosters	4,600	$2,577	3,200	$1,883
Palani 1185 #4 Boosters	6,600	$10,636	6,800	$3,525
Puaa Boosters	3,110	$4,423	36,923	$15,935
Honuaino Medical Boosters	834	$1,003	778	$982
Holualoa	369	$532	363	$531

Table 10.1 (continued): North Kona Energy Accounts

Tank or Pump Station	2013 kWh	2013 Cost	2014 kWh	2014 Cost
Alii Heights Reservoir	157	$444	160	$446
Mamalahoa Hwy	3,581	$1,890	3,581	$1,890
Ahikawa St Reservoir	103	$421	112	$425
Ahulani St Reservoir	372	$534	383	$540
Lalii Pl (Pualani Tank)	18,939	$8,594	21,547	$9,703
Wainani Street	3	$379	119	$429
Keahuolu Reservoir #1	0	$378	4	$380
Nalo Meli (Ctrl Bldg) - Keopu Well	2,872	$1,578	3,655	$1,917
Palani Rd 935 Reservoir	0	$0	0	$0
Total	**26,390,837**	**9,668,145**	**25,837,671**	**9,581,199**

The pump system high-energy accounts (above $25,000) are reviewed in this section.

10.1 Keopu Well

The Keopu Well Pump Station is billed on HELCO Rate Schedule J. The well is equipped with a 2400 V, 400 hp motor and is rated to pump 650 gpm @ 1637' TDH. Energy use data from the electric bills is shown below in Table 10.2.

Table 10.2: Keopu 2014 Energy Use & Costs

Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill	Power Factor Penalty	Rider M Discount	Net Cost/ kWh
1/9/14	130,000	366	367	$3,760	$32,244	$12,870	$48,874	$468	$0	$0.38
2/7/14	117,200	366	367	$3,758	$29,069	$10,980	$43,807	-$427	$0	$0.37
3/10/14	120,000	366	366	$3,756	$29,764	$11,812	$45,332	-$436	$0	$0.38
4/8/14	114,400	366	366	$3,754	$28,375	$10,426	$42,555	-$418	$0	$0.37
5/8/14	127,600	366	366	$3,754	$31,649	$11,838	$47,240	-$460	$0	$0.37
6/9/14	95,200	366	366	$3,756	$23,613	$9,502	$36,870	-$356	$0	$0.39
7/9/14	98,800	366	366	$3,756	$24,506	$10,720	$38,982	-$367	$0	$0.39
8/8/14	97,600	366	366	$3,754	$24,208	$10,950	$38,911	-$364	$0	$0.40
9/9/14	101,600	366	366	$3,754	$25,200	$11,221	$40,175	-$376	$0	$0.40
10/8/14	81,200	366	366	$3,754	$20,140	$8,170	$32,064	-$311	$0	$0.39
11/7/14	31,600	366	366	$3,754	$7,838	$3,035	$14,626	-$139	$0	$0.46
12/8/14	81,200	366	366	$3,752	$20,140	$6,853	$30,744	-$311	$0	$0.38
Totals/Avg	**1,196,400**	**366**	**366**	**$45,057**	**$296,747**	**$118,377**	**$460,181**	**-$3,496**	**$0**	**$0.39**

A summary of 2014 pumpage and well hours for the station is shown in Table 10.3.

Table 10.3: Keopu 2014 Hours & Pumpage

Month	Monthly Energy Use (kWh)	Monthly Net Bill	Total Well Hours	Total Pumpage (kgal)	Average GPM	kWh/kgal	Cost/kgal	Average kW From Hours	Calculated Pump Efficiency
Jan-14	130,000	$48,874	318	11,675	611	11.1	4.2	408	54%
Feb-14	117,200	$43,807	294	10,747	609	10.9	4.1	398	55%
Mar-14	120,000	$45,332	336	12,253	609	9.8	3.7	358	61%
Apr-14	114,400	$42,555	360	13,303	616	8.6	3.2	318	70%
May-14	127,600	$47,240	259	9,559	616	13.3	4.9	493	45%
Jun-14	95,200	$36,870	280	10,314	615	9.2	3.6	341	65%
Jul-14	98,800	$38,982	285	10,473	613	9.4	3.7	347	63%
Aug-14	97,600	$38,911	279	10,255	613	9.5	3.8	350	63%
Sep-14	101,600	$40,175	249	9,187	614	11.1	4.4	407	54%
Oct-14	81,200	$32,064	124	4,559	612	17.8	7.0	654	34%
Nov-14	31,600	$14,626	131	4,781	610	6.6	3.1	242	90%
Dec-14	81,200	$30,744	276	10,115	610	8.0	3.0	294	74%
Totals/Avg	**1,196,400**	**$460,181**	**3190**	**117,221**	**612**	**10.2**	**3.9**	**384**	**61%**

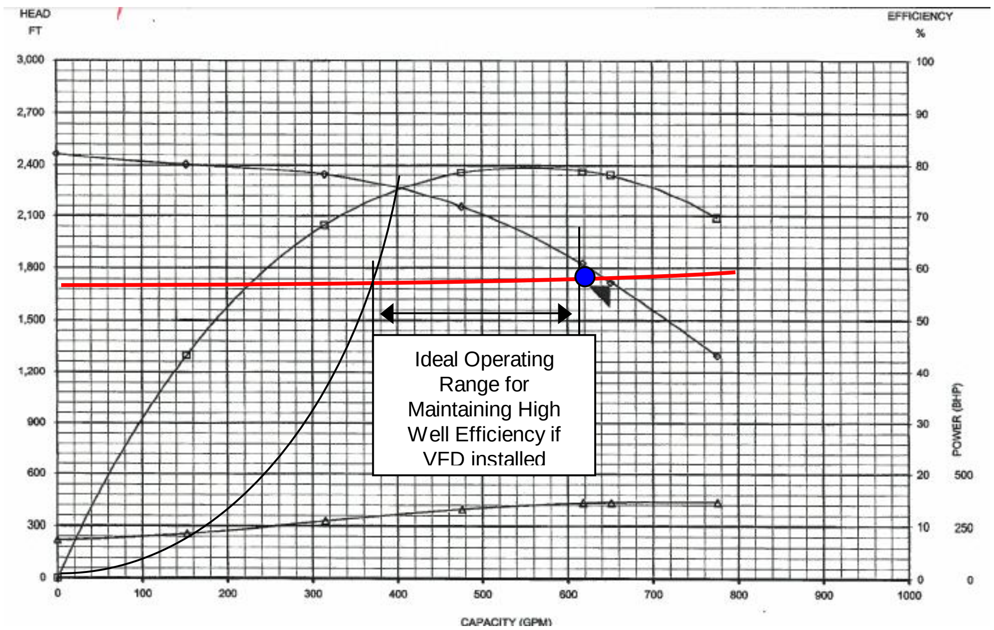
Well Testing

To evaluate existing pump performance, we collected flow data using the existing flow meter. Power was estimated based on amperage and billed kW, and discharge pressure was determined using a Fluke PV-350 pressure transducer. To calculate pump efficiency, we used the original motor efficiency of 89% (submersible motor) and the original well depth data shown below.

Table 10.4: Keopu Energy Testing

Pump Measurements / Calculations	Data
Total Flow (gpm)	629
Discharge Pressure (psi)	12
Baseline Ground Elevation (ft)	1672
Tank Water Level Elevation (ft)	1701
Well Depth to Baseline (ft)	1600
Static Head (ft)	1629
Gauge Height from Baseline (ft)	2
Estimated Column/Velocity Losses (ft) 1ft/100ft	16
Estimated Total Head (ft): P * 2.31 + well depth + losses)	1646
Total Measured Power (kW)	366
Estimated Motor Efficiency (%)	89%
Calculated Pump Efficiency	**60%**
Original Pump Efficiency at Flowrate	**79%**

Figure 10.1: Keopu Pump Curve



Observations and Proposed Recommendations

- During our site visit we noted that the electrical switchgear is equipped with two amperage meters. One indicates 89 amps and one shows 102 amps. Since power factor correction would impact the amperage reading, we have assumed this is the reason for the discrepancy. The high power factor of 93% resulted in a credit of $3,496 in 2014.

- The well is activated at a 25' level in the Keopu Tank and shuts off at 30'. Staff indicated that the future plan is to have a second well on site to increase supply. From an energy perspective, we would normally not recommend a VFD for most deep wells that are used on a regular basis (back up pump VFDs have been recommended in ESM #5). However, as seen on Figure 10.1, the pump curve characteristics for this well provide a flatter efficiency curve that would allow staff to operate the pump efficiently in a range of 380 to 630 gpm. Additional information is needed on how the DWS plans to operate this well with the other deep wells coming back on line before savings can be calculated.

- The full speed efficiency of this well was one of the lowest recorded during field-testing. Based on 2014 operating hours, the savings for improving pump efficiency is reviewed in ECM #2.

- If the DWS moves forward with installing a VFD, it will become easier to adjust pump operation for enough hours to qualify for Rider M. As discussed, as long as the VFD is operated within the recommended range, the pump will provide flow at a reasonable efficiency.

10.2 Kalaoa Well

The Kalaoa Well Pump Station is billed on HELCO Rate Schedule P. The well is equipped with a 2370 V, 418 hp motor and VFD and is rated to pump 700 gpm @ 1750' TDH. Energy use data from the electric bills is shown below in Table 10.5.

Table 10.5: Kalaoa Well 2014 Energy Use & Cost

Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill	Power Factor Penalty	Rider M Discount	Net Bill	Net Cost/ kWh
1/7/14	244,400	311	346	$6,755	$53,324	$24,421	$84,500	-$541	$0	$83,959	$0.34
2/5/14	214,800	311	346	$6,749	$46,866	$20,000	$73,615	-$483	$0	$73,133	$0.34
3/6/14	214,600	315	349	$6,796	$46,822	$21,387	$75,005	-$483	$0	$74,523	$0.35
4/4/14	220,000	325	353	$6,891	$48,000	$20,015	$74,906	-$494	$0	$74,412	$0.34
5/6/14	252,000	363	372	$7,260	$54,982	$23,117	$85,359	-$560	$0	$84,799	$0.34
6/5/14	241,600	339	360	$7,028	$52,713	$23,371	$83,112	-$538	$0	$82,575	$0.34
7/7/14	258,600	340	361	$7,034	$56,422	$27,450	$90,906	-$571	$0	$90,335	$0.35
8/5/14	233,000	339	360	$7,026	$50,837	$25,693	$83,556	-$521	$0	$83,035	$0.36
9/5/14	248,800	383	383	$7,465	$54,284	$27,528	$89,277	-$556	$0	$88,721	$0.36
10/6/14	248,600	337	360	$7,022	$54,241	$24,773	$86,036	-$551	$0	$85,484	$0.35
11/5/14	241,600	367	375	$7,313	$52,713	$22,880	$82,905	-$540	$0	$82,365	$0.34
12/4/14	220,000	361	372	$7,256	$48,000	$18,815	$74,071	-$497	$0	$73,574	$0.34
Totals/Avg	**2,838,000**	**341**	**362**	**$84,593**	**$619,206**	**$279,450**	**$983,249**	**-$6,334**	**$0**	**$976,915**	**$0.35**

A summary of 2014 pumpage and well hours for the station is shown below.

Table 10.6: Kalaoa Well 2014 Hours and Pumpage

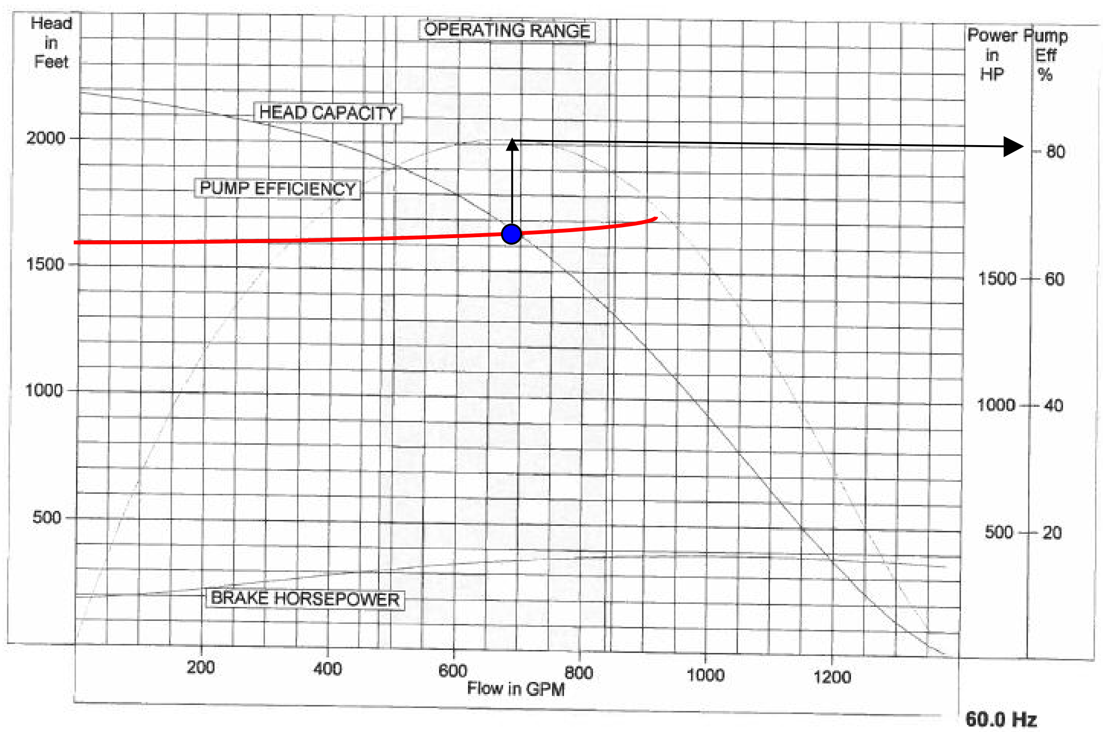
Month	Monthly Energy Use (kWh)	Monthly Bill	Total Well Hours	Total Pumpage (kgal)	Average GPM	kWh/kgal	Cost/kgal	KW Based on Billed Usage and Hours	Average Pump Efficiency
Jan-14	244,400	$83,959	745	28,351	634	8.6	3.0	328	71%
Feb-14	214,800	$73,133	672	25,569	634	8.4	2.9	320	73%
Mar-14	214,600	$74,523	743	28,680	643	7.5	2.6	289	82%
Apr-14	220,000	$74,412	707	28,654	676	7.7	2.6	311	80%
May-14	252,000	$84,799	723	30,161	696	8.4	2.8	349	73%
Jun-14	241,600	$82,575	743	30,879	693	7.8	2.7	325	78%
Jul-14	258,600	$90,335	767	31,854	692	8.1	2.8	337	75%
Aug-14	233,000	$83,035	716	29,878	695	7.8	2.8	325	78%
Sep-14	248,800	$88,721	620	29,828	801	8.3	3.0	401	73%
Oct-14	248,600	$85,484	838	30,714	611	8.1	2.8	297	76%
Nov-14	241,600	$82,365	720	25,541	592	9.5	3.2	336	65%
Dec-14	220,000	$73,574	*707*	*28,654*	*676*	7.7	2.6	311	80%
Totals/Avg	**2,838,000**	**$976,915**	**8,700**	**348,763**	**670**	**8.1**	**2.8**	**327**	**75%**

Table 10.7: Kalaoa Well Pump Test

Pump Measurements / Calculations	Data
Total Flow (gpm)	675
VFD Speed	92%
Discharge Pressure (psi)	4
Baseline Ground Elevation (ft)	1799
Tank Water Level Elevation (ft)	1812
Well Depth to Baseline (ft)	1579
Static Head (ft)	1592
Gauge Height from Baseline (ft)	3
Estimated Column/Velocity Losses (ft) 1ft/100ft	15.79
Estimated Total Head (ft): P * 2.31 + well depth + losses)	1607
Total Measured Power (kW)	370
Estimated Motor Efficiency (%)	89%
VFD Efficiency	85%
Calculated Pump Efficiency	**73%**
Original Pump Efficiency at Flowrate	**80%**

As shown on the pump curve, the calculated pump efficiency is slightly lower than the original efficiency but this inefficiency could also be due to the older Centrilift VFD.

Figure 10.2: Kalaoa Well Pump Curve



Observations and Proposed Recommendations

- Operations staff indicated that the VFD only operates at a maximum of 92% speed to produce 650 gpm. At this time the tank level controls are not used and the well is operated continuously. DWS indicated that the maximum output of the well is capped at 700 gpm, which was the limit approved by the state Department of Land and Natural Resources – Commission of Water Resource Management (CWRM). The well was equipped with a VFD because it was unknown at the time what the sustainable yield would be. Based on the data in Table 10.6, the average efficiency was better than expected. We recommend maintaining the current VFD speed.

- With the well operated continuously, there is no opportunity for Rider M savings at this time. As additional wells come on line, the potential of a Rider M agreement should be re-considered since the savings would be higher with this Rate Schedule P station.

- The high power factor of 94% resulted in a credit of $6,334 in 2014.

10.3 Hualaiai Well

The Hualaiai Well Pump Station is billed on Rate Schedule P and is equipped with a 4000 V, 600 hp motor rated to pump 1050 gpm @ 1480' TDH. The station also has three 30 hp booster pumps rated for 350 gpm @ 200' TDH. Energy use data is shown below in Table 10.8.

Table 10.8: Hualaiai Well 2014 Energy Use /Costs

Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill	Power Factor Penalty	Rider M Discount	Net Bill
1/7/14	0	0	540	$10,938	$0	$0	$10,938	$0	$0	$10,938
2/5/14	0	0	540	$10,938	$0	$0	$10,938	$0	$0	$10,938
3/6/14	200	156	540	$10,938	$0	$0	$10,938	$0	$0	$10,938
4/4/14	200	48	540	$10,938	$0	$0	$10,938	$0	$0	$10,938
5/6/14	0	0	540	$10,938	$0	$0	$10,938	$0	$0	$10,938
6/5/14	0	0	540	$10,938	$0	$0	$10,938	$0	$0	$10,938
7/7/14	0	7	540	$10,938	$0	$0	$10,938	$0	$0	$10,938
8/5/14	0	7	540	$10,938	$0	$0	$10,938	$0	$0	$10,938
9/5/14	0	0	200	$4,300	$0	$0	$4,300	$0	$0	$4,300
10/6/14	0	16	200	$4,300	$0	$0	$4,300	$0	$0	$4,300
11/5/14	800	483	483	$10,109	$0	$0	$10,109	$0	$0	$10,109
12/4/14	200	18	383	$9,887	$0	$0	$9,887	$0	$0	$9,887
Totals/Avg	**1400**	**61**	**499**	**$116,099**	**$0**	**$0**	**$116,099**	**$0**	**$0**	**$116,099**

As shown below, in 2014 the pump did not operate the entire year.

Table 10.9: Hualaiai Well Hours and Pumpage

Month	Monthly Energy Use (kWh)	Monthly Bill	Total Well Hours	Total Pumpage
Jan-14	0	$10,938	0	0
Feb-14	0	$10,938	0	0
Mar-14	200	$10,938	0	0
Apr-14	200	$10,938	0	0
May-14	0	$10,938	0	0
Jun-14	0	$10,938	0	0
Jul-14	0	$10,938	0	0
Aug-14	0	$10,938	0	0
Sep-14	0	$4,300	0	0
Oct-14	0	$4,300	0	0
Nov-14	800	$10,109	0	0
Dec-14	200	$9,887	*0*	*0*
Totals/Avg	**1,400**	**$116,099**	**0**	**0**

Observations and Proposed Recommendations

It is difficult to know how to optimize this well without having historical data to determine how it was typically used with the other wells. Based on the available data, the key issues to reduce energy costs include the following:

- The well is activated at the 12’ tank level and shuts off at 15’ and is typically used to supplement the Kalaoa Well. Although the well has been operated less than 80 hours in the last two years, the DWS has been billed $243,000 in demand charges. At this time, the well repairs are ongoing, which will include the installation of a VFD.

- If the well will be used as a back-up to the Kalaoa Well and is expected to run less than 100 hours annually, the DWS should de-rate the well using the VFD to maintain the demand level lower than 200 kW. This will provide the opportunity to reduce demand charges by approximately 48% by having the station operate on Rate Schedule J.

- If the well is operated more hours, then the DWS should allocate enough run time for this well to qualify for a Rider M rate.

10.4 Queen Liliuokalani Trust (QLT) Deep Well

The QLT Well Pump Station is billed on HELCO Rate Schedule P. The well is equipped with a 4160 V, 600 hp motor and is rated to pump 1000 gpm @ 1760' TDH. Energy use data from the electric bills is shown below in Table 10.10.

Table 10.10: QLT Well 2014 Energy Use /Costs

Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill	Power Factor	Rider M Discount	Net Cost/ kWh
1/9/14	259,400	513	514	$10,019	$56,597	$26,842	$93,458	$600	$0	$0.36
2/7/14	278,400	511	513	$10,005	$60,742	$27,275	$98,023	$637	$0	$0.35
3/10/14	313,200	514	514	$10,027	$68,335	$32,043	$110,405	$705	$0	$0.35
4/8/14	298,000	510	513	$9,996	$65,019	$28,324	$103,338	$675	$0	$0.35
5/8/14	319,400	509	512	$9,984	$69,688	$30,720	$110,392	$717	$0	$0.35
6/9/14	283,200	512	513	$10,009	$61,790	$28,935	$100,734	$646	$0	$0.36
7/9/14	282,800	513	514	$10,025	$61,702	$31,354	$103,081	$646	$0	$0.36
8/8/14	301,600	509	511	$9,968	$65,804	$34,580	$110,353	$682	$0	$0.37
9/9/14	301,600	509	511	$9,968	$74,532	$38,673	$123,173	$761	$0	$0.41
10/8/14	301,400	509	511	$9,968	$65,761	$31,193	$106,922	$682	$0	$0.35
11/7/14	350,400	510	512	$9,980	$76,452	$34,355	$120,787	$778	$0	$0.34
12/8/14	368,400	510	512	$9,980	$80,379	$32,191	$122,550	$813	$0	$0.33
Totals/Avg	**3,657,800**	**511**	**513**	**$119,931**	**$806,801**	**$376,484**	**$1,303,216**	**$8,341**	**$0**	**$0.36**

Run time and pumpage for 2014 is shown below.

Table 10.11: QLT Well 2014 Hours and Pumpage

Month	Monthly Energy Use (kWh)	Monthly Bill	Total Well Hours	Total Pumpage (kgal)	Average GPM	kWh/kgal	Cost/kgal
Jan-14	259,400	$93,458	521	34,672	1,109	7.5	2.7
Feb-14	278,400	$98,023	549	36,321	1,102	7.7	2.7
Mar-14	313,200	$110,405	620	40,243	1,082	7.8	2.7
Apr-14	298,000	$103,338	682	43,527	1,064	6.8	2.4
May-14	319,400	$110,392	517	33,966	1,096	9.4	3.3
Jun-14	283,200	$100,734	586	38,490	1,095	7.4	2.6
Jul-14	282,800	$103,081	628	41,027	1,089	6.9	2.5
Aug-14	301,600	$110,353	634	41,329	1,087	7.3	2.7
Sep-14	301,600	$123,173	607	37,936	1,041	8.0	3.2
Oct-14	301,400	$106,922	738	47,797	1,079	6.3	2.2
Nov-14	350,400	$120,787	706	42,388	1,001	8.3	2.8
Dec-14	368,400	$122,550	*700*	42,388	1,009	8.7	2.9
Totals/Avg	**3,657,800**	**$1,303,216**	**7,487**	**480,084**	**1,071**	**7.7**	**2.7**

Well Testing

To evaluate existing pump performance, we collected flow data using the existing flow meter. Power was measured with a Fluke 43B kW meter, and discharge pressure was determined using a Fluke PV-350 pressure transducer. To calculate pump efficiency, we used a motor efficiency of 89% (submersible motor) and the original well depth data shown below.

Table 10.12: QLT Well Pump Test

Pump Measurements / Calculations	Data
Total Flow (gpm)	1087
Discharge Pressure (psi)	1
Baseline Ground Elevation (ft)	1764
Tank Water Level Elevation (ft)	1699
Well Depth to Baseline (ft)	1550
Static Head (ft)	1485
Gauge Height from Baseline (ft)	2
Estimated Column/Velocity Losses (ft) 1ft/100ft	15.5
Estimated Total Head (ft): P * 2.31 + well depth + losses)	1570
Total Measured Power (kW)	491
Estimated Motor Efficiency (%)	89%
Calculated Pump Efficiency	**74%**
Original Pump Efficiency at Flowrate	**TBD**

Observations and Proposed Recommendations

The QLT motor controls include a soft start and based on the last two years has operated efficiently. In 2014 the well operated 85% of the time. The well is activated at the 13’ tank level and shuts off 18’.

The well is on a soft start, but this has not helped the poor power factor that the station has been charged. In 2014 the DWS was billed $8,341 in penalty charges for a power factor of 0.73. If this can be improved to 0.95 with power factor correction capacitors, a $9,267 credit (in addition to saving the $8,341 in penalties) will be realized. These savings are included in ESM #1.

10.4 Waiaha Well

The Waiaha Well is rated to pump 1400 gpm @ 1550' TDH. The well is a submersible unit equipped with a 700 hp motor with a 4160 V step-up transformer. Energy use data from the electric bills is shown below in Table 10.13.

Table 10.13: Waiaha Well 2014 Energy Use /Costs

Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill	Power Factor Penalty	Rider M Discount	Net Cost/ kWh
1/9/14	152,240	593	593	$6,078	$37,761	$15,872	$59,711	$263	$0	$0.39
2/7/14	130,160	593	593	$6,080	$32,284	$12,930	$51,294	$269	$0	$0.39
3/10/14	126,160	593	593	$6,082	$31,292	$13,135	$50,509	$262	$0	$0.40
4/8/14	127,840	594	594	$6,083	$31,709	$12,375	$50,167	$265	$0	$0.39
5/8/14	119,120	593	593	$6,079	$29,546	$11,734	$47,359	$249	$0	$0.40
6/9/14	104,800	593	593	$6,082	$25,994	$11,070	$43,146	$225	$0	$0.41
7/9/14	102,800	593	593	$6,081	$25,498	$11,755	$43,334	$221	$0	$0.42
8/8/14	123,920	594	594	$6,087	$30,736	$14,605	$51,428	$258	$0	$0.42
9/9/14	125,520	594	594	$6,086	$31,133	$14,573	$51,793	$261	$0	$0.41
10/8/14	152,560	593	594	$6,085	$37,840	$16,185	$60,110	$307	$0	$0.39
11/7/14	241,760	593	594	$6,085	$59,964	$24,318	$90,368	$462	$0	$0.37
12/8/14	273,760	593	594	$6,084	$67,902	$24,502	$98,488	$518	$0	$0.36
Totals/Avg	**1,780,640**	**593**	**593**	**$72,996**	**$441,657**	**$183,055**	**$697,709**	**$3,559**	**$0**	**$0.40**

Run time and pumpage for 2014 is shown below.

Table 10.14: Waiaha Well 2014 Run Time and Pumpage

Month	Monthly Energy Use (kWh)	Monthly Bill	Total Well Hours	Total Pumpage (kgal)	Average GPM	kWh/ kgal	Cost/ kgal
Jan-14	152,240	$59,711	220	16,629	1,261	9.2	3.6
Feb-14	130,160	$51,294	198	14,834	1,249	8.8	3.5
Mar-14	126,160	$50,509	220	16,432	1,243	7.7	3.1
Apr-14	127,840	$50,167	204	15,776	1,286	8.1	3.2
May-14	119,120	$47,359	183	13,428	1,224	8.9	3.5
Jun-14	104,800	$43,146	161	12,140	1,254	8.6	3.6
Jul-14	102,800	$43,334	214	15,935	1,239	6.5	2.7
Aug-14	123,920	$51,428	202	15,143	1,253	8.2	3.4
Sep-14	125,520	$51,793	206	15,276	1,239	8.2	3.4
Oct-14	152,560	$60,110	434	33,382	1,281	4.6	1.8
Nov-14	241,760	$90,368	423	32,437	1,280	7.5	2.8
Dec-14	273,760	$98,488	559	43,040	1,283	8.4	3.0
Totals/Avg	**1,780,640**	**$697,709**	**3,224**	**244,452**	**1,257**	**7.3**	**2.9**

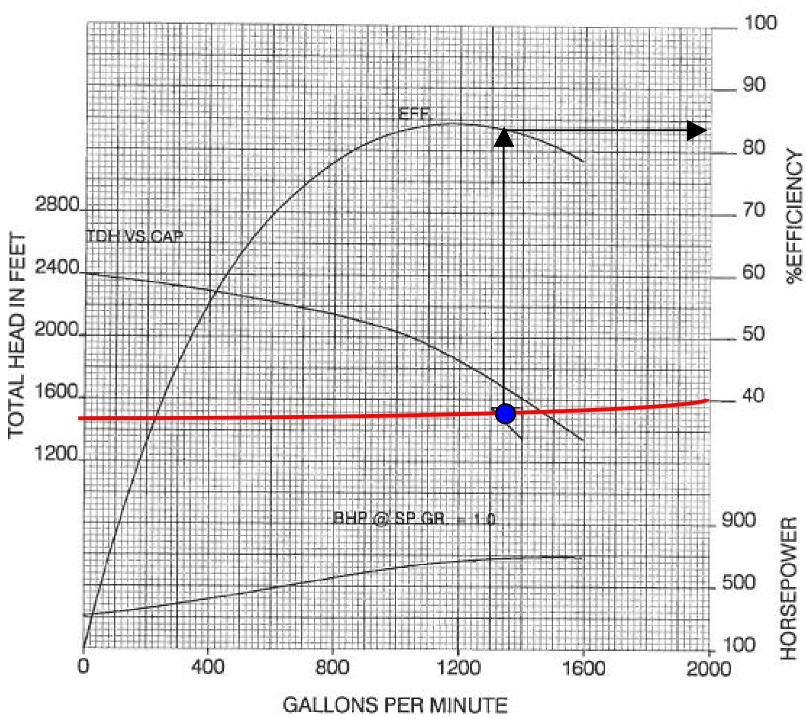
Well Testing

To evaluate existing pump performance, we collected flow data using the existing flow meter. Power was measured with a Fluke 43B kW meter, and discharge pressure was determined using a Fluke PV-350 pressure transducer. To calculate pump efficiency, we used a motor efficiency of 95% and the original well depth data shown below.

Table 10.15: Waiaha Pump Test

Pump Measurements / Calculations	Data
Total Flow (gpm)	1327
Discharge Pressure (psi)	5.0
Baseline Ground Elevation (ft)	1541
Tank Water Level Elevation (ft)	1566
Well Depth to Baseline (ft)	1500
Static Head (ft)	1525
Gauge Height from Baseline (ft)	2
Estimated Column/Velocity Losses (ft) 1ft/100ft	15
Estimated Total Head (ft): P * 2.31 + well depth + losses)	1529
Total Measured Power (kW)	592
Estimated Motor Efficiency (%)	95%
Calculated Pump Efficiency	**68%**
Original Pump Efficiency at Flowrate	**84%**

Figure 10.3: Waiaha Pump Curve



Observations and Proposed Recommendations

Based on the data and discussions with DWS staff, we have the following recommendations:

- In 2014, the station had an average power factor of 0.78, which resulted in $3,559 penalty charges. If this can be improved to 0.95 with power factor correction capacitors, a $5,147 credit (in addition to saving $3,599 in penalties) will be realized. These savings are included in ESM #1.

- The Waiaha Well averaged approximately 200 hours/month for the first 10 months and over 400 hours/month the last two months. DWS staff indicated that they plan on maintaining high operating hours for this well.

- Based on the test data, the Waiaha Well efficiency was 16% lower than the original rate curve efficiency of 84%. If pump efficiency can be improved to 80%, the DWS would save approximately $79,000 annually. This improvement is included in ECM #2.

Staff indicated that the 8” Forcemain will eventually be increased to 16” so it can be used to supplement the shaft well. No specific timeline for this change was provided.

10.5 Honokohau Well

The Honokohau Well is rated to pump 1400 gpm @ 1700’ TDH. The well is equipped with a Centrilift 4160 V, 800 hp motor. The account is billed on Rate Schedule P. Energy use data from the electric bills is shown below in Table 10.16.

Table 10.16: Honokohau Well 2014 Energy Use /Costs

Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill	Power Factor Penalty	Rider M Discount	Net Cost/ kWh
1/3/14	367,800	623	635	$12,388	$80,248	$38,392	$131,029	$556	$2	$0.36
2/3/14	382,800	623	635	$12,388	$83,521	$36,467	$132,376	$575	$2	$0.35
3/4/14	367,000	625	636	$12,406	$80,074	$37,931	$130,411	$555	$17	$0.36
4/2/14	363,600	622	635	$12,379	$79,332	$34,170	$125,881	$550	$8	$0.35
5/2/14	423,400	622	635	$12,377	$92,379	$39,932	$144,688	$629	$2	$0.34
6/3/14	385,600	620	634	$12,353	$84,132	$38,214	$134,699	$579	$2	$0.35
7/2/14	388,000	618	624	$12,170	$84,655	$42,163	$138,989	$581	$2	$0.36
8/1/14	420,000	620	625	$12,195	$91,637	$47,364	$151,196	$623	$19	$0.36
9/3/14	434,600	637	641	$12,496	$94,823	$48,463	$155,781	-$644	$21	$0.36
10/2/14	361,400	647	647	$12,617	$78,852	$36,095	$127,564	-$732	$2	$0.35
11/3/14	3,200	0	0	$13,017	$0	$10	$13,027	$0	$10	$4.07
12/2/14	2,400	10	647	$13,017	$0	$48	$13,065	$0	$10	$5.44
Totals/Avg	**3,899,800**	**522**	**583**	**$149,801**	**$849,652**	**$399,250**	**$1,398,704**	**$3,272**	**$97**	**$1.09**

2014 flow and pumpage for the well is summarized below.

Table 10.17: Honokohau Well 2014 Hours/Pumpage

Month	Monthly Energy Use (kWh)	Monthly Bill	Total Well Hours	Total Pumpage (kgal)	Average GPM	kWh/kgal	Cost/kgal
Jan-14	367,800	$131,029	561	42,561	1,265	8.6	3.1
Feb-14	382,800	$132,376	570	43,299	1,266	8.8	3.1
Mar-14	367,000	$130,411	642	48,580	1,262	7.6	2.7
Apr-14	363,600	$125,881	677	51,338	1,263	7.1	2.5
May-14	423,400	$144,688	598	44,784	1,248	9.5	3.2
Jun-14	385,600	$134,699	657	49,298	1,251	7.8	2.7
Jul-14	388,000	$138,989	728	54,731	1,253	7.1	2.5
Aug-14	420,000	$151,196	0	45,593	--	9.1	3.3
Sep-14	434,600	$155,781	652	46,814	--	9.3	3.2
Oct-14	361,400	$127,564	0	0			
Nov-14	3,200	$13,027	0	0			
Dec-14	2,400	$13,065	*0*	*0*			
Totals/Avg	**3,899,800**	**$1,398,704**	**5,085**	**426,998**	**1,258**	**9.1**	**3.3**

Observations and Proposed Recommendations

- In 2014, the Honokohau Well was on Rider M in 2014 but received a total annual credit of $97 since DWS staff was unable to curtail usage due to several wells being off-line.
- In November 2014, the well went off line and is currently down for repairs.
- Although we were not able to get a well pump curve, the average pump efficiency in 2014 was a respectable 78%.
- In 2014, the station had an average power factor of 0.80, which resulted in $3,272 of penalty charges. If this can be improved to 0.95 with power factor correction capacitors, a $10,025 credit (in addition to saving $3272 in penalties) will be realized. These savings are included in ESM #1.

10.5 Kahaluu Well A, C & Booster

Kalaluu Well A is a Johnson Pump rated for 700 gpm @ 900' TDH and is equipped with a 250 hp motor. Kalaluu Well C is a Layne Pump also rated to pump 700 gpm @ 900' TDH and is equipped with a 250 hp motor. The station has four booster pumps that are currently not in use. The account is currently billed on Rate Schedule J. Energy use data from the electric bills is shown below in Table 10.18.

Table 10.18: Kahaluu Well A, C & Booster 2014 Energy Use & Cost

Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill	Power Factor	Rider M Discount
1/22/14	160,640	428	478	$4,901	$39,844	$15,297	$60,042	-179	0
2/20/14	132,160	527	527	$5,399	$32,780	$13,041	$51,220	-191	0
3/21/14	175,360	527	527	$5,406	$43,495	$16,566	$65,467	-342	0
4/22/14	208,640	455	491	$5,035	$51,750	$19,118	$75,902	-227	0
5/21/14	160,640	430	479	$4,908	$39,844	$15,386	$60,137	-179	0
6/20/14	174,720	426	477	$4,886	$43,336	$18,248	$66,470	-145	0
7/22/14	205,440	320	424	$4,345	$50,956	$22,784	$78,085	-166	0
8/21/14	178,880	321	424	$4,346	$44,368	$20,418	$69,132	-97	0
9/22/14	202,560	322	425	$4,351	$50,242	$21,574	$76,167	-109	0
10/22/14	201,920	385	456	$4,674	$50,083	$20,101	$74,858	-110	0
11/20/14	187,840	426	477	$4,884	$46,591	$17,259	$68,734	-154	0
12/19/14	237,440	493	510	$5,229	$58,893	$18,611	$82,732	-256	0
Totals/Avg	**2,226,240**	**422**	**474**	**$58,362**	**$552,181**	**$218,402**	**$828,946**	**-2156**	**0**

Pumpage and hours for the two wells in 2014 are summarized below

Table 10.19: Kahaluu Well A & C 2014 Hours and Pumpage

Month	Monthly Energy Use (kWh)	Monthly Bill	Well A Hours	Well C Hours	Total Well Hours	Well A Pumpage	Well C Pumpage	Total Pumpage (kgal)	Average GPM	kWh/kgal	Cost/kgal
Jan-14	160,640	$60,042	160	563	723	6,226	22,398	28,624	660	5.6	2.1
Feb-14	132,160	$51,220	222	653	875	8,677	25,971	34,648	660	3.8	1.5
Mar-14	175,360	$65,467	499	706	1,205	19,673	28,213	47,886	662	3.7	1.4
Apr-14	208,640	$75,902	470	710	1,180	18,500	28,277	46,777	661	4.5	1.6
May-14	160,640	$60,137	248	719	966	9,655	28,633	38,288	660	4.2	1.6
Jun-14	174,720	$66,470	666	516	1,182	26,334	20,300	46,634	658	3.7	1.4
Jul-14	205,440	$78,085	765	505	1,270	30,298	19,832	50,130	658	4.1	1.6
Aug-14	178,880	$69,132	719	388	1,106	28,458	15,987	44,445	670	4.0	1.6
Sep-14	202,560	$76,167	720	444	1,164	28,504	16,502	45,006	644	4.5	1.7
Oct-14	201,920	$74,858	742	552	1,294	29,376	21,659	51,035	657	4.0	1.5
Nov-14	187,840	$68,734	720	392	1,113	28,474	15,255	43,729	655	4.3	1.6
Dec-14	237,440	$82,732	*720*	*392*	1,113	28,474	15,255	43,729	655	5.4	1.9
Totals/Avg	**2,226,240**	**$828,946**	**6,650**	**6,540**	**13,190**	**262,649**	**258,282**	**520,931**	**658**	**4.3**	**1.6**

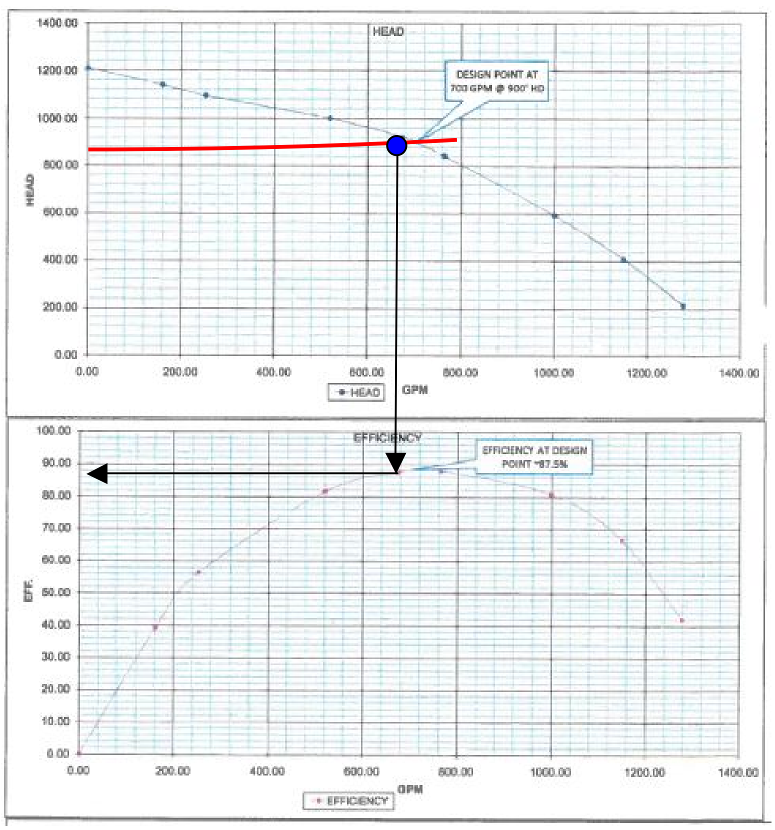
Well Testing

To evaluate existing pump performance, we collected flow data using the existing flow meter. Power was measured with a Fluke 43B kW meter, and discharge pressure was determined using a Fluke PV-350 pressure transducer. To calculate pump efficiency, we used a motor nameplate efficiency of 95% and the original well depth data shown below.

Table 10.20: Kahaluu Well A & C Test Data

Pump Measurements / Calculations	A	C
Total Flow (gpm)	658	657
Discharge Pressure (psi) – estimated based on tank level	~5	~5
Baseline Ground Elevation (ft)	832	832
Tank Water Level Elevation (ft)	845	845
Well Depth to Baseline (ft)	850	850
Static Head (ft)	863	863
Gauge Height from Baseline (ft)	2	2
Estimated Column/Velocity Losses (ft) 1ft/100ft	8.5	8.5
Estimated Total Head (ft): P * 2.31 + well depth + losses)	872	872
Total Measured Power (kW)	167	152
Estimated Motor Efficiency (%)	95%	95%
Calculated Pump Efficiency	**68%**	**75%**
Original Pump Efficiency at Flowrate	**~85%**	**85%**

Figure 10.5: Kahaluu Well C Pump Curve



Observations & Recommendations

For the four Kahaluu Wells (A, B, C and D), the current operating strategy (as of November 2014) is to operate Wells A & D continuously, Well C has the lag pump (operating approximately 50% of the time), and Well B as a back up. These wells primarily support the Kahaluu Shaft Well system.

- The average pump efficiency for Kahaluu Well A was calculated to be 68% and Kahaluu Well C was calculated to be 75% using the data collected during the site visit. If Well C is operated as the primary pump and Well A is used as a back up, approximately 65,700 kWh ($20,000) could be saved. This revised strategy is included in OM #5.

- In 2014, the station had an average power factor of 0.88, which resulted in a $2,156 credit. If this can be improved to 0.95 with power factor correction capacitors, a $10,025 credit will be realized. This improvement is included in ESM #1.

10.6 Kahaluu Well B

Kahaluu Well B is rated for 700 gpm @ 915' TDH. The pump is primarily used for back-up service and is equipped with a 300 hp 460 V motor. As shown in Table 2, the well was used for the first 5 months of 2014 and then taken out of service. The well was taken offline due to failure of the pump and problems with entrained air. Project completion for this well repair is April 30, 2015. This well is billed on Rate Schedule J.

Table 10.21: Kahaluu Well B 2014 Energy Use & Cost

Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill	Power Factor	Rider M Discount	Net Cost/ kWh
1/22/14	115,680	148	148	$1,518	$28,692	$11,388	$41,599	$0	$0	$0.36
2/20/14	102,960	150	150	$1,532	$25,537	$10,531	$37,601	$0	$0	$0.37
3/21/14	105,120	154	154	$1,580	$26,073	$10,279	$37,931	$0	$0	$0.36
4/22/14	119,040	159	159	$1,634	$29,526	$11,292	$42,451	$0	$0	$0.36
5/21/14	42,480	168	168	$1,722	$10,536	$4,246	$16,504	$0	$0	$0.39
6/20/14	480	0	168	$1,786	$0	$0	$1,786	$0	$0	$3.72
7/22/14	240	0	168	$1,786	$0	$0	$1,786	$0	$0	$7.44
8/21/14	480	0	168	$1,786	$0	$0	$1,786	$0	$0	$3.72
9/22/14	0	0	168	$1,786	$0	$0	$1,786	$0	$0	
10/22/14	240	0	168	$1,786	$0	$0	$1,786	$0	$0	$7.44
11/20/14	0	0	168	$1,786	$0	$0	$1,786	$0	$0	
12/19/14	0	0	168	$1,786	$0	$15	$1,801	$0	$0	
Totals/Avg	**486,720**	**65**	**163**	**$20,488**	**$120,365**	**$47,750**	**$188,604**	**$0**	**$0**	**$2.68**

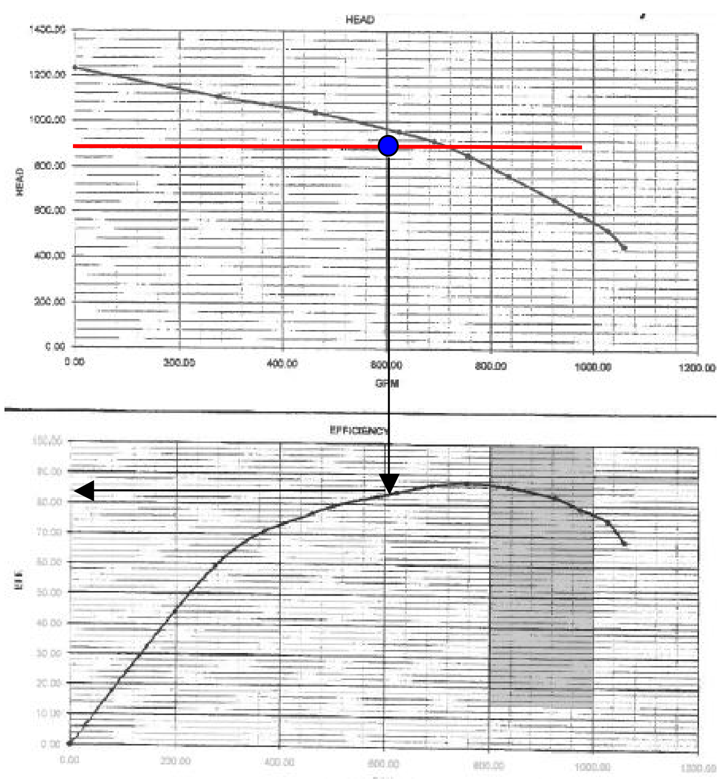
2014 pumpage and run time is shown below.

Table 10.22: Kahaluu Well B 2014 Hours and Pumpage

Month	Monthly Energy Use (kWh)	Monthly Bill	Total Well Hours	Total Pumpage (kgal)	Average GPM	kWh/kgal	Cost/kgal
Jan-14	115,680	$41,599	672	24,188	600	4.8	1.7
Feb-14	102,960	$37,601	672	23,946	594	4.3	1.6
Mar-14	105,120	$37,931	744	27,112	607	3.9	1.4
Apr-14	119,040	$42,451	720	26,524	614	4.5	1.6
May-14	42,480	$16,504	0	0			
Jun-14	480	$1,786	0	0			
Jul-14	240	$1,786	0	0			
Aug-14	480	$1,786	0	0			
Sep-14	0	$1,786	0	0			
Oct-14	240	$1,786	0	0			
Nov-14	0	$1,786	0	0			
Dec-14	0	$1,801	*0*	*0*			
Totals/Avg	**486,720**	**$188,604**	**2,808**	**101,770**	**604**	**4.8**	**1.9**

With the well out of service, we were not able to collect field data to determine pump efficiency. However, based on the calculated flow rate using pumpage and run time in Table 10.22, the average flow of 600 gpm is less than the original rated flow of 700 gpm indicating poor performance.

Figure 10.6: Kahaluu Well B Curve



Observations & Recommendations

If this well will continue to be designated as a back-up pump with low hours, we recommend installing a VFD that can be used to provide minimal flow (and power use) for periodic testing. As long as the other wells are operating, this well will have minimal demand charges and usage. The cost effectiveness of installing a VFD at this station is reviewed in ESM #5.

10.7 Kahaluu Well D

Kahaluu Well D is rated for 700 gpm @ 940' TDH and is equipped with a 200 hp 460 V motor. As shown in Table 10.23, the well was off line for most of 2014. Pumpage and hours are shown in Table 10.24.

Table 10.23: Kahaluu Well D 2014 Energy & Cost Data

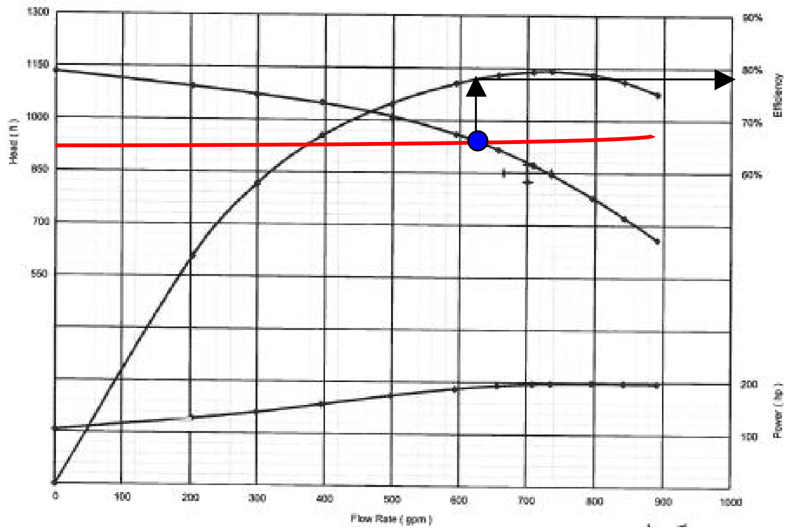
Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill	Power Factor	Rider M Discount	Net Cost/ kWh
1/22/14	0	0	25	$55	$0	$0	$55	$0	$0	
2/20/14	0	0	25	$55	$0	$0	$55	$0	$0	
3/21/14	0	0	25	$55	$0	$0	$55	$0	$0	
4/22/14	0	0	25	$55	$0	$0	$55	$0	$0	
5/21/14	0	0	0	$55	$0	$0	$55	$0	$0	
6/20/14	0	0	0	$55	$0	$0	$55	$0	$0	
7/18/14	0	0	0	$55	$0	$0	$55	$0	$0	
8/21/14	0	0	25	$55	$0	$0	$55	$0	$0	
9/22/14	960	171	25	$55	$303	$108	$466	$0	$0	
10/22/14	62,700	0	0	$55	$767	$25,659	$26,480	$0	$0	$0.42
11/22/14	118,400	0	0	$0	$37,398	$11,572	$48,969	$0	$0	$0.41
12/19/14	118,720	0	0	$256	$29,446	$9,698	$39,400	$0	$0	$0.33
Totals/Avg	**300,780**	**14**	**13**	**$801**	**$67,914**	**$47,036**	**$115,751**	**$0**	**$0**	**$0.39**

Table 10.24: Kahaluu Well D 2014 Hours and Pumpage

Month	Monthly Energy Use (kWh)	Monthly Bill	Total Well Hours	Total Pumpage (kgal)	Average GPM	kWh/kgal	Cost/kgal
Jan-14	0	$55	0	0			
Feb-14	0	$55	0	0			
Mar-14	0	$55	0	0			
Apr-14	0	$55	0	0			
May-14	0	$55	0	0			
Jun-14	0	$55	0	0			
Jul-14	0	$55	0	0			
Aug-14	0	$55	0	0			
Sep-14	960	$466	0	0			
Oct-14	62,700	$26,480	502	22,357	742	2.8	1.2
Nov-14	118,400	$48,969	720	27,048	626	4.4	1.8
Dec-14	118,720	$39,400	720	27,048	626	4.4	1.5
Totals/Avg	**300,780**	**$115,751**	**1,941**	**76,453**	**665**	**3.9**	**1.5**

Based on the original pump curve shown below, the efficiency for the average flow was 78%.

Figure 10.7: Kahaluu Well D Pump Curve



Observations & Recommendations

DWS Staff indicated that Kahaluu Well D is expected to be one of the primary lead pumps to support the Kahaluu Shaft Well System now that it is back on line. Based on the energy and pumpage data for the last two months of 2014, we noted the following:

- Power factor was not available on the energy data sheets in 2014 and has not been recorded in previous years. Based on this we were not able to make a recommendation to improve power factor for the station.
- Pump testing was not performed during our site visit in October 2014 due to the well being out of service at the time.
- If this well will be used as one of the primary wells for the Kahaluu system, Rider M would probably not be feasible for the station.

At this time we have no energy saving recommendations.

10.8 HolualoaWell

The Holualoa Well went down in December. DWS staff indicated that the scope of work is expected to include a new pump, motor, and power cable. The project will also include the installation of a new 480V to 2300V step-up transformer to provide better clearances in the well from the reduction in cable size. The work is scheduled to be complete in March 2016. The existing pump rating is 700 gpm @ 1185' TDH.

A summary of 2014 energy use, costs, pump run time and pumpage is shown in Tables 10.25 and 10.26.

Table 10.25: Holualoa Well 2014 Energy Use & Cost

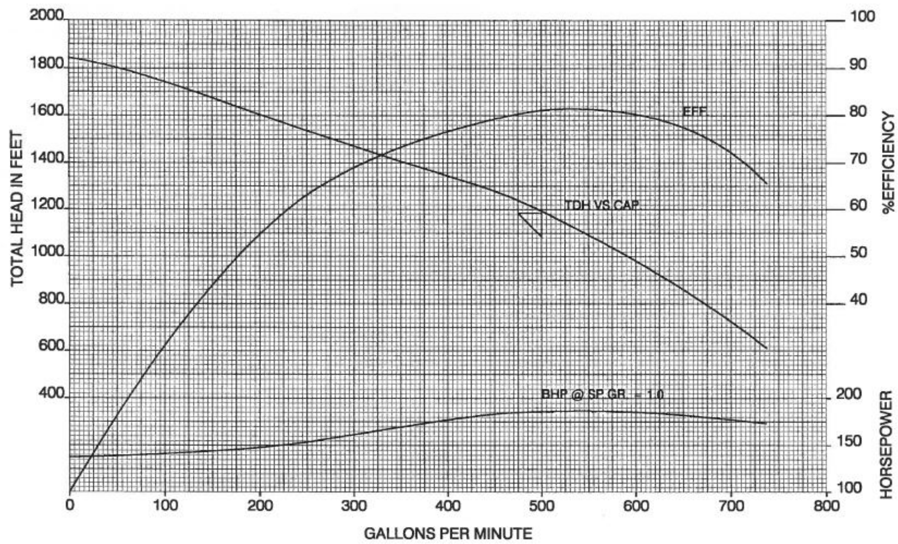
Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill	Power Factor	Rider M Discount
1/10/14	86,200	190	192	$1,967	$21,380	$8,835	$32,182	$0	$0
2/10/14	69,800	162	178	$1,822	$17,313	$6,881	$26,016	$0	$0
3/11/14	63,800	162	178	$1,823	$15,825	$6,502	$24,150	$0	$0
4/9/14	84,800	193	193	$1,979	$21,033	$8,055	$31,068	$0	$0
5/9/14	76,000	192	193	$1,976	$18,851	$7,365	$28,192	$0	$0
6/10/14	51,800	190	192	$1,964	$12,848	$5,410	$20,222	$0	$0
7/10/14	59,400	191	192	$1,972	$14,733	$6,700	$23,406	$0	$0
8/9/14	59,200	189	191	$1,961	$14,684	$6,892	$23,536	$0	$0
9/10/14	56,000	191	192	$1,972	$13,890	$6,400	$22,262	$0	$0
10/9/14	52,000	99	146	$1,500	$12,898	$5,446	$19,844	$0	$0
11/8/14	32,000	190	192	$1,963	$7,937	$3,204	$13,103	$0	$0
12/9/14	400	0	193	$2,040	$0	$7	$2,047	$0	$0
Totals/Avg	**691,400**	**163**	**186**	**$22,940**	**$171,391**	**$71,697**	**$266,028**	**$0**	**$0**

Table 10.26: Holualoa Well 2014 Hours and Pumpage

Month	Monthly Energy Use (kWh)	Monthly Bill	Total Well Hours	Total Pumpage (kgal)	Average GPM	kWh/kgal	Cost/kgal
Jan-14	86,200	$32,182	420	12,470	494	6.9	2.6
Feb-14	69,800	$26,016	379	11,212	493	6.2	2.3
Mar-14	63,800	$24,150	486	14,357	492	4.4	1.7
Apr-14	84,800	$31,068	519	15,326	492	5.5	2.0
May-14	76,000	$28,192	334	9,748	486	7.8	2.9
Jun-14	51,800	$20,222	357	10,426	487	5.0	1.9
Jul-14	59,400	$23,406	400	11,510	480	5.2	2.0
Aug-14	59,200	$23,536	339	9,881	485	6.0	2.4
Sep-14	56,000	$22,262	331	9,665	487	5.8	2.3
Oct-14	52,000	$19,844	307	8,964	487	5.8	2.2
Nov-14	32,000	$13,103					
Dec-14	400	$2,047					
Totals/Avg	**691,400**	**$266,028**	**3,873**	**113,559**	**488**	**6.1**	**2.4**

We were not able to collect data to calculate pump efficiency, but have included the pump curve in Figure 10.8. We made an attempt to calculate efficiency using average flow calculated from the pumpage report and kW for the billed kWh and pump hours, but the data was not consistent enough to provide reliable results.

Figure 10.8: Holualoa Pump Curve



Observations & Recommendations

The only recommendation we can offer for this station is to install power factor correction capacitors to provide annual savings of $2915. This measure is included in ESM #1.

10.9 Kahaluu Shaft Pumps

The four Kahaluu Shaft Pumps are all rated to pump 1400 gpm @ 670' TDH. Each pump is equipped with a 4160 V, 300 hp motor. A summary of 2014 energy use, costs, pump run time and pumpage is shown in Tables 10.27 and 10.28.

Table 10.27: Kahaluu Shaft 2014 Energy Use and Cost

Billing Date	Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill	Power Factor Penalty	Rider M Discount
1/21/14	425,600	697	727	$14,169	$92,859	$39,974	$147,002	-$1,177	$0
2/19/14	301,000	699	727	$14,182	$65,673	$29,214	$109,070	-$878	$0
3/20/14	294,000	699	727	$14,182	$63,841	$27,426	$105,449	-$702	$0
4/21/14	292,600	692	723	$14,100	$63,535	$26,434	$104,070	-$621	$0
5/20/14	350,000	700	727	$14,182	$76,364	$32,522	$123,069	-$905	$0
6/19/14	324,800	762	762	$14,851	$70,866	$32,614	$118,331	-$943	$0
7/21/14	422,800	757	760	$14,810	$92,248	$45,311	$152,369	-$1,071	$0
8/20/14	371,000	752	757	$14,756	$80,946	$41,181	$136,883	-$861	$0
9/19/14	376,600	739	750	$14,633	$82,168	$39,277	$136,077	-$871	$0
10/21/14	396,200	755	758	$14,783	$86,445	$38,419	$139,647	-$911	$0
11/19/14	373,800	757	760	$14,810	$81,557	$33,514	$129,882	-$867	$0
12/18/14	408,800	756	759	$14,797	$89,194	$31,656	$135,646	-$936	$0
Totals/Avg	**4,337,200**	**730**	**745**	**$174,256**	**$945,697**	**$417,542**	**$1,537,494**	**-$10,745**	**$0**

Table 10.28: Kahaluu Shaft 2014 Hours and Pumpage

Month	Well 1 Hours	Well 2 Hours	Well 3 Hours	Well 4 Hours	Total Well Hours	Total Pumpage (kgal)	Average GPM	kWh/ kgal	Cost/ kgal
Jan-14	543	315	602	0	1,459	108,121	1,235	3.9	1.4
Feb-14	489	260	581	0	1,329	106,089	1,330	2.8	1.0
Mar-14	524	217	633	0	1,374	131,318	1,593	2.2	0.8
Apr-14	527	263	625	0	1,416	105,120	1,238	2.8	1.0
May-14	709	266	540	0	1,515	115,839	1,274	3.0	1.1
Jun-14	741	395	261	310	1,707	113,958	1,113	2.9	1.0
Jul-14	590	311	0	763	1,664	143,057	1,433	3.0	1.1
Aug-14	506	253	0	720	1,479	129,546	1,460	2.9	1.1
Sep-14	541	319	0	719	1,578	117,542	1,242	3.2	1.2
Oct-14	298	269	0	744	1,311	144,990	1,843	2.7	1.0
Nov-14	643	263	0	721	1,626	144,742	1,483	2.6	0.9
Dec-14	*643*	*263*	*0*	*721*	1,626	*144,742*	1,483	2.8	0.9
Totals/Avg	**6,753**	**3,392**	**3,242**	**4,698**	**18,085**	**1,505,064**	**1,394**	**2.9**	**1.0**

Well Testing

To evaluate existing pump performance, we collected flow data using the existing flow meter. Power was estimated based on the existing amperage meters (38 to 40 amps), power factor (0.87) and voltage meter (4100V). Head was assumed to be primarily static head (elevation difference) after we observed that flow was proportionally increased as multiple pumps were put on line.

Table 10.29: Kahaluu Shaft Pump Efficiency Data

Pump Measurements / Calculations	1	2	3	4
Total Flow (gpm)	1480	1491	1488	1481
Discharge Pressure (psi)	253	253	253	253
Baseline Ground Elevation (ft)	10	10	10	10
Tank Water Level Elevation (ft)	595	595	595	595
Well Depth to Baseline (ft)	10	10	10	10
Static Head (ft)	595	595	595	595
Gauge Height from Baseline (ft)	2	2	2	2
Estimated Column/Velocity Losses (ft) 1ft/100ft	0.1	0.1	0.1	0.1
Estimated Total Head (ft): P * 2.31 + well depth + losses)	597	597	597	597
Total Measured Power (kW)	232	232	232	232
Estimated Motor Efficiency (%)	94%	94%	94%	94%
Calculated Pump Efficiency	**76%**	**77%**	**77%**	**76%**

Pump curves for Pump #3 and Pump #4 are shown below.

Figure 10.9: Shaft Pump #3 Curve

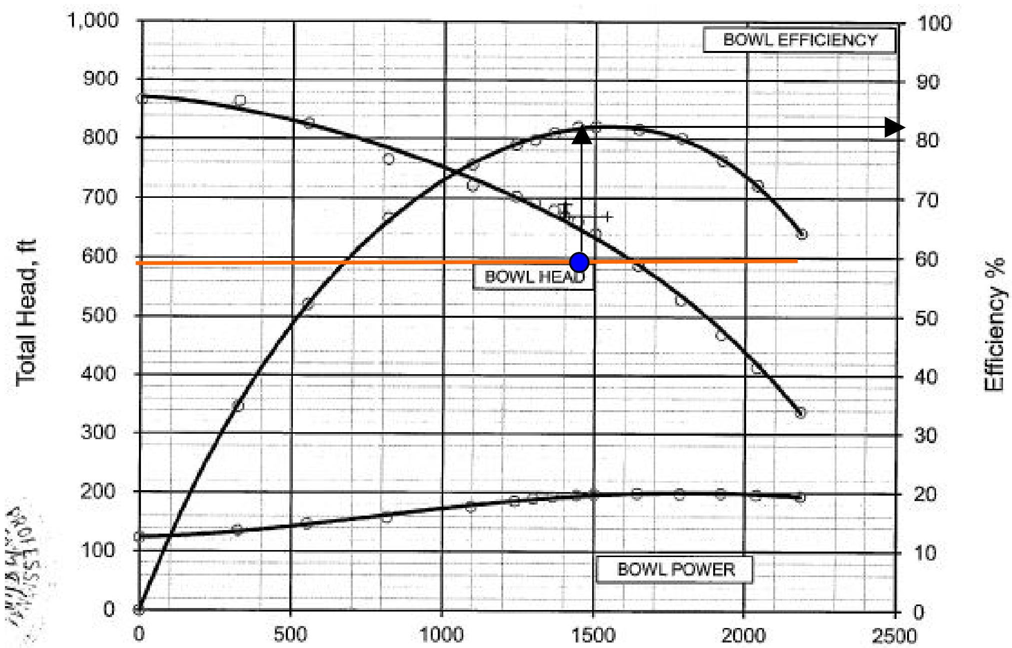
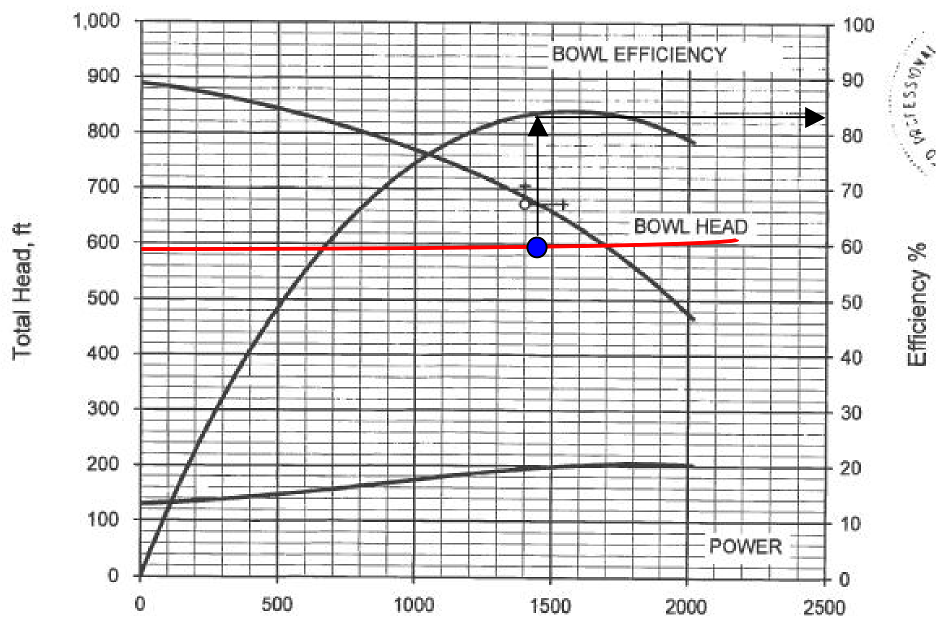


Figure 10.10: Shaft Pump #4 Curve



Observations & Recommendations

- The power data was estimated based on the old amperage meters installed. As part of a future pump station upgrade, we recommend installing a power meter so that efficiency can be more accurately calculated in the future.

- With the Honokohau and Hualalai Wells down, the shaft pumps were used often in 2014. DWS staff indicated that a Rider M application would not be possible until more wells were on-line. Given that HELCO would be evaluating the pump system first to see if a third pump would operate enough hours to qualify for Rider M, this would be the best time to start the process. Based on past records, it looks like Rider M was previously tried at the station.

  Savings included in ESM #4 is based on taking the third shaft pump off line for a two-hour period. The current tank level settings are noted below.

  Pump #1: 15’ on, 18’ off
  Pump #2: 14’ on, 18’ off
  Pump #3: 13’ on and 18’ off

- The power factor was very good at the station (0.93). As seen on Table 10.27, a $10,745 credit was provided to the DWS for the high power factor.

10.10 Aloha Kona (Kailua View) Boosters

The Booster Station has two pumps designated as A&B. Both pumps are rated to pump 170 gpm @ 383’ TDH and have 25 hp motors. Station energy use and costs are shown below.

Table 10.30: Aloha Kona Booster Pump 2014 Energy Use & Costs

Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill
1/27/14	15,270	39	40	$405	$3,787	$1,529	$5,721
2/25/14	12,968	39	40	$405	$3,216	$1,407	$5,028
3/26/14	14,193	39	40	$405	$3,520	$1,417	$5,342
4/25/14	14,809	39	40	$405	$3,673	$1,461	$5,539
5/27/14	14,520	39	40	$405	$3,601	$1,503	$5,509
6/25/14	13,064	39	39	$404	$3,240	$1,486	$5,130
7/25/14	15,449	39	40	$405	$3,832	$1,824	$6,061
8/26/14	15,335	39	40	$405	$3,804	$1,850	$6,059
9/25/14	15,847	39	39	$404	$3,931	$1,757	$6,092
10/27/14	15,179	39	39	$404	$3,765	$1,600	$5,769
11/24/14	13,747	39	39	$404	$3,410	$1,339	$5,153
12/24/14	15,766	39	39	$404	$3,910	$1,323	$5,638
Total/Avg	**176,147**	**39**	**39**	**$4,853**	**$43,690**	**$18,496**	**$67,040**

A summary of 2014 booster pump hours and flow data is shown in Table 10.31.

Table 10.31: Aloha Kona Booster Pump 2014 Hours and Pumpage

Month	Bstr A Hours	Bstr B Hours	Total Hours	Total Pumpage	Average GPM	KWh/kgal
Jan-14	377	378	755	6,795	150	2.25
Feb-14	341	340	681	6,091	149	2.13
Mar-14	343	343	686	6,047	147	2.35
Apr-14	409	408	817	7,196	147	2.06
May-14	666	353	1,018	6,630	109	2.19
Jun-14	76	375	451	6,676	247	1.96
Jul-14	405	405	810	7,434	153	2.08
Aug-14	407	407	814	7,526	154	2.04
Sep-14	372	372	744	6,883	154	2.30
Oct-14	368	397	765	7,169	156	2.12
Nov-14	352	352	704	6,507	154	2.11
Dec-14	475	474	949	8,786	154	1.79
Totals/Avg	**4,590**	**4,604**	**9,193**	**83,740**	**156**	**2.10**

Pump Testing

To evaluate existing pump performance, we collected flow data using the existing flow meter. Power was measured with a Fluke 43B kW meter, and discharge pressure was measured with a Fluke PV-350 pressure transducer. The data is summarized below.

Table 10.32: Aloha Kona Pump Testing

Pump Measurements / Calculations	A	B
Total Flow (gpm)	130	207
Discharge Pressure (psi)	156	158
Suction Pressure	1.5	1.5
Estimated Total Head (ft)	357	362
Static Head (595-244)	351	351
Total Measured Power (kW)	17	22
Estimated Motor Efficiency (%)	90%	90%
Calculated Pump Efficiency	**57%**	**71%**

Observations and Proposed Recommendations

Based on the energy use data we noted the following:

- Both pumps are activated together at least once every month resulting in a steady measured demand of 39 kW.
- Pump A efficiency is lower than B. If Pump B is used the majority of the time, the DWS could save approximately 14,000 kWh annually. This recommendation is included in OM #5.

10.11 Kalaoa Boosters

The Kalaoa Booster Station has two pumps that pump flow from the Kalaoa Tank to the Puukala Tank. Both pumps are rated for 300 gpm @265' TDH and have 30 hp motors.

Table 10.33: Kalaoa Booster Pump 2014 Energy Use & Cost

Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill
1/7/14	7,298	42	42	$432	$1,810	$816	$3,057
2/5/14	5,512	41	42	$429	$1,367	$593	$2,390
3/6/14	6,453	42	42	$432	$1,601	$727	$2,759
4/4/14	5,695	23	33	$337	$1,413	$600	$2,350
5/6/14	7,141	41	42	$427	$1,771	$746	$2,944
6/5/14	5,053	42	42	$433	$1,253	$578	$2,264
7/7/14	6,096	42	42	$431	$1,512	$742	$2,684
8/5/14	5,614	42	42	$432	$1,392	$710	$2,534
9/5/14	6,692	42	42	$432	$1,660	$833	$2,925
10/6/14	8,081	42	42	$433	$2,004	$905	$3,341
11/5/14	5,813	42	42	$432	$1,442	$640	$2,513
12/4/14	5,532	42	42	$431	$1,372	$561	$2,364
Total/Avg	**74,980**	**40**	**41**	**$5,078**	**$18,598**	**$8,450**	**$32,126**

A summary of 2014 booster pump hours and flow data is shown below.

Table 10.34: Kalaoa Booster Pump Hours and Pumpage

Month	Bstr A Hours	Bstr B Hours	Total Hours	Bstr A Pumpage	Bstr B Pumpage	Total Pumpage (kgal)	Bstr A Flow (gpm)	Bstr B Flow (gpm)
Jan-14	243	2	244	3,947	26	3,973	271	255
Feb-14	264	8	272	4,319	128	4,447	273	260
Mar-14	266	0	266	4,349	4	4,353	273	
Apr-14	408	0	408	6,673	0	6,673	273	
May-14	163	7	170	2,699	106	2,805	275	260
Jun-14	246	3	249	4,061	45	4,106	275	259
Jul-14	273	3	276	4,495	43	4,538	274	265
Aug-14	304	12	316	5,030	190	5,220	275	262
Sep-14	302	39	341	4,919	626	5,545	272	265
Oct-14	192	100	292	3,149	1,632	4,781	273	271
Nov-14	88	140	228	1,434	2,291	3,725	272	273
Dec-14	342	0	342	5,569	0	5,569	271	
Totals/Avg	**3,090**	**314**	**3,404**	**50,644**	**5,091**	**55,735**	**273**	**270**

Pump Testing

To evaluate existing pump performance, we collected flow data using the existing flow meter. Power was measured with a Fluke 43B kW meter, and discharge pressure was measured with a Fluke PV-350 pressure transducer. The data is summarized below.

Table 10.35: Kalaoa Pump Testing

Pump Measurements / Calculations	A	B
Total Flow (gpm)	*273*	*272*
Discharge Pressure (psi)	144	142
Suction Pressure (estimated based on tank level)	24	24
Estimated Total Head (ft)	277	273
Static Head (1990-1450)	255	255
Total Measured Power (kW)	20.8	20.6
Estimated Motor Efficiency (%)	90%	90%
Calculated Pump Efficiency	**76%**	**75%**

Observations and Proposed Recommendations

Based on the energy use data, pump hours and efficiency testing we noted the following:

- The pump efficiency is acceptable for both pumps.

- The energy demand and pump hour data shows that a second pump was activated approximately 100 hours/year. The lead pump is activated at a tank elevation of 12' and a second pump is activated at 11'. We recommend lowering the second pump activation to give the lead pump a chance to catch up with fluctuating water demand. If a second pump is not activated, the DWS could save $2,126 annually in demand charges. This adjustment is included in ESM #2.

- Both pumps have standard efficiency motors. As part of future motor repairs, we recommend upgrading the motors to premium efficiency units.

10.12 Kaloko Mauka #1 Boosters

The Kaloko Mauka #1 Booster Station has two pumps. Both pumps are rated for 140 gpm @569' TDH and have 30 hp motors. Normal operation is to operate both pumps at the same time.

Table 10.36: Kaloko Mauka #1 Booster Pump 2014 Energy Use & Costs

Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill
1/3/14	14,400	47	48	$488	$3,572	$1,566	$5,625
2/3/14	13,360	48	48	$492	$3,314	$1,336	$5,142
3/4/14	12,720	48	48	$492	$3,155	$1,381	$5,028
4/2/14	14,160	48	48	$492	$3,512	$1,398	$5,402
5/2/14	12,640	47	48	$488	$3,135	$1,262	$4,885
6/3/14	10,080	47	48	$488	$2,500	$1,082	$4,070
7/2/14	9,520	47	48	$488	$2,361	$1,117	$3,966
8/1/14	10,160	47	48	$488	$2,520	$1,230	$4,238
9/3/14	12,560	47	48	$488	$3,115	$1,519	$5,122
10/2/14	11,440	47	48	$488	$2,838	$1,260	$4,585
11/3/14	15,040	48	48	$492	$3,730	$1,563	$5,786
12/2/14	10,800	47	48	$488	$2,679	$1,042	$4,208
Total/Avg	**146,880**	**47**	**48**	**$5,871**	**$36,431**	**$15,753**	**$58,056**

A summary of 2014 booster pump hours and flow data from the DWS Pumpage Report is shown below.

Table 10.37: Kaloko Mauka #1 Booster Pump 2014 Hours & Pumpage

Month	Bstr A Hours	Bstr B Hours	Total Hours	Bstr A Pumpage	Bstr B Pumpage	Total Pumpage (kgal)	Bstr A Flow (gpm)	Bstr B Flow (gpm)
Jan-14	286	286	572	2,260	1,966	4,226	132	115
Feb-14	250	251	501	1,978	1,720	3,698	132	114
Mar-14	302	302	603	2,379	2,069	4,448	132	114
Apr-14	264	264	527	2,072	1,800	3,872	131	114
May-14	190	190	380	1,499	1,303	2,802	132	114
Jun-14	205	205	410	1,618	1,406	3,024	132	114
Jul-14	219	219	438	1,724	1,498	3,222	131	114
Aug-14	213	205	418	1,687	1,466	3,153	132	119
Sep-14	249	210	459	1,968	1,709	3,677	132	136
Oct-14	82	306	388	2,421	2,102	4,523	--	114
Nov-14	206	207	413	1,628	1,414	3,042	132	114
Dec-14	332	332	664	2,613	2,269	4,882	131	114
Totals/Avg	**2,798**	**2,976**	**5,774**	**23,847**	**20,722**	**44,569**	**131**	**116**

Pump Testing

To evaluate existing pump performance, we collected flow data using the existing flow meter. Power was measured with a Fluke 43B kW meter, and discharge pressure was measured with a Fluke PV-350 pressure transducer. The data is summarized below.

Table 10.38: Kaloko Mauka #1 Pump Testing

Pump Measurements / Calculations	A	B
Total Flow (gpm)	116	131
Discharge Pressure (psi)	235	235
Suction Pressure (estimated based on tank level)	3	3
Estimated Total Head (ft)	536	536
Static Head (1990-1450)	540	540
Total Measured Power (kW)	23.8	22.8
Estimated Motor Efficiency (%)	85%	85%
Calculated Pump Efficiency	**58%**	**68%**

Observations and Proposed Recommendations

Based on the energy use data, pump hours and efficiency testing we noted the following:

- The pressure or elevation data appears to be incorrect based on the static head being higher than the total frictional head.

- This station would benefit from a pump upgrade to improve pump and motor efficiency. This project is reviewed in ECM #2.

10.13 Kaloko Mauka #2 Boosters

The Kaloko Mauka #2 Booster Station has two pumps. Both pumps are rated for 140 gpm @569' TDH and have 30 hp motors.

Table 10.39: Kaloko Mauka #2 Booster Pump Energy Use & Costs

Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill
1/3/14	10,320	48	48	$492	$2,560	$1,140	$4,192
2/3/14	9,680	48	48	$492	$2,401	$986	$3,879
3/4/14	8,960	48	48	$492	$2,222	$992	$3,706
4/2/14	10,400	48	48	$492	$2,580	$1,044	$4,115
5/2/14	9,200	48	48	$492	$2,282	$936	$3,710
6/3/14	7,120	48	48	$491	$1,766	$783	$3,040
7/2/14	6,800	48	48	$491	$1,687	$816	$2,993
8/1/14	7,520	48	48	$491	$1,865	$927	$3,283
9/3/14	9,520	48	48	$491	$2,361	$1,167	$4,019
10/2/14	8,720	48	48	$491	$2,163	$976	$3,629
11/3/14	11,680	48	48	$491	$2,897	$1,228	$4,616
12/2/14	7,680	48	48	$492	$1,905	$760	$3,157
Total/Avg	**107,600**	**48**	**48**	**$5,898**	**$26,688**	**$11,752**	**$44,338**

A summary of 2014 booster pump hours and flow data is shown below. Data for the last three months has been estimated.

Table 10.40: Kaloko Mauka #2 Booster Pump Hours & Run Time

Month	Bstr A Hours	Bstr B Hours	Total Hours	Bstr A Pumpage	Bstr B Pumpage	Total Pumpage	Bstr A Flow (gpm)	Bstr B Flow (gpm)
Jan-14	214	214	427	1335	1771	3,106	104	138
Feb-14	181	182	363	1138	1491	2,629	105	137
Mar-14	221	221	441	1356	1839	3,195	102	139
Apr-14	198	198	395	1240	1678	2,918	105	141
May-14	139	140	279	926	1222	2,148	111	146
Jun-14	151	151	302	950	1399	2,349	105	154
Jul-14	165	166	331	1017	1525	2,542	103	153
Aug-14	167	167	335	985	1525	2,510	98	152
Sep-14	198	199	397	1185	1802	2,987	100	151
Oct-14	198	199	397	1185	1802	2,987	100	151
Nov-14	198	199	397	1185	1802	2,987	100	151
Dec-14	198	199	397	1185	1802	2,987	100	151
Totals/Avg	**2,229**	**2,232**	**4,460**	**13,687**	**19,658**	**33,345**	**103**	**147**

Pump Testing

To evaluate existing pump performance, we collected power with a Fluke 43B kW meter, and discharge pressure was measured with a Fluke PV-350 pressure transducer. The data is summarized below.

Table 10.41: Kaloko Mauka #2 Pump Testing

Pump Measurements / Calculations	A	B
Total Flow (gpm) - estimated	*103*	*147*
Discharge Pressure (psi)	230	230
Suction Pressure	3	3
Estimated Total Head (ft)	524	524
Static Head (1761'-1595')	533	533
Total Measured Power (kW)	22	22
Estimated Motor Efficiency (%)	93%	93%
Calculated Pump Efficiency	**50%**	**71%**

The station flow meter was not working during testing. Flow was estimated based on pumpage reports.

Observations and Proposed Recommendations

Based on the energy use data, pump hours and efficiency testing we noted the following:

- The pressure or elevation data appears to be incorrect based on the static head being higher than the total frictional head.

- The energy billing data shows that measured demand was consistently ~48 kW. With pump hours almost identical for most of the months, this is an indication that the setpoints have been adjusted to operate both pumps together. This practice has resulted in $2,800 in additional demand costs in 2014. In ESM #2, we have recommended staggering the setpoints to allow one pump time to catch up with demand before activating a second pump.

- Both pumps are equipped with premium efficiency motors.

- This station would benefit from a pump upgrade. This project is reviewed in ECM #2.

10.14 Kaloko Mauka #3 Boosters

The Kaloko Mauka #3 Booster Station has two pumps. Both pumps are rated for 140 gpm @569' TDH and have 30 hp motors. Normal operation is to operate both pumps at the same time.

Table 10.42: Kaloko Mauka #3 Booster Pump 2014 Energy Use and Costs

Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill
1/3/14	6,320	43	44	$447	$1,568	$723	$2,737
2/3/14	6,320	43	44	$447	$1,568	$666	$2,680
3/4/14	5,760	43	44	$447	$1,429	$660	$2,536
4/2/14	7,440	43	44	$447	$1,845	$765	$3,057
5/2/14	5,600	43	44	$447	$1,389	$595	$2,431
6/3/14	4,240	43	44	$447	$1,052	$492	$1,991
7/2/14	4,400	44	44	$451	$1,091	$550	$2,093
8/1/14	4,640	43	44	$447	$1,151	$596	$2,194
9/3/14	6,160	43	44	$447	$1,528	$777	$2,752
10/2/14	5,520	43	44	$447	$1,369	$641	$2,457
11/3/14	8,800	43	44	$447	$2,183	$941	$3,571
12/2/14	5,120	43	44	$447	$1,270	$528	$2,245
Totals/Avg	**70,320**	**43**	**44**	**$5,367**	**$17,442**	**$7,935**	**$30,744**

A summary of 2014 booster pump hours and flow data is shown in Table 10.43.

Table 10.43: Kaloko Mauka #3 Booster Pump Hours & Pumpage

Month	Bstr A Hours	Bstr B Hours	Total Hours	Bstr A Pumpage	Bstr B Pumpage	Total Pumpage	Bstr A Flow (gpm)	Bstr B Flow (gpm)
Jan-14	152	152	304	1229	1222	2,451	135	134
Feb-14	130	130	259	838	1045	1,883	108	134
Mar-14	167	167	334	1082	1346	2,428	108	134
Apr-14	133	134	267	1066	1066	2,132	133	133
May-14	91	91	183		739	1,878		135
Jun-14	106	100	206		803	2,508		134
Jul-14	115	115	230		922	2,941		134
Aug-14	119	119	237		954	2,660		134
Sep-14	136	136	271		1088	2,892		134
Oct-14	243	202	445		1623	3,548		134
Nov-14	110	110	220		876	2,659		133
Dec-14	160	160	320		1256	4,596		131
Totals/Avg	**1659**	**1615**	**3,273**		**12,940**	**32,576**		**134**

Pump Testing

To evaluate existing pump performance, we collected power with a Fluke 43B kW meter, and discharge pressure was measured with a Fluke PV-350 pressure transducer. The data is summarized below.

Table 10.44: Kaloko Mauka #3 Pump Testing

Pump Measurements / Calculations	A	B
Total Flow (gpm) - estimated	*135*	*134*
Discharge Pressure (psi)	262	262
Suction Pressure	3	3
Estimated Total Head (ft)	598	598
Static Head (1761'-1595')	587	587
Total Measured Power (kW)	22	23
Estimated Motor Efficiency (%)	89%	89%
Calculated Pump Efficiency	**78%**	**74%**

The station flow meter was not working during testing. Flow was estimated based on the pumpage reports.

Observations and Proposed Recommendations

Based on the energy use data, pump hours and efficiency testing we noted the following:

- The pump efficiencies are good – however, they are based on estimated flow from the pumpage report since the flow meter was out of service during field-testing.

- The energy billing data shows that measured demand was consistently ~44 kW even though pump hours were not high for each pump. With pump hours almost identical for most of the months in

2014, this is an indication that the setpoints have been adjusted to operate both pumps together. This practice has resulted in $2,900 in additional demand costs in 2014. In ESM #2, we have recommended staggering the setpoints to allow one pump time to catch up with demand before activating a second pump.

- The station has fairly new pumps, but the motors appear to be standard efficiency type motors. Since the operating hours are less than 2000 hours, we have not recommended changing out the motors to premium efficiency units.

10.15 Kuakini Pualani Boosters (at Pua Puaa Tank)

The Kuakini Pualani Booster Station has two pumps. Both pumps are rated for 350 gpm @290' TDH and have 30 hp motors. Normal operation is to operate both pumps at the same time.

Table 10.45: Kuakini Pualani Booster Pump 2014 Energy Use & Costs

Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill
1/24/14	5,995	28	40	$412	$1,487	$644	$2,543
2/24/14	6,533	53	53	$541	$1,620	$734	$2,896
3/24/14	5,124	27	40	$411	$1,271	$555	$2,236
4/23/14	6,035	27	40	$410	$1,497	$633	$2,540
5/22/14	5,763	30	41	$423	$1,429	$632	$2,485
6/23/14	6,031	52	53	$539	$1,496	$712	$2,747
7/23/14	6,291	27	40	$410	$1,560	$779	$2,749
8/22/14	6,490	27	40	$410	$1,610	$819	$2,839
9/23/14	6,938	27	40	$410	$1,721	$815	$2,946
10/23/14	6,056	27	40	$410	$1,502	$679	$2,591
11/21/14	5,652	27	40	$410	$1,402	$595	$2,407
12/22/14	6,719	27	40	$410	$1,667	$619	$2,695
Total/Avg	**73,627**	**32**	**42**	**$5,197**	**$18,262**	**$8,215**	**$31,674**

A summary of 2014 booster pump hours and flow data from the DWS Pumpage Report is shown in Table 10.46.

Table 10.46: Kuakini Pualani Booster Pump 2014 Hours & Pumpage

Month	Bstr A Hours	Bstr B Hours	Total Hours	Bstr A Pumpage	Bstr B Pumpage	Total Pumpage	Bstr A Flow (gpm)	Bstr B Flow (gpm)
Jan-14	2	185	186	36	2,376	2,412	353	214
Feb-14	108	107	215	2,336	744	3,080	361	115
Mar-14	179	0	179	3,874	0	3,874	361	
Apr-14	234	0	234	4,189	0	4,189	298	
May-14	209	0	209	2,682	5	2,687	214	181
Jun-14	219	0	219	3,454	0	3,454	263	
Jul-14	246	1	247	5,201	12	5,213	352	263
Aug-14	235	0	235	4,963	0	4,963	351	
Sep-14	216	0	216	4,345	0	4,345	336	
Oct-14	223	0	223	4,765	2	4,767	356	370
Nov-14	200	0	200	4,242	0	4,242	353	
Dec-14	236	0	236	5,591	0	5,591	395	
Totals/Avg	**2,306**	**293**	**2,600**	**45,678**	**3,139**	**48,817**	**333**	**229**

Pump Testing

To evaluate existing pump performance, we collected flow data using the existing flow meter. Power was measured with a Fluke 43B kW meter, and discharge pressure was measured with a Fluke PV-350 pressure transducer. The data is summarized below.

Table 10.47: Kuakini Pualani Pump Testing

Pump Measurements / Calculations	A	B
Total Flow (gpm)	355	304
Discharge Pressure (psi)	129	130
Suction Pressure (estimated based on tank level)	3	3
Estimated Total Head (ft)	291	293
Static Head (590-320)	270	270
Total Measured Power (kW)	25.7	25.5
Estimated Motor Efficiency (%)	91%	91%
Calculated Pump Efficiency	**83%**	**72%**

Observations and Proposed Recommendations

Based on the energy use data, pump hours and efficiency testing we noted the following:

- The pump data shows that the second pump is required for a very brief time when activated. It appears that this was only for a few hours in 2014. Unfortunately it also resulted in a peak demand charge that carried forward after the demand was decreased. If this were a spike in water demand, it would be unavoidable. However, if it were due to tank settings or exercising both pumps together, making adjustments to prevent these occurrences would save approximately

$1,800 annually. Due to the probability that water demand requires both pumps, we have not included the savings in ESM #2.

- Although the tested pump efficiency was good for both pumps, based on the data collected, Pump A efficiency was approximately 10% better than Pump B. It looks like staff has recognized this by operating Booster A more hours.

10.16 Keauhou (Baseyard) Boosters

The Keauhou Booster Station has two pumps. Both pumps are rated for 650 gpm @210’ TDH. Booster A and Booster B have 100 hp motors. A summary of station energy use is shown below.

Table 10.48: Keauhou Booster Pump 2014 Energy Use & Costs

Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill
1/10/14	6,720	51	58	$599	$1,667	$748	$3,013
2/10/14	5,760	51	58	$599	$1,429	$627	$2,654
3/11/14	5,600	51	58	$599	$1,389	$629	$2,617
4/9/14	5,920	51	58	$599	$1,468	$622	$2,689
5/9/14	6,400	90	90	$918	$1,587	$679	$3,185
6/10/14	5,600	90	90	$918	$1,389	$642	$2,949
7/10/14	5,280	51	70	$722	$1,310	$654	$2,685
8/8/14	5,280	51	70	$722	$1,310	$673	$2,704
9/10/14	5,600	51	70	$722	$1,389	$698	$2,809
10/9/14	4,960	51	70	$722	$1,230	$577	$2,529
11/8/14	5,600	86	88	$902	$1,389	$613	$2,904
12/9/14	7,040	50	70	$713	$1,746	$682	$3,142
Total/Avg	**69,760**	**60**	**71**	**$8,733**	**$17,303**	**$7,844**	**$33,879**

A summary of 2014 booster pump hours and flow data is shown in Table 10.49.

Table 10.49: Keauhou Booster Pump 2014 Hours & Pumpage

Month	Bstr A Hours	Bstr B Hours	Total Hours	Bstr A Pumpage	Bstr B Pumpage	Total Pumpage	Bstr A Flow (gpm)	Bstr B Flow (gpm)
Jan-14	33	75	108	1,495	3,456	4,951	760	766
Feb-14	99	0	99	4,505	0	4,505	760	
Mar-14	99	2	101	4,446	70	4,516	752	556
Apr-14	129	0	129	5,860	0	5,860	755	
May-14	95	4	99	4,282	165	4,447	754	625
Jun-14	42	65	107	1,905	2,960	4,865	752	765
Jul-14	97	0	97	4,455	0	4,455	763	
Aug-14	100	0	100	4,556	0	4,556	763	
Sep-14	86	0	86	3,934	0	3,934	762	
Oct-14	97	128	225	4,358	0	4,358	751	
Nov-14	14	97	112	629	4,372	5,001	738	748
Dec-14	0	175	175	0	7,865	7,865		749
Totals/Avg	**890**	**547**	**1,437**	**40,425**	**18,888**	**59,313**	**755**	**692**

Pump Testing

To evaluate existing pump performance, we collected flow data using the existing flow meter. Power was measured with a Fluke 43B kW meter, and discharge pressure was measured with a Fluke PV-350 pressure transducer. The data is summarized below.

Table 10.50: Keauhou Pump Testing

Pump Measurements / Calculations	A	B
Total Flow (gpm)	766	766
Discharge Pressure (psi)	164	166
Suction Pressure (psi)	71	71
Estimated Total Head (ft)	215	219
Static Head (1440-1313)	127	127
Total Measured Power (kW)	50	49
Estimated Motor Efficiency (%)	90%	90%
Calculated Pump Efficiency	**69%**	**72%**

Observations and Proposed Recommendations

Based on the energy use data, pump hours and efficiency testing we noted the following:

- The pumps are oversized for this station and are operated between 100 and 120 hours/month.
- The tested pump efficiency was fair for both pumps. Based on the low pump hours, we do not recommend pump efficiency improvements.

- Two pumps were activated for several months in 2014. This increased the demand charge by $2,400. We recommend adjusting the tank setting setpoints to prevent two pumps from being activated if possible.

- Based on the tank elevations of 1440’ for the Keauhou Tank and the 1313’ elevation for the Kahaluu #1 Tank, there is a substantial amount of system frictional head (~90’). A VFD may be cost effective, but will need to be reviewed in more detail to determine if the frictional losses are due to a local issue (Cla-Valve) or due to frictional head in the piping system. The original pump curve will also provide the data needed to evaluate the potential pump efficiency loss at lower flow rates.

SECTION 11. SOUTH KONA SYSTEM

The communities served by South Kona water system include Captain Cook, Keokea, Kealia, Hookena, Napoopoo, and Honauanau City of Refuge. The service area ranges from Kealakekua at the north to the Hookena School in the south. The system has five wells, seven booster pump stations and thirteen storage tanks. The supply sources include the four Keei Wells and the Halekii Well. The Halekii Well and Keei Well D are the primary wells and Keei Wells A, B, and C is available for back-up. Halekii and Keei D have always been the lead well sources, since the Keei A, B and C wells have higher chlorides.

A summary of all the South Kona electric accounts and 2013/2014 energy usage and costs is shown below.

Table 11.1: South Kona Accounts and Energy Use

Tank or Pump Station	2013 kWh	2013 Cost	2014 kWh	2014 Cost
Halekii Deep Well	2,917,600	$1,033,195	2,900,640	$1,035,529
Keei Well D	1,251,300	$469,418	1,151,400	$437,862
Keei Well A and Boosters	5,120	$7,605	4,480	$2,269
Keei Well B	0	$0	0	$0
Keei Well C and Boosters	7,040	$22,908	8,960	$23,098
Keei #3 Boosters	172,356	$66,214	156,243	$61,044
Machado Boosters	121,615	$47,234	110,334	$43,678
Keei #2 Boosters	7,520	$7,049	7,200	$3,673
Honuaino Medical Boosters	834	$1,003	778	$982
Konawaena Res	0	$378	0	$378
Halekii Tank	0	$0	0	$0
Halekii Hokulia #1	149	$440	152	$442
Halekii Hokulia #2	0	$32	14	$38
Koa Rd	223	$471	215	$469
Kealakekua	6,541	$3,390	6,788	$3,515
Total	**4,483,534**	**$1,655,475**	**4,340,201**	**$1,608,994**

The pump system high-energy accounts (above $25,000) are reviewed in this section.

11.1 Keei Well A View System

The Keei Well A Pump Station includes a 100 hp well rated for 300 gpm @ 788’ TDH and three 20 hp booster pumps. The well and booster pumps are only used as a back-up option if Keei Well D is out of service. In 2014, the well had no operating hours and minimal energy use. Based on historical energy use data, the well and booster pumps were last used in March of 2012. After one month of usage and a peak kW of 117 kW, the typical monthly cost was maintained at $1,200 even though there was no energy use due to the HELCO peak demand ratchet clause. After 11 months of non-use, the monthly bill was eventually reduced to $200.

At this time the well is currently in need of repairs and is not operational. There are no immediate plans to repair this well due to changes in Department of Health rules for reporting. A summary of 2014 energy use and costs is shown below in Table 11.2.

Table 11.2: Keei Well A Pump Station 2014 Energy Use and Cost

Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill
1/22/14	320	0.0	0.0	$0	$101	$65	$166
2/20/14	480	0.0	0.0	$0	$152	$82	$233
3/21/14	320	0.0	0.0	$0	$101	$65	$166
4/22/14	320	0.0	0.0	$0	$101	$63	$164
5/21/14	320	0.0	0.0	$0	$101	$64	$165
6/20/14	480	0.0	0.0	$0	$152	$84	$235
7/22/14	320	0.0	0.0	$0	$101	$69	$170
8/21/14	480	0.0	0.0	$0	$152	$89	$240
9/22/14	480	0.0	0.0	$0	$152	$87	$238
10/22/14	320	0.0	0.0	$0	$101	$66	$167
11/20/14	320	0.0	0.0	$0	$101	$63	$164
12/19/14	320	0.0	0.0	$0	$101	$60	$161
Totals/Avg	**4,480**	**0.0**	**0.0**	**$0**	**$1,415**	**$854**	**$2,269**

Observations and Proposed Recommendations

As part of a future well/booster pump upgrade for this station, we recommend installing VFDs. Although the energy savings (kWh) will be minimal due to the intermittent well use, using the VFDs to operate the pumps at minimum flows when the well is tested periodically will provide long-term cost savings without being penalized by high demand costs. When the well is required for short-term emergency service, if the VFD can be used to maintain a lower flow for longer run times, it will also minimize demand charges. Since this practice will be limited to short duration, the lower pump efficiency will not have a significant cost impact. This recommendation is included in ESM #5.

11.2 Keei Well B Pump System

Keei Well B is also used as a back up to Well D. The well is rated for 375 gpm @ 830’ TDH and is equipped with a 100 hp motor. DWS staff operates the well periodically each month to insure the well is ready for service if needed. Although the operators would like to use the well less than 15 minutes to minimize the HELCO demand charge, the well needs to be operated for a longer duration to purge the well and maintain water quality. The well is activated at a 14’ level in Keei Tank #1 and shut off at 19’. A summary of 2014 energy use and costs is shown below in Table 11.3.

Table 11.3: Keei Well B Pump Station 2014 Energy Use and Cost

Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill	Power Factor	Rider M Discount	Cost/ kWh
1/16/14	40	0	85	$869	$10	$68	$947	$0	$0	$23.68
2/14/14	120	85	85	$870	$30	$76	$976	$0	$0	$8.13
3/17/14	120	85	85	$869	$30	$76	$975	$0	$0	$8.12
4/15/14	520	85	85	$870	$129	$113	$1,112	$0	$0	$2.14
5/15/14	960	85	85	$870	$238	$157	$1,266	$0	$0	$1.32
6/16/14	880	85	85	$870	$7	$367	$1,245	$0	$0	$1.41
7/16/14	960	85	85	$870	$238	$172	$1,280	$0	$0	$1.33
8/14/14	1,000	85	85	$869	$248	$180	$1,297	$0	$0	$1.30
9/16/14	1,040	85	85	$872	$258	$180	$1,310	$0	$0	$1.26
10/16/14	160	85	85	$870	$40	$80	$990	$0	$0	$6.19
11/14/14	200	84	85	$869	$50	$83	$1,002	$0	$0	$5.01
12/15/14	80	84	85	$867	$20	$82	$969	$0	$0	$12.11
Totals/Avg	**6,080**	**78**	**85**	**$10,438**	**$1,297**	**$1,634**	**$13,369**	**$0**	**$0**	**$6.00**

A summary of 2014 pump hours and flow data is shown in Table 11.4.

Table 11.4: Keei Well B 2014 Hours and Flow

Month	Monthly Energy Use (kWh)	Monthly Energy Cost	Well Operating Hours	Total Pumpage (kgal)	Average GPM	kWh/kgal	Cost/kgal
Jan-14	40	$947	0	0	--	--	--
Feb-14	120	$976	0	0	--	--	--
Mar-14	120	$975	0	0	--	--	--
Apr-14	520	$1,112	0	0	--	--	--
May-14	960	$1,266	0	74	--	--	--
Jun-14	880	$1,245	0	0	--	--	--
Jul-14	960	$1,280	63	310	82	3.1	4.1
Aug-14	1,000	$1,297	7	120	290	8.3	10.8
Sep-14	1,040	$1,310	7	127	302	8.2	10.3
Oct-14	160	$990	0	0	--	--	--
Nov-14	200	$1,002	0	0	--	--	--
Dec-14	80	$969	0	0	--	--	--
Totals/Avg	**6,080**	**$13,369**	**77**	**631**	**225**	**6.5**	**8.4**

Observations and Proposed Recommendations

The 2014 electrical demand charges ($10,438) represented a substantial part of the annual total pump station energy cost ($13,369). Given that the well is the primary back up for Well D and is tested on a regular basis, there is an immediate financial benefit for installing a VFD at this station. This project is included in ESM #5.

11.3 Keei Well C & Booster Pump System

Keei Well C is rated for 500 gpm @ 920’ TDH and includes a 200 hp submersible pump motor equipped with a soft start. This well is exercised manually by DWS staff since it is only used as a back-up to Keei Well D. The well is activated at a 10’ tank level and shuts off at 15’.

The station includes two 40 hp boosters rated for 400 gpm @ 246’ TDH that pumps flow out of the 50,000 gallon on-site tank to Keei Tank #2.

As shown in Table 11.5, in 2014 demand charges represented 84% of the station annual energy costs. Based on field measurements taken during our site visit, the well power draw was 148 kW. As shown below, when a booster pump is exercised at the same time, the demand increases by another ~14 kW.

Table 11.5: Keei Well C Pump Station 2014 Energy Use and Cost

Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill	Rider M Discount	Cost/ kWh
1/16/14	320	0	151	$1,616	$0	$0	$1,616	$0	$5.05
2/14/14	640	148	150	$1,535	$159	$178	$1,873	$0	$2.93
3/17/14	320	0	151	$1,616	$0	$0	$1,616	$0	$5.05
4/15/14	640	148	150	$1,535	$159	$175	$1,869	$0	$2.92
5/15/14	1,920	148	148	$1,519	$476	$255	$2,250	$0	$1.17
6/16/14	320	0	148	$1,583	$0	$0	$1,583	$0	$4.95
7/16/14	640	147	148	$1,513	$159	$186	$1,858	$0	$2.90
8/14/14	1,600	176	176	$1,804	$397	$265	$2,465	$0	$1.54
9/16/14	640	148	162	$1,658	$159	$190	$2,007	$0	$3.14
10/16/14	640	147	161	$1,653	$159	$155	$1,967	$0	$3.07
11/14/14	640	148	162	$1,658	$159	$180	$1,997	$0	$3.12
12/15/14	640	147	162	$1,655	$159	$183	$1,997	$0	$3.12
Totals/Avg	**8,960**	**113**	**156**	**$19,347**	**$1,984**	**$1,767**	**$23,098**	**$0**	**$3.25**

The well operating hours and pumpage is listed below. With only 50 hours of use, the well is not normally used for system requirements.

Table 11.6: Keei Well C 2014 Hours & Pumpage

Month	Monthly Energy Use (kWh)	Monthly Energy Bill	Total Well Hours	Total Pumpage kgallon	Average Flow (gpm)	kWh/kgal	Cost/kgal
Jan-14	320	$1,616	0	0			
Feb-14	640	$1,873	0	0			
Mar-14	320	$1,616	0	0			
Apr-14	640	$1,869	0	0			
May-14	1,920	$2,250	0	0			
Jun-14	320	$1,583	0	0			
Jul-14	640	$1,858	44	608	231	1.1	3.1
Aug-14	1,600	$2,465	6	170	497	9.4	14.5
Sep-14	640	$2,007	0	0			
Oct-14	640	$1,967	0	0			
Nov-14	640	$1,997	0	0			
Dec-14	640	$1,997	0	0			
Totals/Avg	**8,960**	**$23,098**	**50**	**778**	**364**	**5.2**	**8.8**

During our site visit, staff activated the well and flow, pressure and kW data was collected. As shown in Table 11.7, although the flow rate was close to the original rating, the pump efficiency was lower than expected. No pump curve or original specification data was available to determine how this compared to new condition pump efficiency. With this well only used for back up, efficiency does not have a significant impact on annual energy costs.

Table 11.7: Keei Well C Pump Testing

Pump Measurements / Calculations	Data
Total Flow (gpm)	497
Discharge Pressure (psi)	5
Baseline Ground Elevation (ft)	884
Tank Water Level Elevation (ft)	899
Well Depth to Baseline (ft)	900
Static Head (ft)	915
Gauge Height from Baseline (ft)	2
Estimated Column/Velocity Losses (ft) 1ft/100ft	9
Estimated Total Head (ft): P * 2.31 + well depth + losses)	923
Total Measured Power (kW)	146
Estimated Motor Efficiency (%)	93%
Calculated Pump Efficiency	**64%**

Observations and Proposed Recommendations

As discussed for Keei Well B, 2014 electrical demand charges ($19,347) represented a substantial part of the annual total pump station energy cost ($23,098). Given that the well is one of the primary back-ups for Well D and is tested on a regular basis, there is a financial benefit for installing a VFD at this station. In ESM #5, we have evaluated the cost savings for this improvement.

11.4 Keei Well D Pump System

The Keei Well D Pump Station is one of the primary wells for the South Kona System. In 2014, the well was operated approximately 42% of the time based on recorded operating hours. The submersible well is rated to pump 1000 gpm @ 1045' TDH and pumps to Keei Tank #3 which has a 200,000 gallon capacity. The 350 hp motor is rated for 4160 volts and includes soft start controls.

Table 11.8: Keei Well D Pump Station 2014 Energy Use and Cost

Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill	Power Factor Charge	Rider M Discount	Cost/ kWh
1/16/14	97,500	309	309	$3,167	$24,183	$9,582	$36,932	-$191	$0	$0.38
2/14/14	89,100	312	312	$3,198	$22,100	$8,744	$34,042	-$177	$0	$0.38
3/17/14	97,800	309	311	$3,183	$24,258	$9,562	$37,002	-$192	$0	$0.38
4/15/14	93,600	312	312	$3,198	$23,216	$8,704	$35,118	-$185	$0	$0.38
5/15/14	98,700	312	312	$3,198	$24,481	$9,463	$37,141	-$194	$0	$0.38
6/16/14	80,700	312	312	$3,198	$20,016	$8,385	$31,599	-$163	$0	$0.39
7/16/14	84,300	309	311	$3,183	$20,909	$9,388	$33,480	-$169	$0	$0.40
8/14/14	84,300	312	312	$3,198	$20,909	$9,653	$33,760	-$169	$0	$0.40
9/16/14	90,000	312	312	$3,198	$22,323	$9,881	$35,402	-$179	$0	$0.39
10/16/14	87,900	312	312	$3,198	$21,802	$8,902	$33,902	-$175	$0	$0.39
11/14/14	105,300	312	312	$3,198	$26,118	$9,984	$39,300	-$205	$0	$0.37
12/15/14	142,200	312	312	$3,198	$35,270	$11,715	$50,184	-$269	$0	$0.35
Totals/Avg	**1,151,400**	**311**	**312**	**$38,315**	**$285,585**	**$113,962**	**$437,862**	**-$2,267**	**$0**	**$0.38**

A summary of 2014 pump hours and flow data is shown below.

Table 11.9: Keei Well D Hours & Pumpage

Month	Monthly Energy Use (kWh)	Monthly Energy Bill	Total Well Hours	Total Pumpage (Kgal)	Average Flow (gpm)	kWh/kgal	Cost/kgal
Jan-14	97,500	$36,932	312	17,246	922	5.7	2.1
Feb-14	89,100	$34,042	284	15,733	924	5.7	2.2
Mar-14	97,800	$37,002	318	17,731	930	5.5	2.1
Apr-14	93,600	$35,118	341	18,887	924	5.0	1.9
May-14	98,700	$37,141	260	14,152	906	7.0	2.6
Jun-14	80,700	$31,599	252	13,863	916	5.8	2.3
Jul-14	84,300	$33,480	305	16,823	921	5.0	2.0
Aug-14	84,300	$33,760	270	15,906	982	5.3	2.1
Sep-14	90,000	$35,402	269	13,896	860	6.5	2.5
Oct-14	87,900	$33,902	330	18,302	924	4.8	1.9
Nov-14	105,300	$39,300	387	21,781	938	4.8	1.8
Dec-14	142,200	$50,184	387	21,781	938	6.5	2.3
Totals/Avg	**1,151,400**	**$437,862**	**3714**	**206,101**	**924**	**5.6**	**2.1**

Pump Testing

During our site visit, we collected well flow, pressure and amperage data. As shown in Table 11.10, the pump efficiency was lower than what we would expect for this size pump, but we were not able to obtain pump curve data to compare this value with the original pump efficiency at the flow and head conditions.

Table 11.10: Keei Well D Pump Testing

Pump Measurements / Calculations	Data
Total Flow (gpm)	974
Discharge Pressure (psi)	5
Baseline Ground Elevation (ft)	1347
Tank Water Level Elevation (ft)	1370
Well Depth to Baseline (ft)	1000
Static Head (ft)	1023
Gauge Height from Baseline (ft)	2
Estimated Column/Velocity Losses (ft) 1ft/100ft	10
Estimated Total Head (ft): P * 2.31 + well depth + losses)	1024
Total Measured Power (kW)	310
Estimated Motor Efficiency (%)	91%
Calculated Pump Efficiency	**67%**
Original Pump Efficiency at Flowrate	**TBD**

Observations and Proposed Recommendations

- The well is activated at 11' tank level and shut off at 28' and serves an area with high agriculture use. During wet weather, DWS staff indicated that well hours are reduced by up to 50%.

- The station benefited from an average power factor of 0.92 that provided a $2,200 annual credit.

- With the existing on/off operation there is an opportunity to apply a two-hour Rider M rate schedule for this station. The annual savings for delaying well operation for the designated two hour time period would be 40% of the curtailed demand multiplied by the $10.25/kW demand cost which amounts to approximately $15,350 using 2014 data. This measure is reviewed in more detail in ESM #4.

  Note: Staff indicated that the tank is small (200,000 gal) and the Keei #2 Boosters may need to be used during the 2 hour Rider M period. Based on this, we have taken this Well off ESM #4.

11.5 Halekii Pump System

The Halekii Deep Well pump station includes a 600 hp submersible well equipped with a six pulse Centrilift VFD rated to pump 1400 gpm @ 1320' TDH. The well is activated at a 12' tank level and shut off at 15' (VFD allows the pump to operate 24/7).

A new Robicon VFD was purchased 5 years ago but has not been installed. It is on the capital improvement list but is listed as a medium priority project for the DWS. The pump station is also equipped with an emergency generator on site.

In 2014 the Halekii Well operated continuously to provide an average flow of 563 gpm to the South Kona System. Although the VFD allows the well flow to vary based on system demand, operating the pump at 40% of the rated flow has resulted in a lower overall pump efficiency due to the high system static head. Staff indicated that the reason for this is that the oversized motor chokes the flow and additional speed does not provide a significant amount of additional flow due to the high friction losses. Even with the VFD speed only decreased to 56 Hz, the high static head makes this a difficult application to maintain system efficiency. A summary of 2014 energy use is shown below in Table 11.11.

Table 11.11: Halekii Pump Station 2014 Energy Use and Charges

Billing Date	Total kWh	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill	Power Factor	Rider M Discount	Net Cost/ kWh
1/14/14	280,640	477	479	$9,331	$61,231	$27,938	$98,500	$0	$0.00	$0.35
2/12/14	240,320	476	478	$9,321	$52,434	$23,552	$85,307	$62	$0.00	$0.35
3/13/14	240,000	475	478	$9,315	$52,364	$23,839	$85,518	$62	$0.00	$0.36
4/11/14	240,960	475	478	$9,313	$52,574	$22,501	$84,388	$62	$0.00	$0.35
5/13/14	265,840	473	477	$9,300	$58,002	$25,254	$92,555	$67	$0.00	$0.35
6/12/14	223,920	474	477	$9,305	$48,856	$22,840	$81,001	$116	$0.00	$0.36
7/14/14	246,080	473	477	$9,294	$53,691	$27,049	$90,034	$126	$0.00	$0.37
8/12/14	229,440	482	482	$9,395	$50,060	$26,042	$85,497	$59	$0.00	$0.37
9/12/14	242,720	472	477	$9,303	$52,958	$26,805	$89,066	$62	$0.00	$0.37
10/14/14	256,480	482	482	$9,403	$55,960	$25,910	$91,272	$65	$0.00	$0.36
11/12/14	210,480	476	479	$9,342	$45,923	$20,100	$75,365	$111	$0.00	$0.36
12/11/14	223,760	460	471	$9,185	$48,821	$19,021	$77,026	$116	$0.00	$0.34
Totals/Avg	**2,900,640**	**475**	**478**	**$111,807**	**$632,873**	**$290,849**	**$1,035,529**	**$909**	**$0**	**$0.36**

A summary of pump station hours, average flow and estimated pump efficiency is shown in Table 11.12

Table 11.12: Halekii Pump Station 2014 Pumpage and Hours

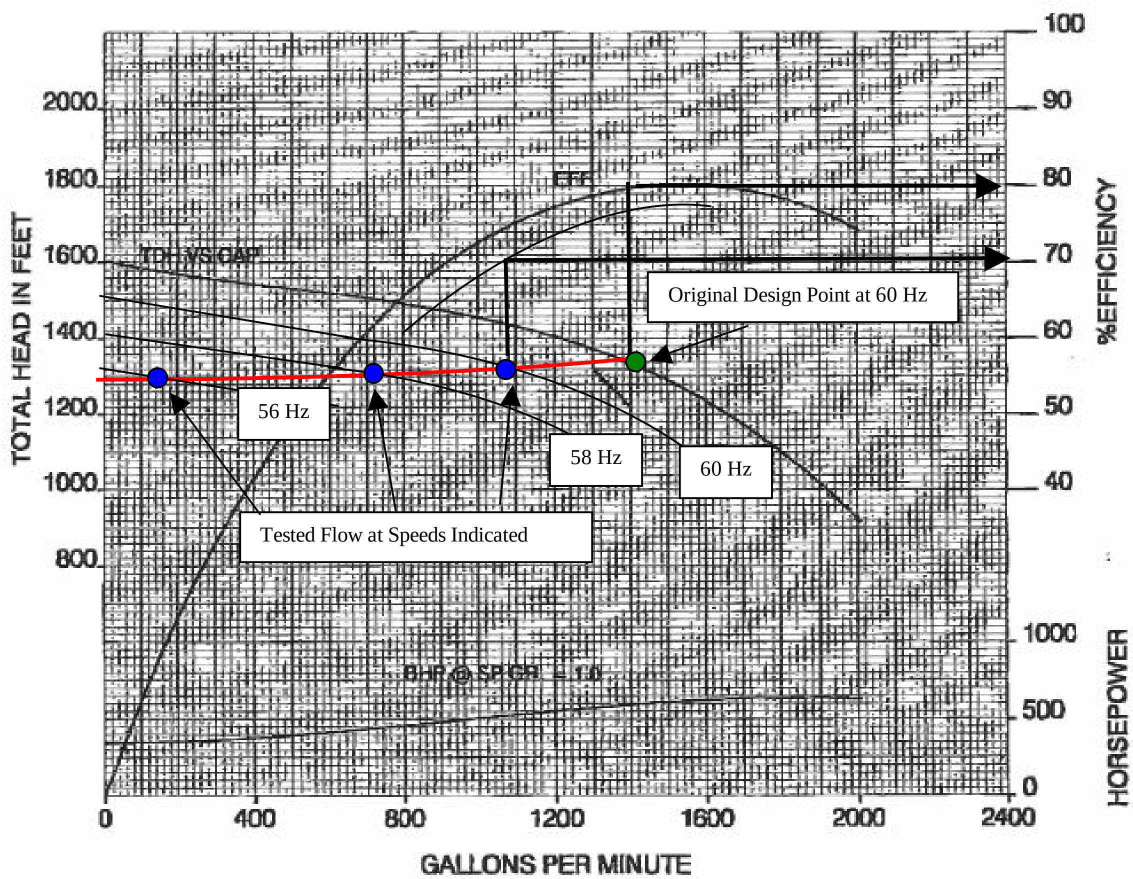
Month	Total kWh	Monthly Net Bill	Total Well Hours	Total Pumpage	Average GPM	kWh/kgal	Cost/kgal	Average kW	Pump Efficiency
Jan-14	280,640	$98,500	767	29,845	648	9.4	3.3	366	53%
Feb-14	240,320	$85,307	672	25,153	624	9.6	3.4	358	52%
Mar-14	240,000	$85,518	744	28,169	631	8.5	3.0	323	58%
Apr-14	240,960	$84,388	724	29,030	669	8.3	2.9	333	60%
May-14	265,840	$92,555	716	21,713	505	12.2	4.3	371	40%
Jun-14	223,920	$81,001	746	22,319	499	10.0	3.6	300	49%
Jul-14	246,080	$90,034	772	25,809	558	9.5	3.5	319	52%
Aug-14	229,440	$85,497	712	23,602	552	9.7	3.6	322	51%
Sep-14	242,720	$89,066	717	25,129	584	9.7	3.5	338	51%
Oct-14	256,480	$91,272	730	22,669	517	11.3	4.0	351	44%
Nov-14	210,480	$75,365	717	20,912	486	10.1	3.6	294	49%
Dec-14	223,760	$77,026	717	20,912	486	10.7	3.7	312	46%
Totals/Avg	**2,900,640**	**$1,035,529**	**8733**	**295,262**	**563**	**9.9**	**3.5**	**332**	**50%**

During our site visit, we collected pump flow; pressure and kW data at three VFD speeds to calculate pump efficiency. This data is summarized below in Table 11.13 and is shown on the original pump curve in Figure 11.1.

Table 11.13 Halekii Well Pump Testing

Pump Measurements / Calculations	60 Hz	58 Hz	56 Hz
Total Flow (gpm)	1087	707	275
Discharge Pressure (psi)	6.4	5.6	5.2
Baseline Ground Elevation (ft)	1747	1747	1747
Tank Water Level Elevation (ft)	1763	1763	1763
Well Depth to Baseline (ft)	1300	1300	1300
Static Head (ft)	1316	1316	1316
Gauge Height from Baseline (ft)	2	2	2
Estimated Column/Velocity Losses (ft) 1ft/100ft	13	13	13
Estimated Total Head (ft): P * 2.31 + well depth + losses)	1330	1328	1327
Total Measured Power (kW)	438	327	245
Estimated Motor Efficiency (%)	93%	93%	93%
Estimated VFD Efficiency (%)	95%	94%	93%
Calculated Pump Efficiency	**70%**	**63%**	**32%**

Figure 11.1 Halekii Pump Curve



Observations and Proposed Recommendations

The energy and pump hour data reveals the following opportunities:

- The older Centri-lift drive does not have a high power factor. However, the new Robicon VFD that is on site will increase VFD efficiency and result in a higher power factor credit. This improvement is included in ECM #5.
- The average pump flow in 2014 was 563 gpm which has resulted in poor pump efficiency (averaging 50%). Increasing the minimum VFD speed to 58 Hz and maximum to 59% will allow the pump to shut off periodically and result in a lower kWh/gallons. As shown in Table 11.12, the lowest kWh/gallon value (8.3) was when the average flow was the highest (669 gpm). This adjustment is reviewed in OM #1.
- The DWS was charged 478 kW when the pump speed increased to maximum flow. If the tank level setpoints can be adjusted to use more of the available storage, the maximum VFD setting can be set at 59 Hz, which would reduce peak station demand to 382 kW saving approximately 86 kW in peak demand costs (savings included in OM #1)
- The DWS has not pursued the application of Rider M for this station since tank water level needs to be maintained to provide adequate pressure for customers close to the tank.

11.6 Keei #3 Booster Station

The Keei #3 (Tsukamoto) Booster Station has three pumps. Pump A is rated to pump 100 gpm @ 240' TDH and uses a 10 hp motor, Pump B is rated for 300 gpm @ 270' TDH and is equipped with a 30 hp motor. Pump C is rated 275 gpm @ 270' TDH and has a 40 hp motor.

Table 11.14: Keei #3 Booster Pump 2014 Energy Use & Costs

Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill
1/16/14	12,219	49	49	$498	$3,031	$1,281	$4,810
2/14/14	10,807	49	49	$498	$2,680	$1,138	$4,317
3/17/14	11,647	48	49	$497	$2,889	$1,218	$4,604
4/15/14	12,089	49	49	$498	$2,998	$1,204	$4,700
5/15/14	12,625	49	49	$498	$3,131	$1,291	$4,921
6/16/14	10,586	49	49	$497	$2,626	$1,177	$4,300
7/16/14	10,126	48	49	$497	$2,512	$1,204	$4,213
8/14/14	10,816	48	49	$497	$2,683	$1,316	$4,496
9/16/14	11,264	49	49	$498	$2,794	$1,315	$4,607
10/16/14	11,920	49	49	$498	$2,957	$1,286	$4,741
11/14/14	17,136	49	49	$498	$4,250	$1,712	$6,460
12/15/14	25,008	49	49	$503	$6,203	$2,170	$8,876
Total/Avg	**156,243**	**49**	**49**	**$5,979**	**$38,753**	**$16,311**	**$61,044**

A summary of 2014 booster pump hours and flow data from the DWS Pumpage Report is shown below.

Table 11.15: Keei #3 Booster Pump 2014 Hours & Pumpage

Month	Bstr A Hours	Bstr B Hours	Bstr C Hours	Total Hours	Bstr A Pumpage	Bstr B Pumpage	Bstr C Pumpage	Total Pumpage	Average GPM	KWh/kgal
Jan-14	59	58	421	539	265	774	8,087	9,126	282	1.34
Feb-14	50	50	448	548	287	655	8,648	9,590	292	1.13
Mar-14	91	91	420	603	458	1,178	7,959	9,595	265	1.21
Apr-14	168	168	444	779	896	2,259	8,290	11,445	245	1.06
May-14	351	351	32	734	2,267	5,426	606	8,299	189	1.52
Jun-14	159	159	267	584	938	3,294	5,032	9,264	264	1.14
Jul-14	136	135	377	647	693	1,763	6,998	9,454	243	1.07
Aug-14	115	115	406	635	585	1,476	6,337	8,398	220	1.29
Sep-14	111	112	343	566	572	1,440	6,563	8,575	253	1.31
Oct-14	191	192	484	866	987	2,481	9,254	12,722	245	0.94
Nov-14	369	369	587	1,325	1,902	4,785	11,233	17,920	225	0.96
Dec-14	526	525	650	1,700	2,772	6,831	12,431	22,034	216	1.13
Totals/Avg	**2,325**	**2,324**	**4,877**	**9,526**	**12,622**	**32,362**	**91,439**	**136,423**	**245**	**1.18**

Pump Testing

To evaluate existing pump performance, we collected flow data using the existing flow meter. Power was measured with a Fluke 43B kW meter, and discharge pressure was measured with a Fluke PV-350 pressure transducer. The data is summarized below.

Table 11.16: Keei #3 Pump Efficiency Test

Pump Measurements / Calculations	A	B	C
Total Flow (gpm)	130	280	315
Discharge Pressure (psi)	125	129	125
Suction Pressure	25	25	25
Estimated Total Head (ft)	231	240	231
Static Head	221	221	221
Total Measured Power (kW)	8.8	22.8	20.2
Estimated Motor Efficiency (%)	90%	92%	94%
Calculated Pump Efficiency	**71%**	**60%**	**72%**

Observations and Proposed Recommendations

- Although the Booster Pump B efficiency was lower than A and C, it did not have a significant impact on the pump station energy costs.
- Based on the demand and operating hours it looks like three pumps are required at least once/month which maintains a stead demand of 49 kW.

We have no energy saving recommendations for this station at this time.

11.7 Keei #4 Booster Station

The Keei #4 Machado (Kahauloa Iki) Station has three pumps. Pump A is rated to pump 100 gpm @ 183' TDH and uses a 7.5 hp motor, Pump B is rated for 300 gpm @ 210' TDH and is equipped with a 25 hp motor. Pump C is rated 300 gpm @ 216' TDH and has a 30 hp motor

Table 11.17: Keei #4 Booster Pump 2014 Energy Use & Costs

Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill
1/16/14	9,037	37	37	$383	$2,241	$964	$3,589
2/14/14	8,324	37	37	$383	$2,065	$891	$3,339
3/17/14	9,088	37	37	$383	$2,254	$964	$3,602
4/15/14	8,836	37	37	$380	$2,192	$897	$3,469
5/15/14	8,452	26	32	$325	$2,096	$885	$3,307
6/16/14	8,062	26	32	$325	$2,000	$912	$3,236
7/16/14	6,662	26	32	$325	$1,652	$814	$2,791
8/14/14	7,198	40	40	$412	$1,785	$897	$3,095
9/16/14	8,116	40	40	$412	$2,013	$965	$3,390
10/16/14	7,772	36	38	$390	$1,928	$861	$3,178
11/14/14	12,363	41	41	$417	$3,066	$1,253	$4,736
12/15/14	16,424	41	41	$421	$4,074	$1,451	$5,946
Total/Avg	**110,334**	**35**	**37**	**$4,557**	**$27,366**	**$11,755**	**$43,678**

A summary of 2014 booster pump hours and flow data from the DWS Pumpage Report is shown below.

Table 11.18: Keei #4 Booster 2014 Pump Hours & Pumpage

Month	Bstr A Hours	Bstr B Hours	Bstr C Hours	Total Hours	Bstr A Pumpage	Bstr B Pumpage	Bstr C Pumpage	Total Pumpage	Average GPM	KWh/kgal
Jan-14	454	90	258	801	2,389	1,603	2,383	6,375	133	1.42
Feb-14	378	68	366	812	1,979	1,269	3,366	6,614	136	1.26
Mar-14	563	130	166	860	2,954	2,352	1,514	6,820	132	1.33
Apr-14	716	211	77	1,004	3,693	3,819	700	8,212	136	1.08
May-14	740	157	0	898	3,839	2,812	0	6,651	123	1.27
Jun-14	563	112	98	772	2,936	2,014	1,835	6,785	146	1.19
Jul-14	73	19	338	429	381	347	6,253	6,981	271	0.95
Aug-14	427	187	91	705	2,214	3,403	1,604	7,221	171	1.00
Sep-14	0	329	0	329	0	5,999	0	5,999	304	1.35
Oct-14	0	527	17	544	0	9,621	264	9,885	303	0.79
Nov-14	581	146	357	1,084	2,869	2,611	6,313	11,793	181	1.05
Dec-14	829	410	425	1,664	3,833	7,134	7,005	17,972	180	0.91
Totals/Avg	**5,323**	**2,386**	**2,191**	**9,900**	**27,087**	**42,984**	**31,237**	**101,308**	**185**	**1.13**

Pump Testing

To evaluate existing pump performance, we collected flow data using the existing flow meter. Power was measured with a Fluke 43B kW meter, and discharge pressure was measured with a Fluke PV-350 pressure transducer. The data is summarized below.

Table 11.19: Keei #4 Test Data

Pump Measurements / Calculations	A	B	C
Total Flow (gpm)	100	307	324
Discharge Pressure (psi)	142	148	149
Suction Pressure	70	70	70
Estimated Total Head (ft)	166	180	182
Static Head (1761'-1595')	166	166	166
Total Measured Power (kW)	6.2	18.8	17.3
Estimated Motor Efficiency (%)	88%	89%	90%
Calculated Pump Efficiency	**57%**	**62%**	**72%**

Observations and Proposed Recommendations

- Based on the efficiency data, we recommend operating Booster C more hours. The savings for this adjustment is included in OM #5.

SECTION 12. KAU SYSTEM

The Kau System includes the Pahala, Waiohinu-Naalehu, and the Hawaiian Ocean View Estate (HOVE) System. The Kau electric accounts and 2014 energy usage and costs are shown below.

Table 12.1: Kau Pump Station Energy Use

Tank or Pump Station	2013 kWh	2013 Cost	2014 kWh	2014 Cost
Naalehu Boosters	423	$831	259	$764
Waiohinu Kau Baseyard	4,976	$2,462	4,916	$2,449
Waiohinu Tank and Boosters	852	$1,011	990	$1,071
Pahala Well #2	287,760	$119,804	288,600	$114,858
Naalehu Deep Well	69,280	$39,189	4,920	$16,231
Paradise Circle Well	405,360	$158,902	281,320	$117,769
Total	**768,651**	**$322,198**	**581,005**	**$253,142**

The drop in energy use and cost between 2013 and 2014 was primarily due to DWS staff making an effort to use more source water from the Mountain House and Haao Spring instead of using the Naalehu Deep Well. A reduction in water use at the Hawaiian Ocean (Paradise Circle) View Estates also contributed to system savings.

The pump system high-energy accounts (above $25,000) are reviewed in this section.

12.1 Surface Water/Spring Sources

The DWS has made an effort to use more spring water from the Haao and Mountain House Springs to reduce Naalehu Well energy costs. These springs are not under the influence of surface water, which has allowed the DWS to continue to use them.

Based on DWS Engineering input, the Alili Tunnel for the Pahala system was deemed a Groundwater Under the Direct Influence of Surface Water (GWUDI) source in April 1998. The Hawaii Department of Health issued an official court order to stop the use of Alili Tunnel after Pahala Well 2 was completed, in October 2009. Although DWS periodically monitors the water quality of the Alili Tunnel for possible use as an emergency backup source, the Alili Tunnel cannot be considered for re-activation until the Department of Health Safe Drinking Water Branch is consulted for their requirements.

According to DWS staff, past data shows average flow from the Alili Spring to be between 82 and 100 gpm (2005-2008) or approximately 118,080 to 144,000 gpd. The average Pahala #2 pumpage in July 2014 was 189,290 gpd. Pahala Well #2 will still need to be pumped to meet average daily (not including peak) demands.

12.2 Pahala System

The Pahala Water System is located along the Hawaii Belt Road between Naalehu and Volcanoes National Park and is supplied by Pahala Wells A and B. The system was formally supplied by the Alili Tunnel, which had a rated capacity of 310 gpm. The tunnel flow started at elevation 3,000 and used four tanks at various elevations to reduce the pressure prior to discharging flow to the Pahala Tank at elevation 1,112. With the tunnel no longer in service, the system only uses the two Pahala Wells to supply the system.

12.2.1 Pahala Well

Pahala Wells A & B are rated for 393 gpm @ 835' TDH. According to DWS records Well A is equipped with a 100 hp motor. No record exists for Well B, but based on the energy data, we estimate that the motor is 125 hp. A summary of 2014 energy use data from facility spreadsheets is shown below in Table 12.2.

Table 12.2: Pahala Well 2014 Energy Use & Costs

Billing Date	Monthly Energy Use (KWh)	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill
1/17/14	23,840	106	106	$1,082	$5,913	$2,408	$9,404
2/15/14	22,360	104	105	$1,076	$5,546	$2,295	$8,917
3/18/14	22,520	101	103	$1,059	$5,586	$2,301	$8,945
4/16/14	21,560	100	103	$1,053	$5,348	$2,110	$8,510
5/16/14	23,720	100	103	$1,053	$5,883	$2,415	$9,351
6/17/14	25,680	100	103	$1,054	$6,369	$2,824	$10,247
7/17/14	26,400	100	103	$1,053	$6,548	$3,094	$10,695
8/18/14	28,160	100	103	$1,053	$6,985	$3,377	$11,414
9/17/14	25,480	106	106	$1,087	$6,320	$2,921	$10,327
10/17/14	22,840	100	103	$1,056	$5,665	$2,450	$9,171
11/17/14	23,880	100	103	$1,055	$5,923	$2,395	$9,373
12/16/14	22,160	100	103	$1,054	$5,496	$1,954	$8,505
Total/Avg	**288,600**	**101**	**104**	**$12,733**	**$71,582**	**$30,543**	**$114,858**

A summary of 2014 pump hours and flow data from the DWS Pumpage Report is shown below.

Table 12.3: Pahala Well Hours & Pumpage

Month	Monthly Energy Use (KWh)	Monthly Net Bill	Well A Hours	Well B Hours	Well A Pumpage	Well B Pumpage	Average GPM	Average GPM
Jan-14	23,840	$9,404	224	9	5,576	200	414	366
Feb-14	22,360	$8,917	0	202	0	5,021		414
Mar-14	22,520	$8,945	0	225	0	5,597		415
Apr-14	21,560	$8,510	0	220	0	5,483		415
May-14	23,720	$9,351	0	265	0	5,410		340
Jun-14	25,680	$10,247	0	232	0	5,377		386
Jul-14	26,400	$10,695	0	252	0	5,868		388
Aug-14	28,160	$11,414	0	275	0	5,605		339
Sep-14	25,480	$10,327	1	254	16	5,544		363
Oct-14	22,840	$9,171	0	234	3	5,833		416
Nov-14	23,880	$9,373	0	224	2	5,605	333	417
Dec-14	22,160	$8,505	0	243	0	6,079		417
Totals/Avg	**288,600**	**$114,858**	**226**	**2,635**	**5,597**	**61,622**	**374**	**390**

Well B was used consistently during 2014 due to maintenance issues with Well A. The average 2014 cost/kgal for the station was $1.71/kgal.

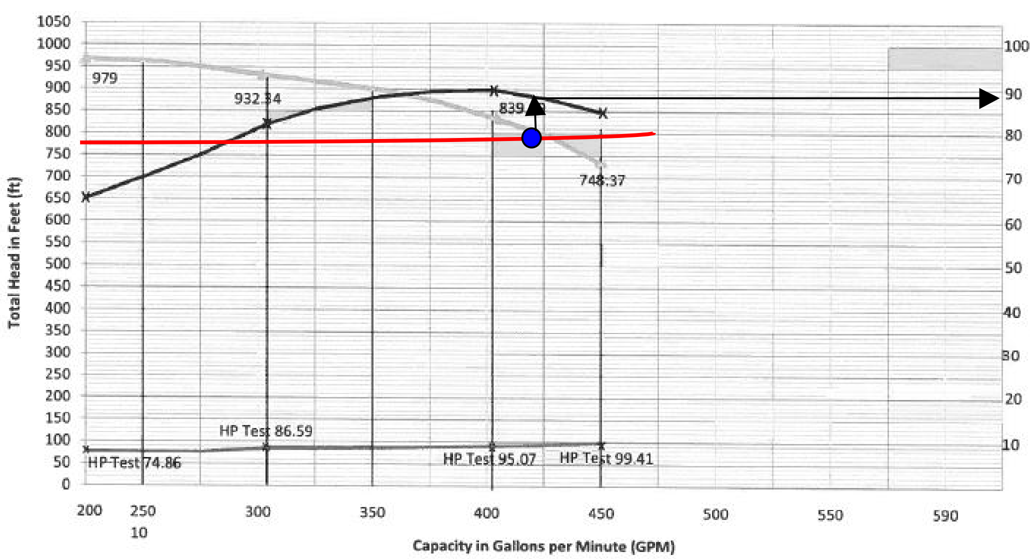
To evaluate existing pump performance, we worked with DWS staff to collect instantaneous flow data using the existing well flow meters. Power was measured with a Fluke 43B kW meter, and discharge pressure was determined using a Fluke PV-350 pressure transducer.

Table 12.4: Pahala Well Test

Pump Measurements / Calculations	Well #1	Well #2
Total Flow (gpm)	423	424
Discharge Pressure (psi)	13.6	12.5
Baseline Ground Elevation (ft)	1112	1112
Tank Water Level Elevation (ft)	1144	1144
Well Depth or Suction Tank to Baseline (ft)	740	740
Static Head (ft)	772	772
Gauge Height from Baseline (ft)	2	2
Estimated Column/Velocity Losses (ft) 1ft/100ft	7.4	7.4
Estimated Total Head (ft): P * 2.31 + well depth + losses)	781	778
Total Measured Power (kW)	103	98
Estimated Motor Efficiency (%)	87%	87%
Calculated Pump Efficiency	**69%**	**73%**
Original Pump Efficiency at Flowrate	**87%**	**87%**

Based on the field data collected, the efficiency of both wells is lower than the original pump rating shown below in Figure 12.1.

Figure 12.1 Pahala Well A Pump Curve



Observations and Recommendations

- Based on the 500,000 gallons of storage available in Pahala Tank #1, we recommend applying a four hour Rider M at the station. This could provide $9,225 in annual savings for the DWS and has been included in ESM #4.

- It appears that the efficiency has degraded for both pumps. Improving the efficiency of Well B by 10% would provide savings if the operating hours remained the same. This measure is included in ECM #2.

12.3 Naalehu System

The Waiohinu-Naalehu Water System is located at the most southern point of the island along the Hawaii Belt Road at South Point Road. The system is supplied by the Haao Spring, Mountain House Tunnel, and Naalehu Well. The water from the Mountain House Tunnel is piped to the Haao Spring and distributed to the South Point, Waiohinu, and Naalehu areas through separate transmission lines. The Mountain House Tunnel has a rated capacity of 450 gpm and the Haao Spring has a rated capacity of 400 gpm. The Naalehu Well, has a capacity of 375 gpm at a TDH of 933 feet.

A break down of pump hours, pumpage, energy use and cost for the Naalehu Well is shown in Table 12.5.

Table 12.5: Naalehu Well 2014 Energy Use, Hours, Pumpage & Costs

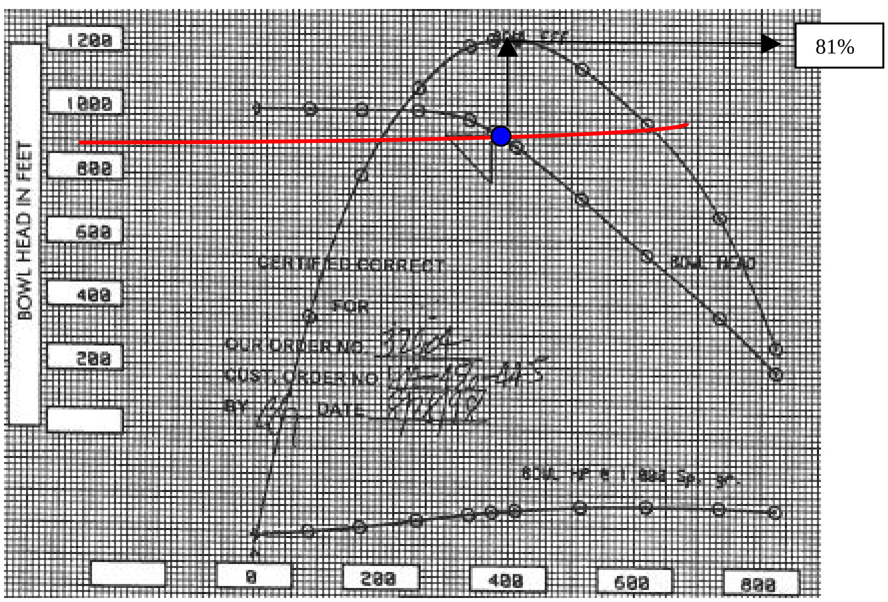
Billing Date	Well Hours	Well Pumpage (kgal)	Total kWh	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill
1/17/14	0	0	400	0	122	$1,315	$0	$0	$1,315
2/15/14	0	0	360	0	122	$1,315	$0	$0	$1,315
3/18/14	2	49	360	0	122	$1,315	$0	$0	$1,315
4/16/14	0	2	600	117	120	$1,226	$149	$121	$1,495
5/16/14	0	0	360	59	122	$1,315	$0	$0	$1,315
6/17/14	0	6	400	0	121	$1,302	$0	$0	$1,302
7/17/14	0	6	400	116	119	$1,216	$99	$109	$1,424
8/18/14	0	0	440	116	119	$1,216	$109	$115	$1,440
9/17/14	0	0	360	93	121	$1,302	$0	$0	$1,302
10/17/14	1	12	440	100	110	$1,123	$109	$109	$1,342
11/17/14	0	3	400	115	116	$1,189	$99	$102	$1,390
12/16/14	0	1	400	66	117	$1,265	$0	$13	$1,278
Total/Avg	**4**	**79**	**4,920**	**65**	**119**	**$15,097**	**$566**	**$569**	**$16,231**

To evaluate existing pump performance, we worked with DWS staff to collect instantaneous flow data using the existing well flow meters. Power was measured with a Fluke 43B kW meter, and discharge pressure was determined using a Fluke PV-350 pressure transducer.

Table 12.6: Naalehu Well Test Data

Pump Measurements / Calculations	Data
Total Flow (gpm)	436
Discharge Pressure (psi)	59.2
Baseline Ground Elevation (ft)	748
Tank Water Level Elevation (ft)	881
Well Depth or Suction Tank to Baseline (ft)	738
Static Head (ft)	871
Gauge Height from Baseline (ft)	2
Estimated Column/Velocity Losses (ft) 1ft/100ft	7.38
Estimated Total Head (ft): P * 2.31 + well depth + losses)	884
Total Measured Power (kW)	115
Estimated Motor Efficiency (%)	95%
Calculated Pump Efficiency	**66%**
Original Pump Efficiency at Flowrate	**81%**

Figure 12.2: Naalehu Well Pump Curve



Observations and Recommendations

- The pump efficiency was reduced, but with the low operating hours this does not impact energy usage significantly.

- The DWS has been able to use more spring water from the Haao and Mountain House Springs to reduce well energy costs. With the Naalehu Well now used primarily for back-up, it would be worthwhile to install a VFD to reduce the $15,000 in annual demand charges. Although pump efficiency would be reduced at lower speeds, given the low well operating hours (average run time of 4 hrs/month in 2014), the reduced efficiency would have a minimal impact on the well energy use. Applying a VFD for the well is reviewed in ESM #5.

Booster Pump Stations

The Naalehu Pump Station has two 30 hp booster pumps (Booster A and B) that have rated capacities of 150 gpm each. The Waiohinu Pump Station also has two 15 hp booster pumps (Booster A and B) with a rated capacity of 100 gpm.

Energy use and cost for both booster stations is minimal due to the low pump operating hours. Both pump station electric accounts are billed on the Schedule G Rate Schedule, which does not impose a demand charge.

12.4 Hawaii Ocean View Estate (HOVE) System

The Hawaiian Ocean View Estate system includes a deep well and 500,000-gallon storage tank. The well consists of a submersible Centrilift deep well/motor and VFD. Due to HELCO electrical system grid capacity, the flow must be maintained below 100 gpm and the well is shut off between 5:00 pm and 10:00 pm Monday through Friday. A summary of 2014 flow and energy use data is shown below in Table 12.7.

Table 12.7: HOVE Well 2014 Energy Use, Hours, Pumpage and Costs

Billing Date	Well Hours	Well Pumpage (kgal)	Average Flow (gpm)	Total kWh	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc. Charges	Total Bill
1/17/14	219	1,310	100	30,480	137	167	$1,713	$7,560	$3,088	$12,361
2/15/14	125	751	100	21,120	137	167	$1,713	$5,238	$2,171	$9,123
3/18/14	148	876	99	21,040	136	167	$1,709	$5,219	$2,141	$9,069
4/16/14	176	1,033	98	18,320	137	167	$1,710	$4,544	$1,791	$8,045
5/16/14	223	1,295	97	26,600	136	167	$1,708	$6,598	$2,654	$10,959
6/17/14	176	1,019	96	35,080	136	167	$1,707	$8,701	$3,763	$14,171
7/17/14	228	1,312	96	24,320	136	137	$1,402	$6,032	$2,806	$10,240
8/18/14	149	854	95	25,400	136	137	$1,403	$6,300	$3,009	$10,712
9/17/14	144	712	82	18,840	136	137	$1,402	$4,673	$2,138	$8,213
10/16/14	119	666	93	18,040	136	137	$1,402	$4,475	$1,912	$7,789
11/17/14	139	777	93	17,640	136	137	$1,400	$4,375	$1,752	$7,528
12/16/14	260	1,450	93	24,440	136	137	$1,400	$6,062	$2,097	$9,559
Total/Avg	**2,107**	**12,055**	**95**	**281,320**	**136**	**152**	**$18,668**	**$69,777**	**$29,324**	**$117,769**

HOVE Well Energy Cost/kgal = $9.77 /kgal

To evaluate existing pump performance, we collected flow data and discharge pressure. We were not able to open up the VFD cabinet (bolted shut), but used the consistent kW data from the power bills for the pump efficiency calculation in Table 12.8.

Table 12.8: HOVE Test Data

Pump Measurements / Calculations	Data
Total Flow (gpm)	95
Discharge Pressure (psi)	7
Baseline Ground Elevation (ft)	2178
Tank Water Level Elevation (ft)	2195
Well Depth or Suction Tank to Baseline (ft)	738
Static Head (ft)	755
Gauge Height from Baseline (ft)	2
Estimated Column/Velocity Losses (ft) 1ft/100ft	7.38
Estimated Total Head (ft): P * 2.31 + well depth + losses)	764
Total Measured Power (kW)	136
Estimated VFD Efficiency (%)	70%
Estimated Motor Efficiency (%)	85%
Calculated Pump Efficiency	**17%**
Original Pump Efficiency at Flowrate	**N/A**

Observations and Recommendations

- Pumpage and corresponding energy use was much lower in 2014 (12,055 kgal) compared to 2013 (18,860 kgal), which reduced energy costs by $40,000. The reason for the lower flow is unknown at this time.

- Shutting the well down between 5:00 pm and 10:00 pm Monday through Friday has been done for the last two years due to the HELCO electrical grid limitations. This coincides with the four-hour Rider M discount but the DWS does not have an agreement with HELCO to benefit from the operating practice, which would reduce annual costs by $12,550. In ESM #3 we have recommended pursuing this agreement.

- Based on the extremely low pump efficiency, some of the data may need to be verified. However, even with including low efficiency values for the motor and VFD, the calculated pump efficiency was only 17%. A pump curve was not available to verify if this pump efficiency matched the curve value at the low flow rate and should be reviewed. After the curve operating point is confirmed, we recommend verifying the power draw with HELCO. If the pump efficiency can be improved to 70% with a smaller pump and no VFD, over $97,000 annually could be saved. This project is reviewed in ECM #2.

SECTION 13. RECOMMENDED MEASURES

This section describes the proposed energy management practices (EMPs), operational measures (OMs), energy conservation measures (ECMs), energy supply measures (ESMs) and future energy measures (FEMs) discussed in the report. The measures are interactive in the order they are listed. All project costs and savings figures are preliminary and should be verified before proceeding with each project.

13.1 Energy Management Practices

Energy management practices cannot be justified based on quantifiable energy savings, but are considered to be good energy efficient practices that will provide long-term benefits.

13.1.1 EMP #1 Assign Staff as a Part-Time Energy Management Analyst

Description

Appointing an existing staff member to handle Energy Management Analyst responsibilities is a critical component of a successful energy program. The Energy Management Analyst is the key person who leads an organization in achieving its efficiency goals by promoting energy performance as a core value and facilitating energy improvement projects.

Although energy management initiatives are pursued at all levels in the organization, having an Energy Management Analyst is critical to manage the 22 million dollar annual energy budget for the DWS. A successful energy saving adjustment at one pump station can easily justify this effort.

For the DWS, the Energy Management Analyst position has included the following responsibilities:

<u>Monitoring Energy Data and Savings</u>

- Track energy use to maximize energy savings
- Manage HELCO data input and report generation
- Research missing or inconsistent data
- Look for trends that effect efficiency
- Monitor and verify savings from projects

<u>Training/Communication</u>

- Review pump system optimization with operators on a regular basis
- Work with engineering to incorporate efficiency into system designs
- Coordinate data collection, recording, and analyzing with the DWS Water Services Investigation section, maintenance staff, pump station operators, and Microlab staff.
- Recognize staff for accomplishments through a recognition /accountability program that promotes efficiency at all levels within the department.
- Chair energy meetings on a regular basis with a designated energy management team, discuss progress of implementing identified ECMs, new ideas and projects and provide a summary of the meeting notes to all DWS managers and supervisors

- Lead energy related issues for the DWS, by participating in and coordinating activities with other agencies and organizations.

Formalize data collection efforts for energy, flow, and water use

- Develop pump system improvement plan based on testing
- Develop and implement Standard Operating Procedures to provide accurate and up-to-date energy, efficiency and flow information.
- Collect, record, analyze, and act upon, on a regular basis, the above data to optimize the operation of each district.
- Research, Analyze and Develop Implementation Plans for Energy Saving Projects -This includes RFP development, technical specifications, financial analysis, energy savings calculations, developing project cost estimates, managing contractors, and follow-up verification of savings. Projects to include:
  - -Power factor correction capacitors
  - -Premium Efficiency Motors
  - -Installing or Removing Variable Speed Drives
  - -Pump Efficiency Improvements
  - -Installing Hydro Turbine Generators
  - -Demand Controls / SCADA systems to take advantage of Rider M Rate Schedules.
  - -Assisting DWS staff with unaccounted for water projects

Research New Technologies / Projects to Reduce Long Term Energy Costs

- Optimizing flow from Waimea WTP (piping improvements).
- Develop specific solutions for using surface water sources.
- Work with HELCO to determine the most cost effective rate schedule.
- Exploring alternative renewable energy sources for DWS facilities such as solar and wind and additional hydro sites.
- Evaluate selective water conservation projects to reduce energy use.

Having an Energy Management Analyst is the highest priority measure in this report and is an essential step that is needed to implement the projects proposed in the report.

13.1.2 EMP #2 Formalize Energy Management Program

Description

Formalizing an energy management program is essential to begin improving systems efficiency and maintaining low operating costs. The DWS has recognized the importance of energy management and has had an energy manager position for over 10 years. However, the Energy Management Analyst needs the support of management and a formal energy management program that emphasizes the importance of this effort to all staff members.

Even though this recommendation cannot be directly related to calculated savings, it is a critical step that will often determine if efficiency projects are successful. Some of the key building blocks of a successful energy management program include the following tasks:

- Establishing an Energy Policy
- Selecting an Energy Management Team
- Developing a baseline of existing facility energy use to track energy use/process data.

<u>Developing an Energy Policy</u>

An Energy Policy provides the foundation for successful energy management. When developing an energy policy, the DWS should consider the following:

- DWS Manager should issue the policy.
- Involve key people in policy development to ensure buy-in.
- Tailor the policy to the organization’s culture.
- Make it understandable to all of the staff and the public alike.
- Consider the skills and abilities of management and staff.
- Include detail that covers day-to-day operations.
- Communicate the policy to all staff, and encourage them to get involved.

<u>Establishing an Energy Team</u>

Creating an energy team helps integrate energy management into all areas of an organization. In addition to planning and implementing specific improvements, the team also measures and tracks energy performance and communicates with management, employees and vendors. The purpose of creating an energy management team is to develop the resources and tools needed to maximize the effectiveness of the energy manager. The energy management team’s role should include:

- Organize and coordinate energy efficiency efforts.
- Develop technical skills to identify and implement projects.
- Assemble pertinent data to identify inefficiencies.
- Create a management focus on water and energy efficiency.

Creating an energy management team involves putting together the right group of people with the appropriate resources to identify opportunities, develop and implement projects, and track results. In addition to the Energy Management Analyst who leads the team, a representative from engineering, accounting, operations and management should also be included.

Meetings should be initially scheduled monthly to get the program started and then can be held every two months after projects have been initiated. These meetings provide an opportunity to present potential energy savings projects, request assistance from departments to obtain additional data, and to get feedback on the proposed projects.

Tools and Resources for the Team

During the process of organizing an energy management team, managers need to recognize and provide resources that the team needs for success. Some of these resources include:

- *Allocating a program annual budget*. Having a budget is critical for the energy management team to obtain needed tools and expertise, commissioning technical studies, implementing appropriate projects, and providing continuity.

- *Team members need time to focus their efforts on efficiency*. It is important that department managers recognize that energy management team members will need to occasionally devote time to help collecting data to support energy efficiency projects. This includes allowing team members the ability to access key people from both inside and outside the team.

- *Training*. Appropriate training provides team members with the tools to achieve efficiency goals. Training can acquaint team members with up to date efficiency technologies, teach energy conscious operations and maintenance practices, and show managers how best to enable their staff to achieve efficiency gains.

- *Documentation*: To improve facility efficiency, it is important to document existing system operations through standard operating procedures.

- *Metering and Monitoring Equipment*. One of the first tasks of the team should be to assess the current metering and monitoring system to identify areas for improvement and determine additional equipment needs (flow meters, pressure gauges, etc…). Data can always be improved by increasing the scope and accuracy of the system's measuring capacity.

- *Pursue Projects*. To prevent a team's efforts from turning into a strictly academic exercise, identified opportunities need to be implemented. Management needs to support projects that meet certain payback goals, and recognize the value of using low- or no-cost projects to help fund more capital-intensive projects.

This measure is an important part of a successful efficiency program to insure savings for all other energy projects are realized

13.1.3 EMP #3 Hire Additional Water Service Investigator

Description

In 2000, the Department of Water recognized that the Island of Hawaii water distribution system had significant amounts of non-revenue water (NRW) and designated a lead person for the Water Service Investigation (WSI) Program. As part of the program, the following key areas of data collection and record keeping were identified:

- Maintain the DWS Pumpage Report and customer service billing system-metered usage (consumption-monthly and bi-monthly).
- Obtain estimates and records of unmetered water used by contractors, fire department, field operation personnel (flushing purposes), and reservoir/tank overflow.
- Document known leaks, main pipeline breakages, reservoir seepage/overflow, unmetered usage (theft), and water hauling by private haulers.

The data collection process requires a significant effort to insure the data is as accurate as possible. This includes a thorough review of the pumpage report each month, identifying and repairing inaccurate meters, and a continuous effort to document non-revenue water.

Since 2007, the program has resulted in over $840,000 in total savings. Based on an investment of almost 2 million dollars in loggers and piping repairs, the simple payback for the program has averaged 2.3 years since 2007.

Table 13.1: Leak Detection Program Savings and Costs

Fiscal Year	Recorded Leakage (Kgal/year)	Annual Energy Savings	Allocated Cost for Repairs & Loggers	Simple Payback (yrs)
2007	55,061	$35,176	$165,283	4.7
2008	51,385	$30,089	$204,082	6.8
2009	89,722	$79,650	$312,216	3.9
2010	172,185	$162,142	$263,326	1.6
2011	175,855	$187,246	$263,005	1.4
2012	328,218	$183,364	$337,344	1.8
2013	79,423	$68,594	$272,269	4.0
2014	61,695	$94,389	$151,006	1.6
Total/Avg	**1,013,544**	**$840,649**	**$1,968,530**	**2.3**

Although the program has been successful, it has been difficult to have one person cover the entire Island to perform data logger monitoring, investigation work to identify the leak, quantify the savings, initiate the repair project, and follow through to be sure the work is performed in a timely manner.

This position had been previously approved years ago, but was not pursued due to budget constraints. Given the significant savings realized from each leak identified and corrected, this position should be filled as soon as possible.

13.1.4 EMP #4 Perform Cost/Saving Study for Small Surface Water Plants

Description

Making every effort to use spring and surface water sources is one of the best long-term solutions for the DWS to protect itself from rising energy costs and minimize its dependence on high-energy deep wells.

In the 1990s, more stringent federal surface water regulations were adopted as part of the Surface Water Treatment Rule (SWTR). Over time, the DWS made the decision to abandon many of the surface water sources that would have required water treatment systems and transition to more deep wells to satisfy water demands. The investment in deep wells was initially a good choice for the DWS to provide a consistent, high quality water supply. The wells were also regulated through less stringent groundwater regulations for water treatment. However, the deep wells have been energy intensive and have had reliability problems over the years.

The DWS was able to continue to use some of the springs that were not under the influence of surface water and is in the process of upgrading the South Kohala Waimea Water Treatment Plant that was originally constructed in the 1980s to increase the plant capacity

The successful use of the Waimea Plant is an example of the significant energy savings that have been realized by the DWS over the last 30+ years. Based on an average flow of 2 million gallons/day, we estimate that since the plant was constructed (using a rough 30 year average deep well energy cost of $1.00/1000 gallons) the DWS has saved over 21 million dollars in energy costs.

The DWS Water Quality Branch has indicated that a significant effort would be required to reactivate the abandoned springs/surface water sources that are located in the other water systems. This would include, but not be limited to, new source water quality testing, microscopic particulate analysis, determination of truly groundwater or groundwater under the influence of surface water (i.e. Waiulili springs and Alili Tunnel), design & construction plans, operation plans, etc. The land acquisition (if not already owned) and design of a new intake box or collection system, storage, and transmission waterlines. If the source were deemed under the influence of surface water, the source would be required to meet the requirements of the Surface Water Treatment Rule, which would require additional cost and effort.

The above issues are valid concerns, but until specific costs and savings are put together the DWS cannot make an informed decision if the long-term benefits outweigh the initial effort to invest in transmission lines and/or water treatment systems.

For this measure, we have recommended performing a detailed evaluation for all the viable spring/surface water sources. This evaluation would include a detailed assessment if the source could be considered a spring without the influence of surface water or if water treatment was required. For a potential water treatment system, the evaluation would include the capital improvements for treatment (i.e. membrane filtration) versus future O&M costs, which could include but not be limited to; chemical requirements for cleaning of membranes, disposal of chemicals, replacement of membrane filters, added personnel (WTPO Grade 2 required), land acquisition, design/construction costs, and disinfection requirements.

To begin this process, we have summarized the water sources in each water system and included the potential energy savings that could be realized to provide justification for the initial evaluation phase.

Hilo Surface Water Sources

The Hilo spring, tunnel and surface water sources are located at high elevations and often have fluctuating flow. Based on previous DWS staff input, the quality of the water is generally good, however the water can be corrosive and during heavy rains, the water turbidity of some of the spring and surface water sources is high. From an energy perspective, the water sources listed in Table 13.2 have the potential of supplying a significant portion of the water needs for Hilo.

Table 13.2 Hilo Spring/Tunnel Water Sources

Water Source	Status on Drawing	Type	1994 Flow Data (MGD)
Olaa Flume	Line cut	Tunnel	3.0
Lyman Spring	Line cut	Spring	3.0
Kohoama Intake	Line cut	Part of Wailuka Intake (surface)	3.0
Waiakea-Uka	Line cut	Spring (water quality issue in 1990s)	0.08

The Olaa Flume has been of interest over the years due to its high flow rates. It is our understanding that the water rights are owned by the United Church of Christ and that the DWS previously had a 50-year agreement to use the source if needed.

Based on input from DWS staff, the Church had expressed an interest in renegotiating the stand-by and use charges. There have also been discussions with several private companies that were interested in putting together a design-build-operate water treatment plant and selling the water to the DWS. Recently *Waimea Water Services* was pursuing the installation of piping back to the spring source. DWS staff indicated that they are currently working with the Department of Health to see if they could get the source deemed as not under the direct influence of surface water.

In 2014, the energy cost of pumping water in Hilo was approximately $1.1 million for 1,912 million gallons. Based on the potential of using 80% of the 3 MGD rated capacity of the Olaa Flume, the following energy savings could be realized:

Annual flow: 3.0 MGD * 80% * 365 days = 876 million gallons
Energy pumping cost: $575/MG
Potential Annual Energy Savings: $503,975

In addition to energy savings, making use of the available surface water would also improve the reliability of the system and reduce the cost exposure the DWS has to rising energy prices.

South Kohala/Hamakua

The successful use of the Waimea Plant is an example of the significant energy savings that have been realized by the DWS over the last 30+ years. Based on an average flow of 2 million gallons/day, we estimate that since the plant was constructed (using an approximate 30 year average deep well energy cost of $1.00/1000 gallons) the DWS has saved over 21 million dollars in energy costs.

The treatment process consists of flocculation, settling, and sand filtration. The water is also disinfected and treated for corrosion control. The DWS is currently upgrading the sand filter system to a microfilter system that will use membrane filters to remove contaminants from water. After the plant upgrade, the existing average flow of 2.0 MGD is expected to increase to approximately 3.0 MGD. Although this flow will be limited due to the available intake water, it has the potential of reducing the Parker Ranch and Waimea deep well energy costs by $780,000 annually (reviewed in OM #3).

Directing a portion of the flow to the Hamakua System also has the potential for reducing well run time. The savings for using treatment plant water to minimize use of the three wells and booster pumps would be approximately $156,000 annually (based on using Waimea Treatment Plant water 80% of the time). This does not include demand charges for each station, which would still be charged by HELCO since the wells would be exercised on a regular basis. More details on this project are included in OM #3.

North Kohala

In the past the North Kohala water system was supplied with multiple surface water sources shown in Table 13.3.

Table 13.3: North Kohala Spring/Surface Sources

Water Source	Status on Drawing	Type	1994 Average Flow Data (MGD)	80% of Rated Flow (annual flow in MG)	DWS Notes
Lindsey	Line cut	Tunnel	.093	27.2	
Watt #1	Line cut	Tunnel	.175	51.1	Turned back over to private land owner
Hapahapai	Line cut	Spring	.045	13.4	Turned back over to private land owner
Kohala #5	Line cut	Unknown	No Data	--	
Bond #1	Line cut	Tunnel	.200	58.4	
Murphy Tunnel	Line cut	Tunnel	.07	20.4	
Maulua	Unkown	Tunnel	No Data	--	

Based on 80% of the Lindsey, Watt, Hapahapai, and Bond water source capacity, the potential exists to contribute 150 million gallons annually to the system. Potential energy savings for the Hawi and Makapala systems are shown below.

Hawi Deep Wells:

Annual tunnel/spring flow: 150 million gallons
Energy pumping cost: $1,500/MG
North Kohala well pumpage: 240 million
Potential annual energy savings: $225,000

Makapala Deep Well:

Annual Murphy Tunnel/Spring flow: 20.4 MG
Well energy pumping cost: $1,700/MG
Makapala annual pumpage: 7.5 MG
Potential annual energy savings: $12,750

Based on the above simple review, the energy saved by using the Murphy Tunnel would not make it worthwhile to pursue the use of this water source.

Kau System

The DWS has made an effort to use more spring water from the Haao and Mountain House Springs to reduce well Naalehu Well energy costs. As discussed, these springs are not under the influence of surface water, which has allowed the DWS to continue to use them.

Based on DWS Engineering input, the Alili Tunnel for the Pahala system was deemed a Groundwater Under the Direct Influence of Surface Water (GWUDI) source in April 1998. Although DWS periodically monitors the water quality of the Alili Tunnel for possible use as an emergency backup source, the Alili Tunnel cannot be considered for re-activation until the Department of Health – Safe Drinking Water Branch is consulted for their requirements.

According to DWS staff, past data shows average flow from the Alili Spring to be between 82 and 100 gpm (2005-2008) or approximately 118,080 to 144,000 gpd. The Pahala Wells will still need to be pumped to meet average daily (not including peak) demands.

The energy saving value of the spring/surface water flow is estimated below.

Annual tunnel/spring flow: 47.8 MG
Well energy pumping cost: $1,700/MG (not including demand charges)
Pahala DW annual pumpage: 67.2 MG
Potential annual energy savings: $81,260

Summary of Potential Savings

A summary of savings for utilizing the full potential of the surface water sources is listed in Table 13.4. The savings indicated for the South Kohala system is based on optimizing the use of the plant intake sources by 10% to make full use of the upgraded Waimea Water Treatment water.

Table 13.4 Summary of Spring/Surface Water Savings

System	Potential Spring/Surface Water Flow (MG/Year)	Average Pumping Cost/MG (not including demand charges)	Annual Savings
Hilo	876	$ 575	$ 503,975
North Kohala	150	$1500	$ 225,000
South Kohala	73	$3572	$ 260,756
Kau	48	$1489	$ 81,260
Total/Average	**1147**	**$1,784**	**$1,070,991**

As discussed, the above savings is the first step to recognize the importance of this effort. The proposed evaluation will provide a detailed life cycle cost analysis to help the DWS evaluate the true cost effectiveness for each source.

Preliminary Cost Estimate

We have estimated an evaluation cost of $150,000 for researching the Hilo, North Kohala and Kau water sources and $50,000 for a detailed review of the Waimea Treatment Plant Intake Sources.

13.2 Energy Supply Measures

Energy supply measures are recommended improvements that may not reduce energy consumption, but provide energy related savings such as power factor correction or application of the HELCO Rider M rate schedule.

13.2.1 ESM #1 Install Power Factor Correction Capacitors

Description

For the pump stations that are on the HELCO "P" or "J" Rate Schedule, an adjustment is made on each monthly bill based on the power factor of the station. When the power factor is below 0.85, a penalty is added to the bill. When it is above 0.85, a credit is provided. The higher the power factor (up to 1.0) the greater the credit.

Power factor is defined as the ratio of real power to apparent power. In a purely resistive circuit, such as an incandescent light, the two are equal and power factor is unity or 1.0. In a circuit with inductive loads such as an AC induction motor, there is reactive energy present (kVAR) and apparent energy (kVA). As power factor decreases, the kVA value increases more than the real energy (kW).

The pump stations that currently have poor power factor, can be improved by adding capacitance to the station electrical distribution system to increase kVAR, to bring the power factor closer to unity (1.0). The DWS has invested in capacitors in some of the stations and have also benefited from the indirect power factor correction that occurs when a variable frequency drive has been installed. A summary of the power factor credits in 2014 is summarized below.

Table 13.5 Existing High Power Factor Pump Stations and 2014 Credit

Pump Station	Equipment used to Improve Power Factor	Average 2014 Power Factor	2014 Credit Provided to the DWS
Waimea Well	VFD	1.00	$9,746
Lalamilo	PF Capacitors	0.95	$10,083
Keei Well D	VFD	0.92	$2,267
Keopu	PF Capacitors	0.98	$3,496
Kahuluu Shaft	PF Capacitors	0.93	$10,745
Kahuluu Well A & C	N/A	0.88	$2,156
Piihonua #3 Well A	N/A	0.87	$412
Piihonua #3 Well B	N/A	0.88	$287
Panaewa Well & Bstrs	N/A	0.88	$2,438
Olaa #3	N/A	0.88	$270
Total	**---**	**--**	**$41,900**

Additional saving can be realized if more pump stations are equipped with capacitors or VFDs. To evaluate the savings, we have listed the pump stations that would benefit from these improvements in Table 13.6.

To increase station power factor up to approximately 95%, we have calculated the amount of capacitance needed for each station below based on existing demand and a power factor correction table multiplier provided by Eaton.

Table 13.6 Proposed Power Factor Improvements

Pump Station	Average 2014 Power Factor	2014 Typical Demand (kW)	Eaton Power Factor Correction Multiplier	KVAR Required
Hawi DW B	.81	193	0.395	76
Hawi DW A *	.85	182	0.291	53
Parker Ranch *	.83	304	0.343	104
Parker #1	.80	422	0.421	178
Parker #2	.83	418	0.343	143
Parker #3 *	.83	428	0.343	147
Parker #4	.83	412	0.343	141
Halekii DW	.84	475	0.317	151
Holualoa Well & Bstrs	.80	190	0.421	80
QLT Well	.76	511	0.526	269
Waiaha	.78	593	0.473	280
Honokoua *	.80	625	0.421	263
Saddle Rd Well	.85	187	0.291	54
Piihonua #3 Well A	.87	311	0.238	74
Piihonua #3 Well B	.87	325	0.238	77
Panaewa Well & Bstrs	.88	690	0.211	146
Piihonua #1 Well C	.79	478	0.447	214
Olaa #3 DW	.88	278	0.211	59
Olaa #6 DW	.85	471	0.291	137

* If VFDs are pursued for these wells (recommended in ESM #5), power factor correction will not be needed

A credit (or penalty if below 85%) is based on 1% of the energy and demand charges for every percent of power factor. The penalty for each of the effected pump stations is shown below along with the potential credit for improving power factor to determine the total annual savings.

Table 13.7 Proposed Power Factor Annual Savings

Pump Station	Energy & Demand Cost	Penalty Saved	Credit for 95% Power Factor	Total Annual Savings
Hawi DW B	$245,400	$1056	$2454	$3,510
Hawi DW A *	$75,143	$0	$751	$751
Parker Ranch Well *	326596	1277	$3,266	$4,543
Parker #1	$314,115	$4,123	$3,071	$7,194
Parker #2	$906,908	$1,508	$7,538	$9,046
Parker #3 *	$610,563	$1,372	$4,857	$6,229
Parker #4	$751,160	$1,164	$5,818	$6,982
Holualoa Well & Bstrs	$194,331	$972	$1,943	$2,915
QLT Well	$926,732	$8,341	$9,267	$17,608
Waiaha	$514,654	$3,559	$5,147	$8,706
Kahaluu Well A & C	$828,946	0	$4,274	$4,274
Honokoua *	$999,454	$3,272	$9,995	$13,267
Saddle Rd Well	$165,675	0	$1,657	$1,657
Piihonua #3 Well A	$177,842	0	$1,423	$1,423
Piihonua #3 Well B	$275,906	0	$2,483	$2,483
Panaewa Well & Bstrs	$734,171	0	$5,139	$5,139
Piihonua #1 Well C	$285,281	$1,924	$2,853	$4,777
Olaa #3	$183,497	0	$1,284	$1,284
Olaa #6	$680,000	0	$3,408	$3,408
Total	**--**	**$28,568**	**$72,354**	**$100,922**

* If VFDs are pursued for these wells power factor correction will not be needed

The cost effectiveness for installing power factor correction capacitors is summarized below. The project cost is based on a unit cost of $20/KVAR and average electrical installation costs of $3,500/station. This project is included in Table 1 as ESM #1.

Preliminary Cost Estimate

Item N°	Source	Description	Qty	Unit	Equipment Cost	Labor Cost	Total
1	--	kVAR PF Capacitors	2646	EA	$20	$0	$52,920
2	--	Installation for Each Station	18	EA	$1,000	$3,500	$81,000
3	--	Misc Electrical	1	LOT	$10,000	$10,000	$20,000
				Subtotal			$153,920
				Contractor Overhead & Profit (20%)			$30,784
				Construction Contingency (10%)			$15,392
				Engineering & Project Management (15%)			$23,088
				Hawaii General Excise Tax (4.167%)			$9,300
				Total			**$232,484**

Cost and Savings Summary

The cost and savings estimate for this measure is summarized below.

Total Energy Cost Savings			**$ 100,922**
Project Cost			**$ 232,484**
Simple Payback			**2.3 years**

13.2.2 ESM #2 Reduce Two Pump Operation

Description

Based on a review of pump operating hours, electric demand and pump capacity, there are some pump systems that operate two pumps in parallel on a regular basis. Typical reasons for this are tank levels set too close or operators unaware of demand charges and set controls to operate two pumps at once. DWS staff also indicated that some stations had both pumps come on after a power outage when the tank had drained to a low level (this occurred at the Laupahoehoe Deep Well Pump Station).

Making every effort to prevent two pumps from operating is an important operational measure that will help maintain demand charges at lower levels. The methods that can be used to adopt this strategy include:

- Space tank levels far enough apart so that the second pump only comes on at the lowest acceptable tank level.
- Have the second pump deactivated and rely on a low level alarm to have the operator manually turn on a second pump if needed after investigating.
- Install more sophisticated controls to prevent two pumps from coming on after a power outage and activate a second pump only after monitoring tank recovery.

Calculations

We believe the first two strategies are the best low-cost options that would capture the majority of the demand savings. Stations identified are listed below.

Table 13.8 Pump Stations and Demand Charges

Pump Measurements / Calculations	2014 Demand (kW)	2014 Demand Charges	Revised Pump Demand (kW)	New Demand Charge	Savings
Olaa #1 Wells A & B	202	$25,044	101	$12,423	$12,621
Olaa #2 Booster Pumps A & B	108	$13,300	54	$6,642	$6,658
Olaa #4 Booster Pumps A & B	65	$8,169	23	$2,829	$5,340
Olaa #5 Booster Pumps A & B	46	$5,758	29	$3,567	$2,191
Kalapana Wells A & B	140	$17,356	56	$6,888	$10,468
Keohepoko Wells A & B	266	$32,711	144	$17,712	$14,999
Panaewa 3rd Well Operation Panaewa 2nd Booster Operation	695	$162,529	397	$92,898	$69,631
Laupahoehoe Wells A & B	106	$13,063	66	$8,118	$4,945
Kalaoa Boosters A & B	42	$5,078	24	$2,952	$2,126
Kaloko Mauka #2 Boosters	48	$5,898	24	$2,952	$2,946
Kaloko Mauka #3 Boosters	44	$5,367	22	$2,706	$2,661
Haihai Boosters	97	$12,271	60	$7,380	$4,891
Keauhoa Boosters	71	$8,733	51	$6,273	$2,460
Total	**1930**	**$315,277**	**1051**	**$173,340**	**$141,937**

The operating strategy of the Olaa accounts are changing due to Olaa #6 well being on line and may not be an issue in the future.

Demand Savings are as follows:

Rate P: Panaewa Pump Systems 695 kW – 397 kW = 298 kW
Rate J: All other Stations: 1235 kW- 654 kW = 581 kW

Preliminary Cost Estimate

Minimal

Cost and Savings Summary

The cost and savings estimate for this measure is summarized below.

Annual Energy Savings (Rate J)	0 kWh	$0.34/kWh	$ 0
Annual Energy Savings (Rate P)	0 kWh	$0.28/kWh	$ 0
Annual Demand Savings (Rate J)	581 kW	$10.25/kW	$ 71,463
Annual Demand Savings (Rate P)	298 kW	$19.50/kW	$ 69,732
Total Energy Cost Savings			**$ 141,195**
Project Cost			**$ Minimal**
Hawaii Energy Funding			**N/A**
Simple Payback			**Immediate**

13.2.3 ESM #3 Optimize Existing Rider M Accounts

Description

We identified two stations that are curtailed for the 4-hour peak HELCO demand period that are not getting the full Rider M benefit. We recommend working with HELCO to determine how to make full use of the curtailment discount.

<u>Saddle Rd</u>

A 2-hour Rider M curtailment has been applied at this station and resulted in a credit of $5,166 in 2014. The monthly value is based on 118 kW * .40 * 10.25 = $484/month. We are unsure of why the value is 118 kW instead of the full 178 kW (178 kW measured during the site visit) that occurs when the pump is shut off.

To optimize the Rider M agreement at this station, we recommend evaluating if the well off time period can be extended to 4 hours to qualify for the additional savings and to adjust the contract to the actual demand of 178 kW. These adjustments would provide additional annual savings of $11,254.

<u>HOVE Well</u>

The HOVE well is shut down between 5:00 pm and 10:00 pm Monday through Friday due to HELCO electrical grid capacity. This coincides with the four-hour Rider M discount but the DWS does not have an agreement with HELCO to benefit from the operating practice, based on a pump power draw of approximately 136 kW, a Rider M rate would reduce annual costs by $12,550. As part of this measure, we recommend pursuing this agreement with HELCO.

Calculations

Noted above

Preliminary Cost Estimate

NA

Cost and Savings Summary

The cost and savings estimate for this measure is summarized below.

Total Cost Savings			**$ 23,804**
Project Cost			**$ Minimal**
Hawaii Energy Funding			**N/A**
Simple Payback			**Immediate**

13.2.4 ESM #4 Pursue Additional Rider M Accounts

Description

The HELCO Rate Schedule Rider M provides an energy use demand charge discount from the electric utility if specific pump loads can be curtailed during a four hour period from 5:00 pm until 9:00 pm, or over a two hour interval from 5:30 pm to 7:30 pm. This rider can be applied for pump systems that can be deactivated for a period of time, while utilizing water tank capacity to supply distribution needs. The DWS has applied this discount for many of the stations over the last 10 years. The savings realized for 2014 are shown below.

Table 13.9 Existing 2014 Rider M Savings

Month	Kalapana Wells	Piihonua Well C	Olaa #3 DW	Panaewa	Piihonua 3B	Saddle Rd	Paauilo Well	Parker Well #2	Hawi Well B
Jan	$1,056	$3,680	$1,774	$2,814	$2,481	-$8	$798	$4,244	$1,253
Feb	$1,062	$3,686	$1,769	$2,817	$2,478	$485	$783	$4,238	$1,213
Mar	$1,058	$3,677	$10	$2,586	$2,484	$485	$770	$4,251	$1,252
Apr	$1,065	$3,684	$4	$2,817	$4,290	$485	$752	$4,265	$1,215
May	$633	$3,683	$341	$2,595	$2,486	$485	$699	$4,259	$1,214
Jun	$1,070	$3,683	$1,770	$2,814	$2,355	$485	$713	$4,248	$1,249
Jul	$1,060	$3,690	$1,752	$1,746	$2,153	$485	$710	$4,275	$1,233
Aug	$505	$3,676	$1,801	$2,817	$1,956	$485	$709	$4,289	$1,227
Sep	$1,065	$3,686	$216	$2,634	$1,916	$485	$793	$4,304	$1,229
Oct	$1,065	$3,687	$217	$2,598	$1,511	$485	$270	$4,316	$1,231
Nov	$1,068	$3,681	$1	$2,814	$2,244	$323	$792	$4,314	$1,231
Dec	$1,083	$3,681	$2	$2,814	$2,244	$485	$792	$4,302	$1,251
Total	**$11,791**	**$44,195**	**$9,655**	**$31,865**	**$28,597**	**$5,166**	**$8,578**	**$51,305**	**$14,797**

The challenges for applying Rider M include the following:

- When a well is down for major repairs (which can last up to a year), there are no savings and the agreement expires.
- For the Kona area, multiple wells serve various parts of the distribution system. If one of the wells is down even for a short period of time, other wells that serve the same area have a harder time keeping up with demand.
- Control system timer issues also occur occasionally resulting in well operation during the curtailment period.

In the past, DWS and HELCO have worked together to qualify many of the pump stations for the Rider M rate. As part of discussions with staff we identified several additional pump stations that could be considered for the rate.

Calculations

The Rider M savings calculation is based on the actual monthly demand and unit cost of demand at the pump station multiplied by either 75% for the four-hour option or 40% for the two-hour option.

For example, a pump station on Rate Schedule J with a 312 kW demand that can be deactivated daily between 5:30 and 7:30 PM will have the following monthly credit applied to the bill:

$10.25/kW * 312 kW * 40% = $1,279

Based on 2014 operating hours and input from DWS staff, the following pump stations appear to be potential Rider M candidates.

Table 13.10 Proposed Stations with Potential Rider M Savings

Pump Station	2014 Percentage of Time Wells are On-line	Demand Curtailed (kW)	Cost/kW	Four or Two Hour Rider M Discount	Annual Savings
Olaa #6 Well	23%	511	$19.50	4 hour	$89,681
Keonepoko Wells	40%	120	$10.25	4 hour	$21,060
Waimea Well	100% (last 6 months)	541	$10.25	4 hour	$49,907
Parker Ranch	0% (last 6 months)	304	$19.50	4 hour	$53,352
Keopu Well	36%	366	$10.25	2 hour	$18,007
QLT DW	85%	510	$19.50	2 hour	$47,736
One Shaft Well	52%	232	$19.50	2 hour	$21,715
Total	**--**	**--**	**--**	**--**	**$301,458**

<u>Olaa #6 DW</u>

This well was put on line in 2014 and draws 511 kW. Over the last 4 months of the year, the well operated approximately 175 hours/month. With a one million gallon reservoir and low operating hours, this well would be ideal for a 4-hour curtailment. With this well on Rate Schedule P, it should be a high priority for investigating a Rider M agreement.

<u>Keonepoko Well</u>

We have recommended not operating both of the Keonepoko Wells together in ESM #2. After this is done, a 4 hour Rider M could be applied at the station. One well typically draws 120 kW.

<u>Parker Ranch/Waimea Well</u>

At this time, the DWS operates either one well or the other to supplement flow from the Waimea Treatment Plant. For this measure, we recommend operating both wells on a regular basis to qualify for Rider M (which requires that pump stations normally operate between 5:00 pm and 9:00 pm to qualify). Since the DWS is charged for peak demand at both stations every month, operating them together periodically will not change the energy costs significantly.

After this new operating mode is established, a Rider M agreement can be pursued for both stations.

Keopu Well

The Keopu well is activated at a 25’ level in the Keopu Tank and shuts off at 30’. Staff indicated that the future plan is to add a VFD and not use the well as often. If the DWS moves forward with the VFD project, it will become easier to adjust pump operation to qualify for Rider M while supplementing QLT. As long as the VFD is operated within an efficient range, the VFD should be cost effective.

Although a 4-hour curtailment may be possible, we have initially recommended a 2-hour interval to be sure it can be maintained.

QLT Well

With the QLT Well operated almost continuously in 2014, the well would not qualify for Rider M. However, based on discussions with staff, the QLT hours will be reduced as more wells come back on line. With this well on Rate Schedule P, it should be a high priority for investigating a Rider M agreement. For this well we have included the savings for a 2-hour curtailment.

Shaft Wells

With the Honokohau and Hualalai Wells down, the shaft pumps were used often in 2014. DWS staff indicated that a Rider M application would not be possible until more wells were on-line. Given that HELCO would be evaluating the pump system first to see if a third pump would operate enough hours to qualify for Rider M, this would be the best time to start the process. Based on past records, it looks like Rider M was previously tried at the station.

Savings included in ESM #3 is based on taking the third shaft pump off line for a two-hour period. The current tank level settings are noted below.

Pump #1: 15’ on, 18’ off
Pump #2: 14’ on, 18’ off
Pump #3: 13’ on and 18’ off

We recommend installing timers on all four pumps to provide flexibility for the operators to use other pumps if needed to alternate the Rider M designated pump.

Preliminary Cost Estimate

Item N°	Source	Description	Qty	Unit	Equipment Cost	Labor Cost	Total
1	--	Timers	11	LOT	$3,000	$3,000	$66,000
2	--	Misc Electrical Work	1	LOT	$10,000	$10,000	$20,000
				Subtotal			$86,000
				Contractor Overhead & Profit (20%)			$17,200
				Construction Contingency (10%)			$8,600
				Engineering & Project Management (15%)			$12,900
				Hawaii General Excise Tax (4.167%)			$5,196
				Total			**$129,896**

Cost and Savings Summary

The cost and savings estimate for this ESM is summarized below.

Total Energy Cost Savings			**$ 301,458**
Project Cost			**$ 129,896**
Hawaii Energy Funding			**TBD**
Simple Payback			**< 1 year**

13.2.5 ESM #5 VFDs for Back-up Pumps

Description

When variable speed drives (VSDs) are properly applied, they can provide energy savings by reducing the motor and pump speed to reduce the pump system dynamic head. For static head dominated systems such as deep wells, VSDs are not normally pursued since the smaller reduction in dynamic head will typically not yield significant savings.

The DWS has many wells that are used for backup to the primary wells designated for each system. When these back-up wells are required for several weeks during a primary well repair or when the well is tested to maintain water quality, the station is charged for the peak demand reached. This charge is carried forward for 11 months even if the well is not used.

The impact of these demand charges can be reduced with the application of variable speed drives that reduce the flow and power output of the well. Some of the DWS stations will immediately benefit from a VFD installation. For these stations, we have recommended installing VFDs as part of this measure. Although the energy savings (kWh) will be minimal due to the intermittent well use, using VFDs to operate the pumps at minimum flows when the well is tested periodically will provide long-term demand cost savings. When the well is required for short-term emergency service, if the VFD is used to maintain a lower flow for longer run times, this operating strategy will also minimize demand charges. Since this practice will be limited to short duration, the lower pump efficiency will not have a significant cost impact.

Calculations

Savings calculations for each well is shown below

Table 13.11: Proposed VFDs for Back-up Pumps

Pump Measurements / Calculations	Keei Well A	Keei Well B	Keei Well C	Olaa #1	Honomu	Papaikou
Existing Flow (gpm)	300	375	500	800	250	375
Existing Head (ft)	788	830	920	350	540	460
Motor Efficiency (%)	90%	90%	90%	90%	90%	90%
Pump Efficiency (%)	75%	75%	75%	75%	75%	75%
Current Average Monthly Demand (kW)	117	85	156	112	44	48
New Flow (gpm)	150	187.5	250	400	125	187.5
VFD Efficiency (%)	96%	96%	96%	96%	96%	96%
Pump Efficiency (%)	70%	70%	70%	70%	70%	70%
Reduced Head in feet	783	825	915	345	535	455
New Monthly Demand (kW)	37	48	71	43	21	27
Demand Savings	**80**	**37**	**85**	**69**	**23**	**21**

Table 13.12: Proposed VFDs for Back-up Pumps

Pump Measurements / Calculations	Kiaeie Mauka	Ookala Well	Haina	Honokaa	Ahualoa	Hawi Well A
Existing Flow (gpm)	100	230	373	300	753	790
Existing Head (ft)	1140	686	977	1434	1326	844
Motor Efficiency (%)	90%	90%	92%	89%	87%	91%
Pump Efficiency (%)	70%	56%	62%	71%	72%	77%
Current Average Monthly Demand (kW)	43	59	123	129	297	179
New Flow (gpm)	50	115	186.5	150	376.5	395
VFD Efficiency (%)	96%	96%	96%	96%	96%	96%
Pump Efficiency (%)	65%	51%	57%	66%	67%	72%
Reduced Head in feet	1135	681	972	1429	1321	839
New Monthly Demand (kW)	19	33	68	72	167	99
Demand Savings	**24**	**26**	**55**	**57**	**130**	**80**

Table 13.13: Proposed VFDs for Back-up Pumps

Pump Measurements / Calculations	Parker Ranch	Parker #3 Well	Kahaluu Well B	Keopu VFD
Existing Flow (gpm)	554	1254	700	629
Existing Head (ft)	1491	1305	915	1646
Motor Efficiency (%)	94%	89%	92%	89%
Pump Efficiency (%)	55%	78%	82%	60%
Current Average Monthly Demand (kW)	302	430	160	366
New Flow (gpm)	277	627	350	314.5
VFD Efficiency (%)	96%	96%	96%	96%
Pump Efficiency (%)	50%	73%	70%	55%
Reduced Head in feet	1486	1300	908	1641
New Monthly Demand (kW)	172	246	97	207
Demand Savings	**130**	**184**	**63**	**159**

Preliminary Cost Estimate

Item N°	Source	Description	Qty	Unit	Equipment Cost	Labor Cost	Total
1		500 hp, 2300 V VFD	1	EA	$130,000	$50,000	$180,000
2		400 hp, 2300 V VFD	2	EA	$100,000	$50,000	$300,000
3	--	350 hp, 2300 V VFD	1	EA	$100,000	$50,000	$150,000
4	--	200 hp, 480 V VFD	4	EA	$30,000	$10,000	$160,000
5	--	150 hp, 480 V VFD	1	EA	$20,000	$10,000	$30,000
6	--	100 hp, 480 V VFD	2	EA	$15,000	$5,000	$40,000
7		75 hp, 480 V VFD	1	EA	$10,000	$5,000	$15,000
8		60 hp, 480 V VFD	3	EA	$10,000	$5,000	$45,000
9	--	Misc Electrical Work	1	LOT	$50,000	$50,000	$100,000
				Subtotal			$1,020,000
				Contractor Overhead & Profit (20%)			$204,000
				Construction Contingency (10%)			$102,000
				Engineering & Project Management (15%)			$153,000
				Hawaii General Excise Tax (4.167%)			$61,630
				Total			**$1,540,630**

Cost and Savings Summary

The cost and savings estimate for this ECM is summarized below.

Annual Demand Savings (P)	260 kW	$19.50/kW	$ 60,840
Annual Demand Savings (J)	963 kW	$10.25/kW	$ 118,449
Total Energy Cost Savings			**$ 179,289**
Project Cost			**$1,540,630**
Hawaii Energy Funding			**TBD**
Simple Payback			**8.6 years**

13.3 Operational Measures

Operational measures are low cost improvements that can be made without a substantial capital investment.

13.3.1 OM #1 Investigate Maukaloa (Pepeekeo) Spring Flow Reduction

Description

The Pepeekeo water system (District 1 Hilo System) is supplied by the Maukaloa Spring (also called the Makea Spring) and Kulaimano Well #1 and Well #2. Based on input from DWS staff, this spring is suitable for use and does not have a surface water influence. In 1994 (only data available), the Maukaloa Spring had a capacity of 0.40 mgd (277 gpm). The operator indicated that a few years ago the source went dry and may have been diverted at a higher elevation. The spring was only used one month in 2012 and one month in 2013.

For this measure, we have recommended having DWS staff investigate this issue. If the spring can be restored back to its original flow, well energy use could be decreased significantly. DWS Staff has also indicated that corrosion control equipment would be required at Kulaimano Well #2 and at the tank site.

Calculations

With the spring off line, Kulaimano Well #1 and #2 total pumpage in 2014 was 53,769 kgal (102 gpm average flow). If the 1994 capacity could be restored, the flow could supply the system on a regular basis with minimal well operating hours. Based on the expectation that both wells would still have demand charges for periodic exercising, the following savings could be realized:

<u>Kulaimano Well #1:</u>

Energy (kWh) Cost: $240 (well down for most of the year)
Demand (kW) Cost: $7,815 (carryover kW from previous year)

<u>Kulaimano Well #2:</u>

Energy (kWh) Cost: 221,000 kWh ($77,000)
Demand (kW) Cost: $9,788

Savings after spring is restored: 221,000 kWh * 80% = 176,800 kWh

Preliminary Cost Estimate

We have estimated a cost of $40,000 for corrosion control equipment at the well and tank sites.

Cost and Savings Summary

The cost and savings estimate for this OM is summarized below.

Annual Energy Savings	176,800 kWh	$0.34/kWh	$ 60,112
Annual Demand Savings	0 kW	$10.25/kW	$ 0
Total Energy Cost Savings			**$ 60,112**
Project Cost			**$ 40,000**
Hawaii Energy Funding			**--**
Simple Payback			**< 1 year**

13.3.2 OM #2 Optimize Use of Waimea WTP Flow

Description

Current treatment at the Waimea Water Treatment Plant consists of flocculation, settling, and sand filtration. The water is also disinfected and treated for corrosion control. There is one in-ground, 4 mg reservoir for treated water, Reservoir No. 2 (also called the clearwell) before it flows to the distribution system. Water supplied from the Parker Ranch and Waimea Well is blended with treated surface water in the treatment plant clearwell prior to distribution to the water system.

The DWS is currently upgrading the sand filter system to a microfilter system that will use membrane filters to remove contaminants from water. After the plant upgrade, the existing average flow of 2.0 mgd is expected to increase to approximately 3.0 mgd. Although this flow will be limited due to the available intake water, it has the potential of reducing deep well energy costs in portions of South Kohala and Hamakua (District II).

DWS staff indicated that the coagulation, flocculation and settling system capacity may have difficulty handling the higher flows and that the intake stream sources may have issues that have resulted in a diminished flow. Given the significant savings presented in this measure, we have included working with a consultant to investigate these issues in EMP #4.

In 2014, the amount of flow supplied by the Waimea and Parker Ranch Wells averaged 0.89 mgd. The benefits of reducing run time for these two wells is the first step to maximize the energy savings that will be realized after the upgrade is complete.

The use of flow from the Waimea Treatment Plant for the Hamakua System also has the potential for significant savings. The potential savings for using treatment plant water to minimize use of the three wells and booster pumps would be approximately $320,000 annually (based on using Waimea Treatment Plant water 80% of the time). This does not include demand charges for each station, which would still be charged by HELCO since the wells would be exercised on a regular basis. These savings justify the cost of ammonia injection systems at the wells.

Calculations

The calculations shown below are based on the expectation that the well runtime (and flow) will be reduced by 80%. Savings do not include the annual $141,000 in demand costs since operating the wells periodically will maintain the same demand.

Table 13.14: Reducing Parker Ranch and Waimea Well Flow

Month	Parker Well Pumpage (kgal)	Waimea Well Pumpage (kgal)	Total Pumpage From Both Wells (kgal)	Expected Additional Flow (80% of well flow) After Waimea Upgrades (kgal)	Avg mgd/day that can be used from upgraded plant	Energy Saved (kWh) saved using average 9.1 kWh/kgal well cost
14-Jan	23,825	12,867	36,692	29,354	0.97	267,118
14-Feb	22,155	0	22,155	17,724	0.58	161,288
14-Mar	24,395	0	24,395	19,516	0.64	177,596
14-Apr	23,815	0	23,815	19,052	0.63	173,373
14-May	23,508	0	23,508	18,806	0.62	171,138
14-Jun	0	20,839	20,839	16,671	0.55	151,708
14-Jul	712	35,910	36,622	29,298	0.96	266,608
14-Aug	0	43,314	43,314	34,651	1.14	315,326
14-Sep	0	42,611	42,611	34,089	1.12	310,208
14-Oct	0	42,053	42,053	33,642	1.11	306,146
14-Nov	0	44,086	44,086	35,269	1.16	320,946
14-Dec	0	44,086	44,086	35,269	1.16	320,946
Totals/Avg	**118,410**	***238,544***	**404,176**	**323,341**	**0.89**	**2,942,401**

Table 13.15: Reducing Haina, Honokaa and Ahualoa Well Flow

Month	Haina Well Pumpage (kgal)	Honokaa Well Pumpage (kgal)	Ahualoa Well Pumpage (kgal)	Total Pumpage From Wells (kgal)	Avg mgd/day that can be used from upgraded plant	Energy Saved (kWh) saved using average 6 kWh/kgal well cost
14-Jan	6,330	0	10,459	16,789	0.55	100,734
14-Feb	5,963	0	9,631	15,594	0.51	93,564
14-Mar	6,310	0	11,913	18,223	0.60	109,338
14-Apr	6,558	0	9,000	15,558	0.51	93,348
14-May	2,928	0	0	2,928	0.10	17,568
14-Jun	0	0	0	0		0
14-Jul	0	0	0	0		0
14-Aug	0	0	0	0		0
14-Sep	0	0	0	0		0
14-Oct	0	13,917	0	13,917	0.46	83,502
14-Nov	0	12,960	0	12,960	0.43	77,760
14-Dec	0	12,960	0	12,960	0.43	77,760
Totals/Avg	**28,089**	**39,837**	**41,003**	**108,929**	**0.45**	**653,574**

<u>Parker Ranch and the Ahualoa Well (Rate Schedule P)</u>

Energy Savings from Tables 13.14 and 13.15 with a reduction of energy savings by 20% for reduced flow during drought periods:

1,077,531 kWh +246,018 kWh = 1,293,549 kWh * 80% = 1,034,839 kWh

Haina, Honokaa and Waimea Well (Rate Schedule J)

Energy Savings from Tables 13.15 with reduction of energy savings by 20% for reduced flow during drought periods:

168,534 kWh +239,022 kWh +2,170,750 kWh = 2,578,306 kWh * 80% = 2,062,644 kWh

Preliminary Cost Estimate

The installation of chloramination systems for both the Waimea and Parker Ranch Wells is already in progress as part of the capital improvement program. However these systems would also need to be added to the Haina, Honokaa and Ahualoa Wells to maximize the use of the available treatment plant flow.

The cost estimate does not include the existing improvement projects at the Waimea and Parker Pump Stations.

Item N°	Source	Description	Qty	Unit	Equipment Cost	Labor Cost	Total
1	--	Chloramination Systems	3	EA	$10,000	$10,000	$60,000
2	--	Misc Piping/Mechanical	1	LOT	$5,000	$5,000	$10,000
3	--	Misc Electrical	1	LOT	$5,000	$5,000	$10,000
				Subtotal			$80,000
				Contractor Overhead & Profit (20%)			$12,000
				Construction Contingency (10%)			$8,000
				Engineering & Project Management (15%)			$12,000
				Hawaii General Excise Tax (4.167%)			$4,667
				Total			**$116,667**

Cost and Savings Summary

The cost and savings estimate for this OM is summarized below.

Annual Energy Savings (Rate J)	1,034,839 kWh	$0.34/kWh	$ 251,845
Annual Energy Savings (Rate P)	2,062,644 kWh	$0.28/kWh	$ 577,540
Total Energy Cost Savings			**$ 829,385**
Project Cost			**$ 116,667**
Hawaii Energy Funding			**TBD**
Simple Payback			**< 1 year**

13.3.3 OM #3 Optimize Use of Hakalau Iki Spring

Description

The Hakalau water system (in Hilo System) is supplied by the Hakalau Well and the Hakalau Iki Spring. The Hakalau Well has a capacity of 50 gpm at 460' TDH and the Hakalau Iki Spring has a rated capacity of 180 gpm. Improvements were made to the spring intake box to prevent surface water influence.

In 2014, the well was used an average of 224 hours/month. Based on discussions with DWS staff, there is a possibility that the full capacity of the spring is not being utilized. Based on 2014 pumpage reports, and average of 9 gpm of spring water was used compared to 16 gpm of well water. It should be possible to reduce well use by at least 80% based on the 180-gpm capability of the spring. Optimizing usage of the spring may just require tank setpoint adjustments at minimal cost. Savings are summarized below.

Table 13.16: Hakalau Energy Use/Cost

Billing Date	Monthly Energy Use (kWh)	Measured Demand (kW)	Well Pumpage (kgal)	Spring Flow (kgal)	Energy Charge	Misc. Charges	Total Bill
1/4/14	2,463	11	595	417	$778	$324	$1,102
2/3/14	2,014	11	546	439	$636	$258	$894
3/4/14	2,034	11	645	467	$642	$274	$916
4/2/14	2,085	11	598	517	$659	$260	$918
5/2/14	2,081	11	774	568	$657	$260	$918
6/3/14	2,774	11	694	492	$876	$344	$1,220
7/2/14	2,338	11	722	697	$738	$321	$1,059
7/31/14	2,309	11	896	424	$729	$327	$1,056
9/2/14	3,275	11	844	492	$1,034	$447	$1,482
10/2/14	2,874	11	808	467	$908	$366	$1,274
11/1/14	2,769	11	645	419	$875	$342	$1,217
12/2/14	2,263	11	389	420	$715	$265	$980
Total/Avg	**29,279**	**11**	**8,161**	**5,819**	**$9,248**	**$3,789**	**$13,037**

Calculations

Since the well is on Rate Schedule G, there would be no peak demand penalty.
Total Energy: 29,729 kWh * 80% = 23,783 kWh
Total Energy Cost: $13,037 * 80% -$648 monthly services charge = $9,782

Cost and Savings Summary

The cost and savings estimate for this OM is summarized below.

Annual Energy Savings	23,783 kWh	$0.41/kWh	$ 9,782
Annual Demand Savings	N/A	N/A	$ 0
Total Energy Cost Savings			**$ 9,782**
Project Cost			**$ 0**
Hawaii Energy Funding			**--**
Simple Payback			**Immediate**

13.3.4 OM #4 Operate More Efficient Pumps

Description

For systems that have redundant booster pump systems or wells serving the same areas, we have recommended operating the most efficient wells to provide immediate savings until a well or booster pump can be improved.

Calculations

Pump systems identified for this measure include the following:

<u>Operate Kahaluu C as the lead pump instead of Kahaluu A (hours below expected in 2015).</u>

Kahaluu A: 167 kW * 8760 hours = 1,462,920 kWh
Kahaluu C 152 kW * 4380 hours = 665,760 kWh
Total: 2,128,680 kWh

Measured flow for both of the pumps was: 658 gpm

<u>Proposed Operational Plan</u>

Kahaluu A: 167 kW * 4380 hours = 731,460 kWh
Kahaluu C: 152 kW * 8760 hours = 1,331,520 kWh
Total: 2,062,980 kWh

Savings: 65,700 kWh

Karpovich Boosters: Operate Booster C more often than Booster A.

Table 13.17: Karpovich Energy Savings

Month	Monthly Energy Use (kWh)	Bstr A	Bstr B	Bstr C	Total Pumpage	kWh/1000 gallons	Bstr C kWh/1000 gallons
14-Jan	8,800	0	0	248	4,045	2.2	8,495
14-Feb	7,400	0	1	228	3,741	2	7,856
14-Mar	8,400	0	210	91	4,160	2	8,736
14-Apr		0	0	1	25		0
14-May							0
14-Jun	8,800	602	50	0	4,187	2.1	8,793
14-Jul	10,240	437	9	3	2,928	3.5	6,149
14-Aug	8,040	425	0	0	2,763	2.9	5,802
14-Sep	7,800	407	0	0	2,947	2.6	6,189
14-Oct	7,000	437	3	7	2,911	2.4	6,113
14-Nov	6,960	349	0	0	2,232	3.1	4,687
14-Dec	6,360	385	17	0	2,550	2.5	5,355
Totals/Avg	**95,680**	**3,463**	**838**	**577**	**39,057**	**2.4**	**68,174**
					Savings		**27,506**

Pahoa Well #1 and #2

Pahoa Well #1: 55 kW (rated for 200 gpm) * 0 hours = 0 kWh
Pahoa Well #2: 88 kW (rated for 350 gpm) * 808 hours = 71,104 kWh
Demand Cost: $11,880 (two pumps operated together in 2014 for short amount of time)
Total pumpage: 16,436,000

Proposed Pahoa Well #1 & #2 Operational Plan

Pahoa Well #1: 55 kW (rated for 200 gpm) * 1370 hours = 75,332 kWh
Pahoa Well #2: 88 kW (rated for 350 gpm) * 0 hours = 0 kWh
Demand Cost: $6,765 (two pumps operated together in 2014 for short amount of time)
Total pumpage: 16,436,000

Demand Savings: $5115
Extra energy consumption = - 4228 kWh

Aloha Booster Flow and Energy Use

Total pumpage: 82,779 kgal
Total energy: 179,318 kWh

Proposed Aloha Booster Operational Plan

Booster A: 17 kW (110 gpm) * 1315 hours = 22,355 kWh
Booster B: 22 kW (190 gpm) * 6500 hours = 143,000 kWh
Total pumpage: 82,779 kgal
Total energy: 165,355 kWh

Savings: 13,963 kWh

Keei #4 Flow & Energy Use

Total pumpage: 101,308 kgal
Total energy: 110,334 kWh

Proposed Keei #4 Booster Operational Plan

Booster A: 6.2 kW (100 gpm) * 100 hours = 620 kWh
Booster B: 18.8 kW (307 gpm) * 200 hours = 3,760 kWh
Booster C: 17.3 kW (324 gpm) * 5000 hours = 86,500 kWh
Total pumpage: ~101,000 kgal
Total energy: 90,880 kWh

Savings: 19,454 kWh

Cost and Savings Summary

The cost and savings estimate for this OM is summarized below.

Annual Energy Savings (Sch J)	105,432 kWh	$0.34/kWh	$ 35,847
Annual Demand Savings (Sch J)	41.6	$10.25	$ 5,115
Total Energy Cost Savings			**$ 40,962**
Project Cost			**$ 0**
Hawaii Energy Funding			**--**
Simple Payback			**Immediate**

13.4 Energy Conservation Measures

The recommendations discussed in this section are categorized as energy conservation measures or "ECMs" for projects that require a larger capital investment with simple paybacks exceeding one year.

13.4.1 ECM #1 Purchase Additional Leak Detection Loggers

Description

Since 2005, the DWS has made a substantial investment in leak detection equipment to reduce unaccounted for water. To begin the process the DWS contracted with Fluid Conservation Services (FCS) to perform a comprehensive Non-Revenue Water Loss Study of the Hilo area based on its high-unaccounted water figure. For the project, FCS installed over 625 PermaLog noise loggers throughout the City of Hilo in existing valve boxes. Using a patroller hand held device, information was retrieved from each PermaLogger and then uploaded and analysed to a software program to determine each suspected leak location. A technician then investigated each of these locations with a leak noise correlator to pinpoint the leak location. DWS staff repaired the identified leaks and savings were verified based on flow data and station energy use.

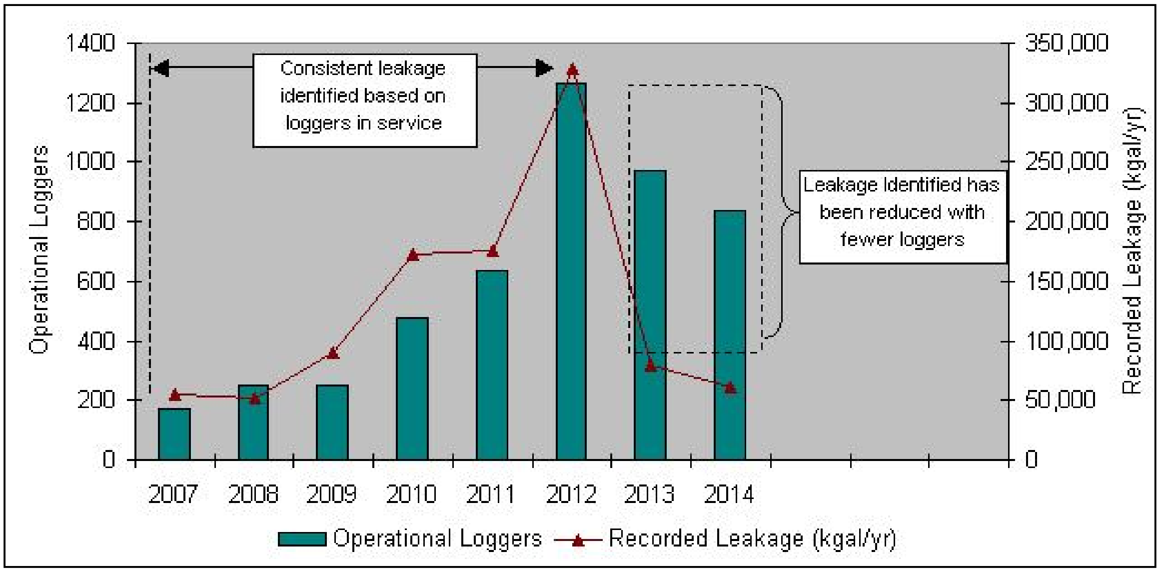
As shown in Table 13.18, this investment has resulted in over $840,000 in total savings. Based on an investment of almost 2 million dollars in loggers and piping repairs, the simple payback for the program has averaged 2.3 years since 2007.

Table 13.18: Leak Detection Program Loggers, Savings and Costs

Fiscal Year	Loggers Deployed	Loggers Removed	Loggers Net Operational	Recorded Leakage (Kgal/year)	Energy Savings	Allocated Cost for Repairs & Loggers	Simple Payback (yrs)	Savings/ Operational Logger
2007	325	153	172	55,061	$35,176	$165,283	4.7	$205
2008			249	51,385	$30,089	$204,082	6.8	$121
2009			249	89,722	$79,650	$312,216	3.9	$320
2010	225		474	172,185	$162,142	$263,326	1.6	$342
2011	164		638	175,855	$187,246	$263,005	1.4	$293
2012	625		1263	328,218	$183,364	$337,344	1.8	$145
2013		292	971	79,423	$68,594	$272,269	4.0	$71
2014		136	835	61,695	$94,389	$151,006	1.6	$113
Total/Avg	--	--	--	**1,013,544**	**$840,649**	**$1,968,530**	**2.3**	**$232**

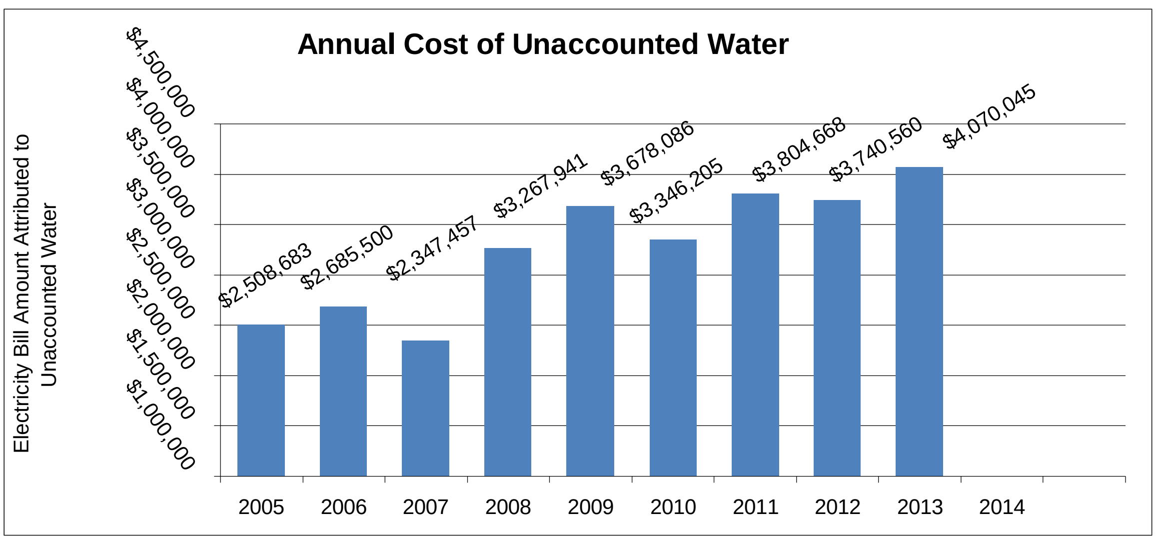
Although the program has been successful, the DWS has been challenged to provide enough funding to keep up with data logger deployment. As shown on the next page, the result has been a drop off in operational loggers and a reduction in recorded leakage and energy savings.

Figure 13.1: Annual Loggers and Recorded Leakage



With energy costs increasing, the annual cost of unaccounted water reached a record level of over four million dollars in 2013 as shown below.

Figure 13.2: Annual Cost of Unaccounted Water



<u>Past Permalogger Issues</u>
(*Summarized from Earl Fukunaga Notes)*

The original Permaloggers (Generation P-3's) were purchased in 2004 from Fluid Conservation Systems (FCS) and deployed in 2005. The units began to fail when the antennas had to be bent to accommodate setting the loggers in each valve box. FCS claimed it was reasonable to bend the antennas, which later resulted in logger failures associated with this generation. FCS recognized this error and a new batch of Permalog "P's" were replaced at a settled price of $100 each for the DWS.

In 2009 the Permalog "P" models started to fail before the three year warranty expired. These loggers exhibited failures beyond normal as many units started to fail as early as nine months after installation. After investigation, it was found that "double-labeling" occurred and that the loggers appeared to be refurbished units instead of new units. Fluid Conservation System denied these allegations and required sample loggers to be sent back. FCS did not admit that the failures of the Permalog 3 and P loggers could have been caused by older refurbished loggers and stated that the failures may have been from additional antenna leaks.

The decision to use Metrotech/Vivax Metro loggers and the N3 units was based on dependability, excellent service, simple battery replacement, and a "no-question" exchange for failed loggers. The DWS conducted a "pilot-study" with 30 Metro-loggers and found that the units lasted beyond their normal battery warranty of 7.5 years without any problems or leaks from the antenna connector points. Any non-performing Metrologgers were replaced at no-cost from the manufacturer.

The new N3 loggers have interchangeable batteries that can be replaced locally instead of sending the unit back to the service department on the mainland. This has been a huge cost benefit for the DWS by saving on downtime and freight expense to the mainland service department.

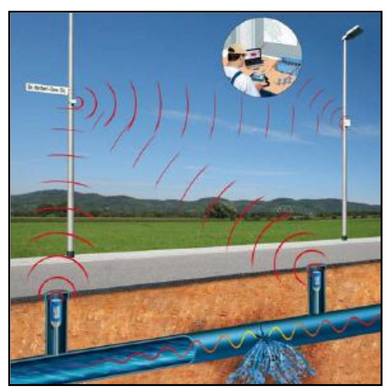
The quality and dependability of these units have been excellent through 7.5 years of tested service with only a .03% failure rate. The support and cooperation from the West Coast Manager and local dealer has been excellent and any problems or concerns have been addressed immediately (Mr. Dale Berryman (W.C.M.) and Mr. Harold Wong Jr., Wong's Service).

<u>Proposed New Equipment</u>

To continue the high level of savings realized in recent years, the DWS has proposed continuing their relationship with Metrotech/Vivax by investing in 575 additional loggers, leak detection equipment and additional training. A summary of the proposed equipment is as follows:

Sebalog Metro N3 Loggers & Antennas

The Sebalog N3 fixed loggers are essential to provide continuous leak monitoring and are capable of "filtering out ambient noise" for accurate data account of pipeline or breaks. Using these fixed loggers will help DWS staff to perform island wide patrol and leak surveys.



The logger extension antenna allows additional length for deep valve boxes and assists in improving the logger retrieval using the Sebalog Commander. The commander data retrieval improved from 5-6 minutes for a single N-3 data upload to 1-6 seconds by using the extension antennas. This is an important option that will increase the efficiency of the DWS Water Service Investigator by reducing patrolling and data retrieval man-hours.

Leak Detection Monitors

The HL-5000 Leak Detection Monitors are fundamental in pin-pointing exact or near-to-exact point of leak or leaks on pipeline. These units assist field personnel before excavating to reduce the man-hours involved for misplaced locations or “dry-holes”. Dry holes occur when the leak noise frequency may not always be at the highest frequency point since high pressure leak noise may travel and “resonate” at pipe hub or bends that create false points.

Correlating Sebalog Leak Loggers

The Sebalog “LogCorr” correlating leak loggers are essential for areas that have a main pipeline within traffic lanes or heavy vehicular traffic that impede good data from fixed loggers. Correlating loggers actually listen to leak noise “real-time” and give data to the investigator at “real-time” speed. This enables the investigator to analyze and pin point the location of a leak occurring without the need to analyze fixed logger data which is only for a specified time range (generally off-peak periods where ambient noises are at its lowest point). Correlating loggers can detect and pinpoint leak noises in “real-time” saving hours of analyzing and leak investigation time - especially in high traffic zones.

Savings Calculation

To estimate the potential energy savings for this investment, we used historical data to develop a savings/unit logger average value of 506 kWh or $192 (using 2013 unit cost of 0.38/kWh). Using this benchmark value, for the 575 proposed loggers a potential first year annual water savings of 120,138 kgal and energy savings of 290,950 kWh would be realized as summarized below.

Table 13.19: Leak Detection Program Loggers Savings

Fiscal Year	Operational Loggers Operational	Recorded Leakage (Kgal/year)	Energy Savings (kWh)	Energy Cost Savings	Energy Savings (kWh) / Logger	Cost Savings/ Operational Logger
2007	172	55,061	109,000	$35,176	634	$205
2008	249	51,385	85,968	$30,089	345	$121
2009	249	89,722	265,501	$79,650	1,066	$320
2010	474	172,185	523,037	$162,142	1,103	$342
2011	638	175,855	567,411	$187,246	889	$293
2012	1263	328,218	470,164	$183,364	372	$145
2013	971	79,423	185,391	$68,594	191	$71
2014	835	61,695	248,392	$94,389	297	$113
Total/Avg	**4,851**	**1,013,544**	**2,454,864**	**$840,649**	**506**	**$192***

*The average cost savings is based on the 2013 energy use rate.

To estimate project costs for the leak repairs, we calculated the cost using 145,413 kgal * $1.67 average leak repair cost/kgal = $242,840 based on the data below.

Table 13.20 Leak Detection Program Loggers Savings

Fiscal Year	Loggers Purchased	Recorded Leakage (Kgal/year)	Energy Savings (kWh)	Cost for Loggers/ Equipment	Cost for Repairs	Total Allocated Cost for Repairs & Loggers	First Year Repair Cost/1000 gallons saved
2007	325	55,061	109,000	$0	$165,283	$165,283	$3.00
2008	--	51,385	85,968	$28,875	$175,207	$204,082	$3.41
2009	--	89,722	265,501	$0	$312,216	$312,216	$3.48
2010	225	172,185	523,037	$84,375	$178,951	$263,326	$1.04
2011	164	175,855	567,411	$61,500	$201,505	$263,005	$1.15
2012	625	328,218	470,164	$62,500	$274,844	$337,344	$0.84
2013	--	79,423	185,391	$39,075	$233,194	$272,269	$2.94
2014	--	61,695	248,392	$0	$151,006	$151,006	$2.45
Total/Avg	**1,339**	**1,013,544**	**2,454,864**	**$276,325**	**$1,692,206**	**$1,968,531**	**$1.67**

As discussed, the proposed leak detection equipment will include loggers with extension antennas, leak detection monitors and a correlator unit. The individual component costs based on recent quotes obtained by the DWS is summarized below.

Preliminary Cost Estimate

Item N°	Source	Description	Qty	Unit	Equipment Cost	Labor Cost	Total
1	--	Metro Loggers N3	575	EA	$521	$0	$299,483
2	--	Logger Extension Antenna	575	EA	$115	$0	$65,884
3	--	Leak Detection Monitors	2	EA	$4,682	$0	$9,365
4	--	Metro/Vivax 3 Day Site Visits	6	EA	$0	$5,312	$31,872
5	--	Sebalog "LogCorr"Equipment	1	Lot	$20,833	$0	$20,833
				Subtotal			$427,436
				Contractor Overhead & Profit (15%)			$0
				Technical Assistance (10%)			$0
				Total with Mark-up			**$427,436**

Cost and Savings Summary

The cost and savings estimate for this measure is summarized below. We have also included the Hawaii Energy incentive that was approved in 2014.

Annual Energy Savings	290,950 kWh	$0.38/kWh	$110,561
Annual Demand Savings	N/A	N/A	$ 0
Total Energy Cost Savings			**$110,561**
Cost for Loggers & Equipment			$ 427,436
Estimated Cost for Repairs			$ 242,840
Total Project Cost			**$ 670,276**
Hawaii Energy Funding			**$135,000**
Simple Payback			**4.8 years**

13.4.2 ECM #2 Pump Efficiency Improvements

Description

The pump efficiency testing performed as part of this evaluation identified several pump systems with efficiencies lower than expected. Since the efficiency testing performed can only provide "total system efficiency" we were not able to determine if the reduced efficiency was due to other component issues.

Before recommending a specific improvement, we suggest that additional data be collected to verify the initial measurements, and to investigate if the pump had ever achieved the rated efficiency after installation was completed. After this has been researched, potential areas of improvement that should be reviewed include:

- Replacing pumps with more efficient units
- Rebuilding pumps or adjusting bowl clearances

The pumps that had the largest efficiency difference and had enough annual hours to make the project cost effective were included in this ECM.

Calculations

A summary of the test data and system efficiencies are shown below.

Table 13.21: Stations with Pump Efficiency Opportunities

Pump Measurements / Calculations	HOVE Well	Panaewa Well #1	Panaewa Well #2	Keopu Well
Total Flow (gpm)	100	1690	2182	629
Estimated Total Head (ft)	764	281	284	1646
Total Measured Power (kW)	136	124	175	366
Estimated VFD/Motor Efficiency (%)	60%	95%	95%	89%
Calculated Pump Efficiency	19%	76%	70%	60%
2014 Pump Hours	2107	7750	3898	3190
2014 Pump Energy Use (kWh)	286,552	961,000	682,150	1,167,540
Improved Pump Efficiency	70%	80%	80%	80%
Motor Efficiency	87%	95%	95%	89%
New Power Draw (kW)	24	118	154	274
New Energy Use (kWh)	50,568	912,273	598,749	873,846
Demand Savings (kW)	**112**	**6**	**21**	**92**
Energy Savings (kWh)	**235,984**	**48,727**	**83,401**	**293,694**
Rate Schedule	**J**	**P**	**P**	**J**

A sample calculation for the HOVE Well is shown below

$$\text{Pump kW} = \frac{100 \text{ gpm} * 764' * .746}{3960 * 70\% * 87\%} = 24 \text{ kW} * 2107 \text{ hours} = 50{,}568 \text{ kWh}$$

Table 13.22: Stations with Pump Efficiency Opportunities

Pump Measurements / Calculations	Waiaha Well	Keei Well D	Kaloko Mauka #1A	Kaloko Mauka #1A	Kaloko Mauka #2A	Kaloko Mauka #2B
Total Flow (gpm)	1327	974	116	131	103	147
Estimated Total Head (ft)	1529	1024	536	536	524	524
Total Measured Power (kW)	592	310	24	23	22	22
Estimated VFD/Motor Efficiency (%)	95%	91%	85	85	93	93
Calculated Pump Efficiency	68%	67%	58	68	50	71
2014 Pump Hours	3088	3714	2798	2976	2229	2232
2014 Pump Energy Use (kWh)	1,828,096	1,151,340	67,152	68,448	49,038	49,104
Improved Pump Efficiency	80%	80%	80%	80%	80%	80%
Motor Efficiency	95%	91%	91%	91%	91%	91%
New Power Draw (kW)	503	258	16	18	14	20
New Energy Use (kWh)	1,553,051	958,546	45,018	54,073	31,131	44,489
Demand Savings (kW)	**89**	**52**	**8**	**5**	**8**	**2**
Energy Savings (kWh)	**275,045**	**192,794**	**22,134**	**14,375**	**17,907**	**4,615**
Rate Schedule	**J**	**J**	**J**	**J**	**J**	**J**
Savings for Improving One Bstr Pump			**36,509**		**22,522**	

The HOVE well is the highest priority replacement at this time. The low 100-gpm limit is requiring the pump to operate far to the left of the best efficiency point (this is assumed to be the case and can be confirmed after the pump curve is received).

The remaining wells require a more detailed investigation that should include:

- Determine the original tested efficiency to see if the rated curve efficiency was ever achieved.
- Determine what Kona Wells will be the lead units after the repaired units are back on line. Savings versus costs should be re-evaluated for each pump with revised operating hours.
- Re-evaluate each pump unit based on age and past repairs to determine if the units should be refurbished or replaced.

Preliminary Cost Estimate

The costs below are placeholders until a specific plan is developed for each well.

Item N°	Source	Description	Qty	Unit	Equipment Cost	Labor Cost	Total
1	--	HOVE Well	1	EA	$100,000	$80,000	$180,000
2	--	Panaewa Well #1	1	EA	$120,000	$80,000	$200,000
3	--	Panaewa Well #2	1	EA	$120,000	$80,000	$200,000
4	--	Keopu Well	1	EA	$200,000	$100,000	$300,000
5	--	Waiaiha Well	1	EA	$200,000	$100,000	$300,000
6	--	Keei Well D	1	EA	$200,000	$100,000	$300,000
7	--	Kaloko Mauka #1	1	EA	$30,000	$10,000	$40,000
8	--	Kaloko Mauka #2	1	EA	$30,000	$10,000	$40,000
				Subtotal			$1,560,000
				Contractor Overhead & Profit (20%)			$234,000
				Construction Contingency (10%)			$35,100
				Engineering & Project Management (15%)			$5,265
				Hawaii General Excise Tax (4.167%)			$0
				Total			**$1,834,365**

Cost and Savings Summary

The cost and savings estimate for this ECM is summarized below.

Annual Energy Savings (Rate J)	1,078,682 kWh	$0.34/kWh	$ 366,752
Annual Energy Savings (Rate P)	132,128 kWh	$0.28/kWh	$ 36,996
Annual Demand Savings (Rate J)	361 kW	$10.25/kW	$ 44,403
Annual Demand Savings (Rate P)	27 kW	$19.50/kW	$ 6,318
Total Energy Cost Savings			**$ 454,469**
Project Cost			**$ 1,834,365**
Hawaii Energy Funding			**TBD**
Simple Payback			**4.0 years**

13.4.3 ECM #3 Replace Cla-Val Globe Valves with Ball/Butterfly Valves

Description

The DWS has replaced many of the old globe type Cla-Valves with Masoneilan and Pratt ball type valves, which have a pressure drop of less than 2 psi or 4.6' of head. During our review, we were able to measure the pressure loss across the Piihonua #3 Booster Pump B Cla-Val and found the loss to be 10 psi or 23.1'of head. Even though this project has been done at several stations, there are still many pump systems that have not been improved (including Booster Pump #2). Stations that we initially identified include:

- Panaewa Booster A
- Panaewa Booster B
- Panaewa Well #2
- Piihonua #3 Booster B

DWS staff has also been looking at high performance butterfly valves that are expected to be less maintenance intensive than the ball valves currently used. Either one of these valve types will provide approximately the same savings calculated below and have similar installation costs.

Calculations

Calculating the energy impact of the additional head loss can be estimated using the pump equation for each pump system using the head loss determined from sample measurements.

Average head loss reduction: 23.1' – 4.6' = 18.5'
Flow and efficiency data based on pump testing data.

<u>Panaewa Pumps (P)</u>

$$\text{Panaewa Bstr A kW savings} = \frac{1753\text{ gpm} * 18.5 * .746}{3960 * 94\% * 76\%} = 8.6\text{ kW}$$

2014 Annual hours: 3096 hours * 8.6 kW = 26,625 kWh

$$\text{Panaewa Bstr B kW savings} = \frac{1688\text{ gpm} * 18.5 * .746}{3960 * 94\% * 74\%} = 8.5\text{ kW}$$

2014 Annual hours: 3016 hours * 8.5 kW = 25,636 kWh

$$\text{Panaewa Well \#2 kW savings} = \frac{2182\text{ gpm} * 18.5 * .746}{3960 * 95\% * 70\%} = 11.4\text{ kW}$$

2014 Annual hours: 3898 hours * 11.4 kW = 44,437 kWh

Piihonua #3 Booster Pumps (J)

$$\text{Bstr \#1 kW savings} = \frac{1312 \text{ gpm} * 18.5 * .746}{3960 * 94\% * 72\%} = 6.8 \text{ kW}$$

2014 Annual hours: 1403 hours * 6.8 kW = 9,540 kWh

Preliminary Cost Estimate

Item N°	Source	Description	Qty	Unit	Equipment Cost	Labor Cost	Total
1	--	New Ball or Gate Valves	4	EA	$30,000	$4,000	$136,000
3	--	Misc Piping/Mechanical	1	LOT	$5,000	$5,000	$10,000
				Subtotal			$146,000
				Contractor Overhead & Profit (20%)			$21,900
				Construction Contingency (10%)			$14,600
				Engineering & Project Management (15%)			$21,900
				Hawaii General Excise Tax (4.167%)			$8,517
				Total			**$212,917**

Cost and Savings Summary

The cost and savings estimate for this ECM is summarized below.

Annual Energy Savings (Rate J)	9,540 kWh	$0.34/kWh	$ 3,244
Annual Energy Savings (Rate P)	96,698 kWh	$0.28/kWh	$ 27,072
Annual Demand Savings (Rate J)	6.8 kW	$10.25/kW	$ 836
Annual Demand Savings (Rate P)	28.5 kW	$19.50/kW	$ 6,669
Total Energy Cost Savings			**$ 37,821**
Project Cost			**$212,917**
Hawaii Energy Funding			**TBD**
Simple Payback			**5.6 years**

13.4.4 ECM #4 Replace Old Flow Meters & Strainers

Description

The DWS has installed new magnetic flow meters (virtually no head loss) at many of the pump stations in place of turbine meters and in-line strainers that are used for meter protection. During our site visit we were able to measure head loss for one of the strainers (Panaewa Well #1) which had a pressure drop of 3 psi (6.9’). Even though the DWS has replaced many of these flow meters/strainers, there are still multiple pump systems that have not been improved (including Panaewa Well #1). Stations that were identified include:

- Panaewa Well #1 (this well has a new flow meter but the strainer is still in service)
- Parker Well #2
- Lalamilo Wells B & C
- Piihonua #3 Booster B
- Keei Well D

Calculations

Calculating the energy impact of the additional head loss was estimated using the pump equation and the following assumptions:

- Average head loss reduction: 6.9’
- Flow and efficiency data based on pump testing
- Pump run time based on 2014 hours

Panaewa Well #1 kW savings = $\frac{1690 \text{ gpm} * 6.9 * .746}{3960 * 95\% * 76\%}$ = 3.0 kW * 7750 hours = 23,250 kWh (P)

Parker Well #2 kW savings = $\frac{1071 \text{ gpm} * 6.9 * .746}{3960 * 89\% * 72\%}$ = 2.2 kW * 7121 hours = 15,666 kWh (P)

Lalamilo Well B kW savings = $\frac{900 \text{ gpm} * 6.9 * .746}{3960 * 94\% * 72\%}$ = 1.7 kW * 1213 hours = 2,062 kWh (P)

Lalamilo Well C kW savings = $\frac{952 \text{ gpm} * 6.9 * .746}{3960 * 94\% * 77\%}$ = 1.7 kW * 1280 hours = 2,176 kWh (P)

Piihonua #3 Bstr B kW savings = $\frac{1429 \text{ gpm} * 6.9 * .746}{3960 * 94\% * 72\%}$ = 2.7 kW * 1987 hours = 5,365 kWh (J)

Keei Well D kW savings = $\frac{974 \text{ gpm} * 6.9 * .746}{3960 * 91\% * 67\%}$ = 2.1 kW * 3714 hours = 7,799 kWh (J)

Total Schedule J Demand Savings: 4.8 kW
Total Schedule P Demand Savings: 8.6 kW

Total Schedule J Energy Savings: 13,164 kWh
Total Schedule P Energy Savings: 43,154 kWh

Preliminary Cost Estimate

The cost estimate does not include the flow meter already installed for Panaewa Well #1.

Item N°	Source	Description	Qty	Unit	Equipment Cost	Labor Cost	Total
1	--	New Flow Meters	5	EA	$8,000	$4,000	$60,000
2	--	Misc Piping/Mechanical	1	LOT	$5,000	$5,000	$10,000
				Subtotal			$70,000
				Contractor Overhead & Profit (20%)			$10,500
				Construction Contingency (10%)			$7,000
				Engineering & Project Management (15%)			$10,500
				Hawaii General Excise Tax (4.167%)			$4,084
				Total			**$102,084**

Cost and Savings Summary

The cost and savings estimate for this ECM is summarized below.

Annual Energy Savings (Rate J)	13,164 kWh	$0.34/kWh	$ 4,476
Annual Energy Savings (Rate P)	43,154 kWh	$0.28/kWh	$ 12,083
Annual Demand Savings (Rate J)	4.8 kW	$10.25/kW	$ 590
Annual Demand Savings (Rate P)	8.6 kW	$19.50/kW	$ 2,012
Total Energy Cost Savings			**$ 19,161**
Project Cost			**$ 102,084**
Hawaii Energy Funding			**TBD**
Simple Payback			**5.3 years**

13.4.5 ECM #5 Downsize Halekii Pump to Improve Efficiency

Description

The pump efficiency of the Halekii Well could be improved by downsizing the pump to allow the unit to operate further up the system curve closer to the best efficiency point.

The well includes a 600 hp submersible well equipped with a six pulse Centrilift VFD rated to pump 1400 gpm @ 1320’ TDH. In 2014 the Halekii Well operated continuously to provide an average flow of 563 gpm to the South Kona System. The VFD allows the well flow to vary based on system demand between 56 Hz and 60 Hz, operating the pump at 40% of the pump rated flow has resulted in a lower overall pump efficiency due to the high system static head.

During our site visit, we collected pump flow; pressure and kW data at three VFD speeds to calculate pump efficiency. This data is summarized below.

Table 13.23: Halekii Field Data

Pump Measurements / Calculations	60 Hz	58 Hz	56 Hz
Total Flow (gpm)	1087	707	275
Discharge Pressure (psi)	6.4	5.6	5.2
Baseline Ground Elevation (ft)	1747	1747	1747
Tank Water Level Elevation (ft)	1763	1763	1763
Well Depth to Baseline (ft)	1300	1300	1300
Static Head (ft)	1316	1316	1316
Gauge Height from Baseline (ft)	2	2	2
Estimated Column/Velocity Losses (ft) 1ft/100ft	13	13	13
Estimated Total Head (ft): P * 2.31 + well depth + losses)	1330	1328	1327
Total Measured Power (kW)	438	327	245
Estimated Motor Efficiency (%)	93%	93%	93%
Estimated VFD Efficiency (%)	95%	94%	93%
Calculated Pump Efficiency	**70%**	**63%**	**32%**

The data is shown on the pump curve in Figure 13.3 (speed curves are based on the flow data).

Figure 13.3 Halekii Pump Curve

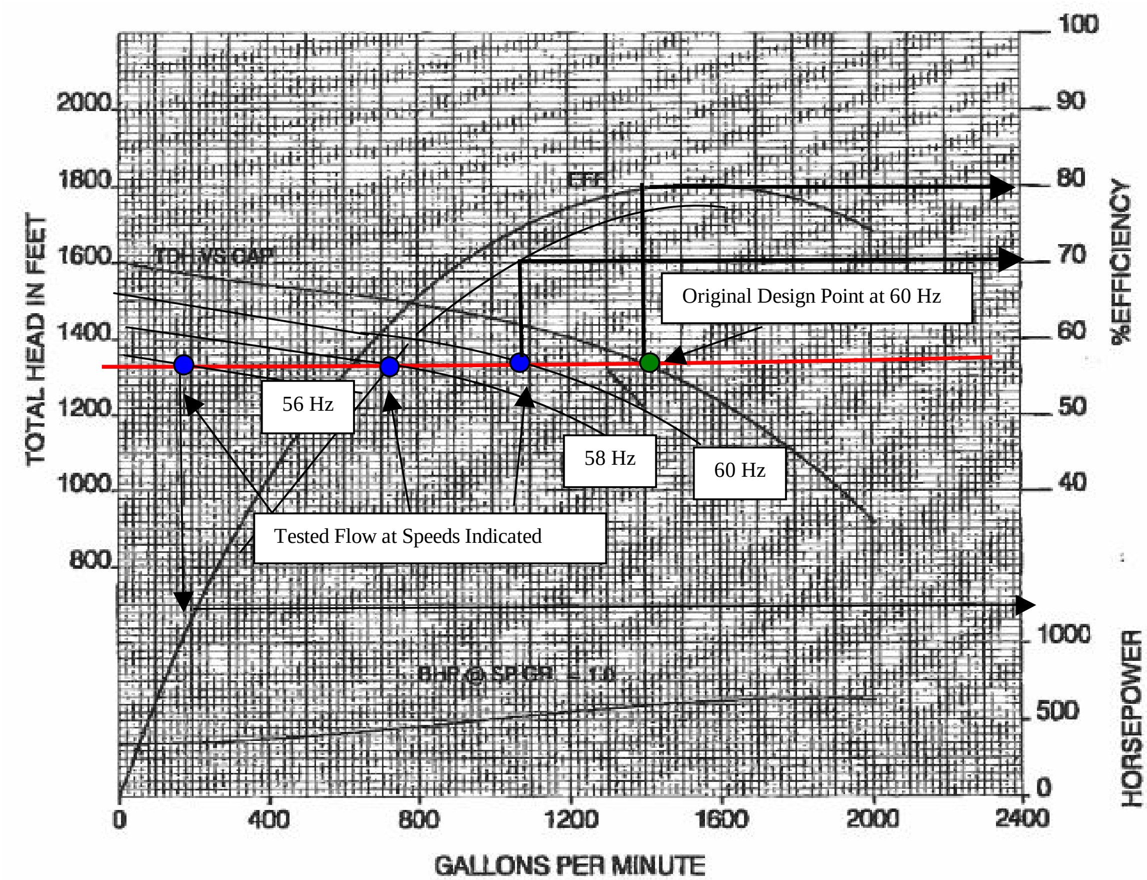


Table 13.24: Halekii Well Data

Month	Total kWh	Monthly Net Bill	Total Well Hours	Total Pumpage (kgal)	Average GPM	kWh/kgal	Cost/kgal	Average kW	Pump Efficiency
Jan-14	280,640	$98,500	767	29,845	648	9.4	3.3	366	53%
Feb-14	240,320	$85,307	672	25,153	624	9.6	3.4	358	52%
Mar-14	240,000	$85,518	744	28,169	631	8.5	3.0	323	58%
Apr-14	240,960	$84,388	724	29,030	669	8.3	2.9	333	60%
May-14	265,840	$92,555	716	21,713	505	12.2	4.3	371	40%
Jun-14	223,920	$81,001	746	22,319	499	10.0	3.6	300	49%
Jul-14	246,080	$90,034	772	25,809	558	9.5	3.5	319	52%
Aug-14	229,440	$85,497	712	23,602	552	9.7	3.6	322	51%
Sep-14	242,720	$89,066	717	25,129	584	9.7	3.5	338	51%
Oct-14	256,480	$91,272	730	22,669	517	11.3	4.0	351	44%
Nov-14	210,480	$75,365	717	20,912	486	10.1	3.6	294	49%
Dec-14	223,760	$77,026	717	20,912	486	10.7	3.7	312	46%
Totals/Avg	**2,900,640**	**$1,035,529**	**8733**	**295,262**	**563**	**9.9**	**3.5**	**332**	**50%**

The average pump flow in 2014 was 563 gpm, which has resulted in an average pump efficiency of 50.3%. If the pump is downsized from 1400 gpm @ 1320 ft TDH to 800 gpm @ 1320’ TDH, the pump will be able to maintain a higher efficiency at the 563 gpm average flow rate without shutting the pump down.

Calculations

The manufacture will need to be contacted to provide a better estimate of how pump efficiency will change with a downsized (or smaller) pump. But if the efficiency can be improved from the existing 50% value to 60%, the following kWh savings would be realized.

$$kW = \frac{563 \text{ gpm} * 1315 \text{ ft} * .746}{3960 * 60\% * 94\% * 93\%} = 266 \text{ kW}$$

266 kW * 8760 hours = 2,330,160 kWh

Demand savings would be based on the new peak flow of 800 gpm @ 1320 ‘ TDH using a conservative efficiency of 70% as shown below.

$$kW = \frac{800 \text{ gpm} * 1320 \text{ ft} * .746}{3960 * 70\% * 94\% * 93\%} = 325 \text{ kW}$$

To calculate savings we started with the existing 2014 pump system energy use shown below for the existing baseline.

Table 13.25: Existing Halekii Energy Data

Month	Total kWhs	Measured Demand (kW)	Billed Demand (kW)	Demand Charge	Energy Charge	Misc Charges	Total Bill
Jan-14	280,640	477	479	$9,331	$61,231	$27,938	$98,500
Feb-14	240,320	476	478	$9,321	$52,434	$23,552	$85,307
Mar-14	240,000	475	478	$9,315	$52,364	$23,839	$85,518
Apr-14	240,960	475	478	$9,313	$52,574	$22,501	$84,388
May-14	265,840	473	477	$9,300	$58,002	$25,254	$92,555
Jun-14	223,920	474	477	$9,305	$48,856	$22,840	$81,001
Jul-14	246,080	473	477	$9,294	$53,691	$27,049	$90,034
Aug-14	229,440	482	482	$9,395	$50,060	$26,042	$85,497
Sep-14	242,720	472	477	$9,303	$52,958	$26,805	$89,066
Oct-14	256,480	482	482	$9,403	$55,960	$25,910	$91,272
Nov-14	210,480	476	479	$9,342	$45,923	$20,100	$75,365
Dec-14	223,760	460	471	$9,185	$48,821	$19,021	$77,026
Totals/Avg	**2,900,640**	**475**	**478**	**$111,807**	**$632,873**	**$290,849**	**$1,035,529**

Energy Savings: 2,900,640 kWh – 2,330,160 kWh = 570,480 kWh
Demand Savings: 478 kW – 325 kW = 153 kW

Preliminary Cost Estimate

A preliminary cost estimate for the project is shown below. The cost will vary depending on if the existing pump can be modified or if a new pump/motor is needed.

Item N°	Source	Description	Qty	Unit	Equipment Cost	Labor Cost	Total
1	--	New Pump & Motor	1	EA	$200,000	$100,000	$300,000
				Subtotal			$300,000
				Contractor Overhead & Profit (20%)			$45,000
				Construction Contingency (10%)			$30,000
				Engineering & Project Management (15%)			$45,000
				Hawaii General Excise Tax (4.167%)			$17,501
				Total			**$437,501**

Cost and Savings Summary

The cost and savings estimate for this measure is summarized below.

Annual Energy Savings	570,480 kWh	$0.30/kWh	$ 171,144
Annual Demand Savings	153 kW	$19.50/kW	$ 35,802
Total Energy Cost Savings			**$ 206,946**
Project Cost			**$ 437,501**
Hawaii Energy Funding			**TBD**
Simple Payback			**2.1 years**

13.4.6 ECM#6 Replace Old Halekii VFD

Description

The Halekii Deep Well is equipped with an older Centrilift VFD. We were not able to get the specifications to confirm the type of drive but we suspect that it's a voltage source inverter type drive based on the low power factor (86%).

The DWS has already purchased a new Robicon VFD that is on site and ready to be installed so installation costs would be the only expense at this time.

Calculations

The higher power factor of the new drive will avoid the $900 penalty charged in 2014 and provide the DWS with a credit of $7,447 for a total benefit of $8,356.

Preliminary Cost Estimate

Pricing is based on DWS Electricians doing a portion of the work.

Item N°	Source	Description	Qty	Unit	Equipment Cost	Labor Cost	Total
1	--	VFD Installation Work	1	LOT	$10,000	$10,000	$20,000
				Subtotal			$20,000
				Contractor Overhead & Profit (20%)			$4,000
				Construction Contingency (10%)			$2,000
				Engineering & Project Management (15%)			$3,000
				Hawaii General Excise Tax (4.167%)			$833
				Total			**$29,833**

Cost and Savings Summary

The cost and savings estimate for this ECM is summarized below.

Total Cost Savings			**$ 8,356**
Project Cost			**$ 29,833**
Hawaii Energy Funding			**TBD**
Simple Payback			**3.6 years**

13.5 Future Energy Measures

The recommendations discussed in this section are categorized as future energy measures or "FEMs" for projects that are either not cost effective based on 2014 energy data, or that require more research to evaluate the measure cost effectiveness.

13.5.1 FEM #1 Consider Larger Storage Tanks

Description

The effective use of water available in the system storage tanks is based on a number of factors including fire flow, adequate pressure for high elevation services and sufficient turnover for water quality. In regards to energy costs, using the maximum storage available allows staff to curtail operation of select pump stations between 5:00 and 9:00 pm to take advantage of the utility Rider M rate schedule to decrease energy costs.

An evaluation was performed in June 2006 by RW Beck (*Titled: 20 year Master Plan*) to determine potential benefits and trade-offs between two strategies for providing storage capacity. The evaluation reviewed the potential of building larger reservoirs to allow the DWS to refill reservoirs at night, to take advantage of lower off-peak electricity prices.

Capital construction costs and pumping costs were determined to be the significant factors when comparing small and large storage facilities for the following scenarios.

1. Construction of larger storage facilities and pump stations capable of refilling the reservoirs during off-peak periods for electricity rates (10 hours/day during the night).
2. Construction of minimum storage capacity required to meet storage needs with pump operation similar to existing installations.

The evaluation results indicate that the total costs (including capital and pumping costs) are of similar magnitude for the two scenarios. The higher capital costs of putting in a larger reservoir are offset in the long term by decreased pumping costs (with breakeven results). This review was based on a generalized case and was not applied to specific reservoir site.

We recommend using the RW Beck example as a guide to evaluate future tank size decisions to reduce system energy costs.

13.5.2 FEM #2 Investigate Additional Hydro Generation Sites

Description

The DWS has installed hydro generation systems at three sites in the water distribution system. The sites were chosen based on consistent flow & pressure and a suitable piping configuration for installing the hydro unit. A summary of the sites and energy generation over the last five years is shown below.

Table 13.26: DWS Hydro Turbine Projects

Hydro Turbine Site	Years Data Collected	Average Energy Generated (kWh)	Average Annual Cost Value of Energy	Revenue Unit Cost/kWh	Project Cost	DOE Grant Funding	Adjusted Simple Payback
Waimea Treatment Plant	5	60,752	$16,960	$0.28/kWh	$200,000	--	11.8
Kaloko Tank	5	139,300	$22,133	$0.16/kWh	$400,000	$200,000	9.0
Kahaluu Shaft	1	105,430	$30,030	$0.28/kWH	$560,000	$280,000	9.3
Total	**--**	**305,482**	**$69,123**	**--**	**$1,200,000**	**$480,000**	**--**

* The above costs do not include $12,000 in annual maintenance costs for the Kaloko and Kahaluu Shaft units.

Although the hydro turbine cost/benefit may not support additional hydro turbine projects unless DOE funding is available, we believe a more detailed review is needed to understand why the original energy/cost projections changed from the initial estimates. If the up front costs can be reduced and the cost/energy production risk is transferred to a third party, we believe future projects could still provide value to the DWS.

According to Soar Technologies (the original hydro turbine supplier), the following sites would be worthwhile considering for additional hydro turbine projects.

- Kaloko #1 Tank
- Palani System (just before the new transmission line enters Tank #2)
- Lalamilo/Parker Site

A proposal has been started for the Lalamilo site, which appears to have the greatest potential.

13.5.3 FEM #3 Evaluate Potential Savings for Combining Piihonua #3 Accounts

Description

A measure that will require additional investigation is to combine the Well A/Booster A electric account with the Well B/Booster B account. This improvement would require electrical system changes and discussions with HELCO to evaluate the most cost effective approach. The change would increase the demand high enough to qualify for Rate Schedule P, which would reduce overall cost/kWh even though demand charges will be higher. Rider M could still be applied as it is now for Well B/Booster B.

SECTION 14. PROJECT IMPLEMENTATION

The projects identified in this report were chosen based on the expectation that the investment in design, new equipment and installation work would be offset by savings to provide a reasonable return on investment (ROI). For Hawaii, high-energy costs provided an excellent opportunity for savings, however the cost of equipment, installation work and financing fees are the critical factor to determine if the projects presented will be cost effective.

14.1 Project Delivery

In this section we will be reviewing several methods for project delivery that include:

- Developing projects with in-house resources
- The traditional Design-Bid-Construct Method
- Design-Build
- Performance Contracting

For any of the above project delivery options, it is critical that an experienced project developer is part of the effort to help determine how the project can be pursued in the most effective manner. For many projects, a combination of the above methods are used based on the skills available in-house, the ability for the equipment supplier to “package projects”, and the needs for project financing and savings.

14.1.1 Developing Projects with In-House Resources

The DWS has very capable staff that could do a majority of the work proposed in this report. If the staff is motivated and willing to dedicate a team of individuals to “special projects”, project costs can be reduced considerably, and staff would be able to get first-hand experience working with the equipment during the construction phase. They also would have the opportunity to make adjustments during the implementation phase to make the project more “operator friendly”.

There are many case studies throughout the country where water department staff has taken on projects using in-house staff and saved a considerable amount on installation costs. Often times a project that was too costly initially, proved to be very cost effective after project costs were reduced using in-house staff for a portion of the work.

The disadvantages of using in-house resources include non-performance of work due to competing maintenance and operational responsibilities, inexperience performing the work, and project delays that are critical when lost savings are a factor. Some of these problems can be avoided if a dedicated team is created, or if specific tasks are assigned during the project planning phase.

14.1.2 Traditional Design-Bid-Construct

This is the traditional approach that many municipalities pursue. It includes the following steps:

- Assembling an engineering RFP
- Selecting a consultant engineer
- Putting together formal plans, specifications and cost estimate

- Application for financing through issuing a bond
- Bidding the project
- Selecting a contractor
- Construction management services
- Commissioning project

This process can take several years and typically results in higher costs, since the engineer includes a level of conservatism in the project and lost savings that could have been realized sooner with a faster project development process. The project may also be delayed until capital funds are available for the project. Energy projects initially identified as cost effective often do not survive when this project delivery approach is selected. Typically this is due to the recommendation for redundant equipment and a conservative design approach that drives costs up. For this method, there is no guarantee that the project cost will come close to the engineer's estimate, and no savings guarantee is provided.

14.1.3 Design-Build

The design-build approach is typically a "fast-track" approach since the selection of designer and contractor is done at the same time. The selection of a design/build team provides sole source responsibility for the project. However, preliminary design work still must be done to provide biddable performance criteria for the design builders. It typically includes the following steps:

- Assembling an engineering RFP
- Selecting a consultant engineer for prelim engineering
- Putting together 30% set of plans, specifications and cost estimate
- Application for financing through issuing a bond
- Bidding the project to design/builders
- Selecting a contractor
- Commissioning project

Engineer-led design build teams instead of contractor-led teams may provide a better choice to ensure the design intent is not compromised. This project delivery method does not speed up the process significantly if capital funds are not available. However, the owner does benefit from a guaranteed cost estimate and sole source responsibility. No savings guarantee is provided for this method.

14.1.4 Performance Contracting

In 1987, the Energy Division of the State of Hawaii Department of Business, Economic Development, and Tourism (DBEDT) examined the existing state procurement and contracting regulations to determine what revisions would be needed to permit the performance contracting procurement process. Based on this review, legislation was introduced to amend HRS 36-41 to define performance contracting and to encourage state agencies to develop energy projects through this process. Since that time, many performance contracts have been successfully developed in Hawaii resulting in millions of dollars in energy savings.

The performance contracting approach combines the sole source responsibility of design-build with the additional benefit of a savings guarantee and financing. These features include the following:

1. The single procurement process is used to purchase a complete package of services in which the performance contractor is accountable for design, purchase, installation and often long term maintenance.
2. The package of services includes structuring project financing for all project costs.
3. The energy performance contract includes guaranteed savings by the performance contractor. Since payments to the contractor are contingent on the savings achieved, it is in the performance contractor's interest to maximize savings.

Performance contracting offers a number of important benefits. First, it allows facilities to go ahead with projects that tight budgets would otherwise prevent. The performance contractor arranges financing for the entire project cost, including up-front engineering and construction costs, allowing projects to proceed without capital improvement or repair funds. The facility receives new and improved equipment, and the cost of this equipment is offset by reduced O&M costs. After the equipment cost has been paid off, the facility owns the equipment and retains all of the savings from reduced utility bills. Even if the payments to the performance contractor offset much of the energy savings in the short run, upgrading equipment allows all of the non-energy benefits, such as improved system operation, to be realized immediately.

The steps to pursue a performance contract typically include the following:

- Assemble a performance contract RFP.
- Select a performance contractor and sign an Energy Services Agreement that commits the Owner to a cost effectiveness criterion. If the performance contractor is not able to meet these criteria, the Owner pays no fee.
- Performance contractor submits a technical proposal that includes a preliminary design, a guaranteed project cost, financing proposal and a savings guarantee. If agreeable, the Owner signs a design/build contract, a financing agreement with a leasing company, and a guaranteed savings contract with the performance contractor.
- The financing company holds the total project funding in an escrow account that can be drawn on (as approved by the Owner) when the performance contractor begins work.
- When construction is complete, the performance contractor is paid for the project cost (with retainage held), the savings are verified and the savings guarantee contract begins.
- The performance contractor verifies savings on a regular basis and submits a report to the Owner. If the savings are less that the guaranteed amount, the performance contractor must attempt to adjust equipment operation to achieve the savings or is obligated to compensate the Owner to make up the savings difference.

In the past, the majority of performance contracts were either structured as a "shared savings contract", or as a "guaranteed savings contract". The shared savings contract was typically financed by a performance contractor and as savings are realized, an agreed upon percent of savings was given to the performance contractor. Although these types of contracts appear to be simple, they were usually more expensive since the performance contractor assumed more risk. The "guaranteed savings contract" is now the favored approach for performance contractors since they assume the role of arranging financing, instead of actually providing it. Municipalities often select this method, since it can be structured as a tax-exempt municipal lease, which offers a low financing rate and does not show up as a liability on the municipality's balance sheet.

Performance contracting streamlines the purchasing process for efficiency projects, reducing the cost and time required to bring cost-saving projects on line. A single company takes responsibility for designing, building, financing and maintaining all necessary improvements. The performance contractor employs a team of consultants and subcontractors to accomplish this, but one company is still accountable for the ultimate success of the project. Streamlining the procurement process in this way makes it possible for facilities to implement more comprehensive projects, reduces the time and cost to manage projects, and gives on-site facility staff the opportunity for input into the project design.

14.1.5 Recommended Approach

We recommend a combination of the above approaches to optimize the potential of developing a performance related project for the County. Our approach is based on working with performance contractors at several facilities and recent experiences by water and wastewater agencies that could not successfully apply the performance contracting concept due to insufficient data to back-up project savings. To prevent this shortcoming for the DWS, we recommend including the following strategies:

- Develop a baseline for the performance contractor to reduce up-front costs, and reduce the uncertainty of quantifying savings (this report could serve as the initial baseline).
- Identify acceptable methods for energy savings calculations.
- Identifying reasonable maintenance savings that can be included in analysis.
- Use an "open-book" performance contracting method previously used by the County of Hawaii.
- Identify suppliers and project "integrators" that simplify on-site installation costs and reduce pricing risk for the performance contractor.
- Identify tasks that the DWS will be responsible for.

The data in this report is a starting point that will help the performance contractor develop their proposal.

14.2 Project Financing

In the event that capital budget funds are not available to pay for the proposed energy projects, several options exist for project financing. These include:

- General Obligation Bond
- Commercial Loan
- Municipal Lease Arrangement
  -Capital Lease
  -Operating Lease
- Private financing

The general obligation bond is the most common method used by municipalities to finance capital projects. The process is often long and complicated, but interest rates can be low. The municipality often waits for enough capital projects to be identified before initiating this process. For an energy related project, this means lost savings that will not be realized until financing is in place.

A commercial loan from a conventional bank may also be an option, however this type of debt appears on the County's balance sheet affecting future borrowing capabilities. Compared to municipal tax-exempt lease financing, this approach is not as cost effective.

Municipal leases are the favored approach to finance equipment related projects for many state and local governments. Municipal leases are available only to entities that can take advantage of tax-exempt financing. Municipal leases are typically used for projects under 5 million.

The two types of municipal leases include a capital lease and an operating lease. The differences between the two are discussed below.

With a capital lease the County essentially owns the equipment and has the option of purchasing the equipment at the end of the lease term. The County simply makes regular payments to a leasing company for the term of the project. The capital lease will appear on the County's balance sheet as both an asset and a liability.

An operating lease has the advantage of shifting the assets from the County to the leasing firm and appears as a periodic expense on the income statement instead of a liability. This lease arrangement is typically more expensive than a capital lease. The leasing company retains ownership of the equipment and at the end of the lease, the County has the option to take title of the equipment, based on the fair market value of the equipment, rather than at a price stipulated in the lease.

The last alternative presented is private financing. Although most performance contractors are capable of providing financing, interest rates are higher and the performance contractor takes on another element of risk that is added to the risk already in place for the guaranteed savings and project cost risk. The higher cost of this financing typically is not a good choice for municipalities compared to less expensive financing sources.

APPENDIX A: RATE SCHEDULES

SCHEDULE "G"

General Service Non-Demand

Availability:

Applicable to general light and/or power loads less than or equal to 5,000 kilowatthours per month, and less than or equal to 25 kilowatts, and supplied through a single meter.

When the customer's load exceeds 5,000 kilowatthours per month three times in a twelve-month period, or in the opinion of the Company, the load will exceed 25 kilowatts of demand, a demand meter will be installed and the customer's billing will be transferred to Schedule "J" beginning with the next billing period.

Service will be delivered at secondary voltages as specified by the Company, except where the nature or location of the customer's load makes delivery at secondary voltage impractical, the Company may, at its option, deliver the service at a nominal primary voltage as specified by the Company. Service supplied at primary voltage shall be subject to the special terms and conditions set forth below.

RATE:

CUSTOMER CHARGE:

Single phase service - per month	$31.50
Three phase service - per month	$54.50

ENERGY CHARGE: (To be added to Customer Charge)

All kWhr per month - per kWhr	31.5858 ¢

Energy Cost Adjustment Clause:

The energy cost adjustment provided in the Energy Cost Adjustment Clause shall be added to the Customer and Energy Charges.

Integrated Resource Planning Cost Recovery Provision:

The Integrated Resource Planning Cost Recovery Provision shall be added to the Customer and Energy Charges, and energy cost adjustment.

Minimum Charge: Customer Charge

Schedule "G" (Continued)

Primary Supply Voltage Service:

Where, at the option of the Company, service is delivered and metered at the primary supply line voltage of 2400 volts or more, the above energy charge will be decreased by 2.8%. When customers' transformers are adjacent to the delivery point, the Company may permit the customer to be metered at a single point on the secondary side of his transformers where such point is approved by the Company. When the energy is metered on the secondary side of the customers' transformers, the above energy charge will be decreased by 0.7%.

Rules and Regulations:

Service supplied under this rate shall be subject to the Rules and Regulations of the Company.

SCHEDULE "J"

General Service Demand

Availability:

Applicable to general light and/or power loads which exceed 5,000 kilowatthours per month three times within a twelve-month period or which exceed 25 kilowatts but are less than 200 kilowatts per month, and supplied through a single meter.

Service will be delivered at secondary voltages as specified by the Company, except where the nature or location of the customer's load makes delivery at secondary voltage impractical, the Company may, at its option, deliver the service at a nominal primary voltage as specified by the Company. Service supplied at primary voltage shall be subject to the special terms and conditions set forth below.

This Schedule is closed to new customers with the kW demand equal to or greater than 200 kW after January 13, 2011. Existing customers with maximum measured kW demand equal to, or greater than 200 kW per month may continue to receive service under this Schedule, until the customer transfers to other applicable rate schedule.

Customers who have loads that are less than or equal to 5,000 kilowatt hours per month and less than or equal to 25 kilowatts, for 12 consecutive months, will be transferred to Schedule G at the beginning of the next billing period.

RATE:

CUSTOMER CHARGE:

Single phase service - per month	\$38.00
Three phase service - per month	\$64.00

DEMAND CHARGE: (To be added to Customer Charge)

All kW of billing demand - per kW	\$10.25

ENERGY CHARGE: (To be added to Customer and Demand Charges)

All kWhr - per kWhr 24.8033 ¢

Energy Cost Adjustment Clause:

The energy cost adjustment provided in the Energy Cost Adjustment Clause shall be added to the Customer, Demand, and Energy Charges.

Schedule "J" (Continued)

Integrated Resource Planning Cost Recovery Provision:

The Integrated Resource Planning Cost Recovery Provision shall be added to the Customer, Demand, and Energy Charges, and energy cost adjustment.

Minimum Charge:

The monthly minimum charge shall be the sum of the Customer and Demand Charges. The Demand Charge shall be computed with the above demand charge applied to the kilowatts of billing demand, but not less than $256.25 per month. The kilowatts of billing demand for the minimum charge calculation each month shall be the highest of the maximum demand for such month, the greatest maximum demand for the preceding eleven months, or 25 kw.

Determination of Demand:

The maximum demand for each month shall be the maximum average load in kilowatts during any fifteen-minute period as indicated by a demand meter. The billing demand for each month shall be the maximum demand for such month or the mean of current monthly maximum demand and the greatest maximum demand for the preceding eleven months, whichever is higher, but not less than the minimum billing demand of 25 kilowatts.

Power Factor:

For customers with maximum measured demands in excess of 200 kilowatts per month for any one time within a twelve-month period, the following power factor adjustment will apply to the above energy and demand charges.

The above energy and demand charges are based upon an average monthly power factor of 85%. For each 1% the average power factor is above or below 85%, the energy and demand charges as computed under the above rates will be decreased or increased, respectively, by 0.10%.

The average monthly power factor will be determined from the readings of a kWhr meter and kvarh meter, and will be computed to the nearest whole percent and not exceeding 100% for the purpose of computing the adjustment. The kvarh meter shall be ratcheted to prevent reversal in the event the power factor is leading at any time.

Schedule "J" (Continued)

Primary Supply Voltage Service:

Where, at the option of the Company, service is delivered and metered at the primary supply line voltage of 2400 volts or more, the energy and demand charges as computed under the above rates will be decreased by 2.8%. When customers' transformers are adjacent to the delivery point, the Company may permit the customer to be metered at a single point on the secondary side of his transformers where such point is approved by the Company. When the energy is metered on the secondary side of the customers' transformers, the above energy and demand charges will be decreased by 0.7%.

Rules and Regulations:

Service supplied under this rate shall be subject to the Rules and Regulations of the Company.

Docket No. 2009-0164; Order No. 30301, filed April 4, 2012.
Transmittal Letter Dated April 5, 2012.

SCHEDULE "P"

Large Power Service

Availability:

Applicable to large light and/or power service loads equal or greater than 200 kilowatts, supplied and metered at a single voltage and delivery point.

This Schedule is closed to new customers with the kW demand less than 200 kW after January 13, 2011. Existing customers with maximum measured kW demand less than 200 kW per month may continue to receive service under this Schedule, until the customer transfers to other applicable rate schedule.

If a Schedule P customer has loads less than 200 kW for 12 consecutive months, the customer will be transferred to Schedule J at the beginning of the next billing month.

RATE:

CUSTOMER CHARGE - per month	$400.00
DEMAND CHARGE - (To be added to Customer Charge)	
All kW of billing demand - per kW	$19.50
ENERGY CHARGE - (To be added to Customer and Demand Charges)	
All kWhr-per kWhr 21.8184 ¢	

Energy Cost Adjustment Clause:

The energy cost adjustment provided in the Energy Cost Adjustment Clause shall be added to the Customer, Demand, and Energy Charges.

Integrated Resource Planning Cost Recovery Provision:

The Integrated Resource Planning Cost Recovery Provision shall be added to the Customer, Demand, and Energy Charges, and energy cost adjustment.

Minimum Charge:

The minimum monthly charge shall be the sum of the Customer and the Demand Charges. The Demand Charge shall be computed with the above demand charges applied to kilowatts of billing demand.

Schedule "P" (Continued)

Determination of Demand:

The maximum demand for each month shall be the maximum average load in kW during any fifteen-minute period as indicated by a demand meter. The billing demand for each month shall be the maximum demand for such month or the mean of current monthly maximum demand and the greatest maximum demand for the preceding eleven months, whichever is higher, but not less than the minimum billing demand of 200 kW.

The billing kW for the minimum charge calculation each month shall be the maximum demand for the month but not less than the greatest maximum demand for the preceding eleven months nor less than 200 kW.

Power Factor:

The above demand and energy charges are based upon an average monthly power factor of 85%. For each 1% the average power factor is above or below 85%, the demand and energy charges as computed under the above rates shall be decreased or increased, respectively, by 0.10%. The power factor will be computed to the nearest whole percent.

In no case, however, shall the power factor be taken as more than 100% for the purpose of computing the adjustment.

The average monthly power factor will be determined from the readings of a kWhr meter and kvarh meter. The kvarh meter shall be ratcheted to prevent reversal in the event the power factor is leading at any time.

Special Terms and Conditions

Supply Voltage Delivery:

If the customer takes delivery at the Company's supply line voltage, the demand and energy charges will be decreased as follows:

Transmission voltage supplied without further transformation	4.4%
Distribution voltage supplied without further transformation	2.8%

Metering will normally be at the delivery voltage. When customer's transformers are adjacent to the delivery point, the customer may elect to be metered at a single point on the secondary side of his transformers where such point is approved by the Company. When the energy is metered on the secondary side of the customer's transformers, the above decreases will be 3.5% and 0.7%, respectively.

Schedule "P" (Continued)

Excessive Instantaneous Demands:

The maximum demand may be limited by contract. In order to guard against excessive instantaneous loads on its system, the Company reserves the right to install load limiting circuit breaker equipment on the customer's service to automatically limit the maximum demand to the contract capacity.

Term of Contract:

Contracts for service under this rate shall be for not less than one year and thereafter until cancelled by six months written notice given by either party.

Rules and Regulations:

Service supplied under this rate shall be subject to the Rules and Regulations of the Company.

RIDER "M"

Off-Peak and Curtailable Rider

AVAILABILITY:

This Rider is available to customers served under rate Schedule "J" or "P" whose maximum measured demands prior to any load modifications effected under this rider, exceed 100 and 300 kilowatts, respectively. This Rider cannot be used in conjunction with Rider T, Rider I, Schedule U, Schedule TOU-J and Schedule TOU-P.

RATE:

A. Basic Rates:

The rates for service under this Rider shall be as specified under the regular Schedule "J" or "P", whichever is applicable except that the Minimum Charge and the determination of billing demand used in the calculation of demand and energy charges shall be as defined below, subject to the requirements of the Determination of Demand provision of the applicable rate schedule.

The customer shall select Option A - Off-Peak Service, or Option B - Curtailable Service:

OPTION A - OFF-PEAK SERVICE:

1) Any demand occurring during the off-peak period shall not be considered in determining the billing kW demand for each month, but shall be used in determining the excess off-peak charge. Only the maximum kW demand occurring during the on-peak period shall be used in the determination of the billing kW demand for the calculation of the demand charge, energy charge and minimum charge as specified in the regular Schedule J or P.

2) An Excess Off-Peak Charge of $1.00 per kilowatt shall be added to the regular rate schedule charges for each kilowatt that the maximum off-peak kW demand exceeds the maximum kW demand during the on-peak period.

3) For calculation of the excess off-peak charge for each month, the maximum off-peak demand and maximum demand during the on-peak period shall be the highest measured demands during the respective periods for such month.

Rider "M" (Continued)

4) The time-of-use rating periods shall be defined as follows:

On-Peak Period	7 a.m.-9 p.m.	Fourteen hours, Daily
Off-Peak Period	9 p.m.-7 a.m.	Ten continuous hours, Daily

5) The monthly minimum charge shall be the sum of the customer charge and demand charge in the applicable rate schedule, and the Excess Off-Peak Charge and Time of Day Metering Charge specified below.

OPTION B - CURTAILABLE SERVICE:

1) A customer who chooses curtailable service shall curtail its kW load during the Company's curtailment hours, and shall specify the curtailable kW load. This curtailable load must be load that is normally operated during the Company's curtailment hours and must be at least 50 and 150 horsepower for motor loads under Schedules "J" and "P", respectively, or 50 and 150 kilowatts for other than motor loads. The Company may install a meter to measure the customer's curtailable load prior to start of curtailable service under this Rider.

2) For billing purposes, the curtailed demand shall be determined monthly as the difference between the maximum kW demand outside of the curtailment hours and the maximum kW demand during the curtailment hours measured for each month, but not to exceed the curtailable kW load specified in the customer's Rider M contract.

3) The customer shall choose one of the curtailment periods specified below. The billing demand under this curtailable service option shall be the normal billing demand under Schedule "J" or "P" reduced by:

Option 1) 75% of the curtailed demand if the curtailment period is fixed throughout the year from 5 p.m. to 9 p.m., Monday through Friday; or

Option 2) 40% of the curtailed demand if the curtailment period is two (2) consecutive hours as specified by the Company.

Docket No. 05-0315; *Order Approving Hawaii Electric Light Company, Inc.'s Revised Tariff Sheets and Rate Schedules, Filed on November 12, 2010, As Amended*, Filed January 7, 2011
Transmittal Letter dated January 13, 2011.

Rider "M" - Continued

5) The monthly minimum charge shall be the sum of the customer charge and demand charge in the applicable rate schedule, and the Time-of-Day Metering Charge specified below.

Where the Company specifies the curtailment hours, the Company shall give the customer at least 30 days notice prior to changing the curtailment period.

B. TIME-OF-DAY METERING CHARGE:

The Company shall install a time-of-use meter to measure the customer's maximum kW load during the time-of-day rating periods and curtailment periods.

An additional time-of-day metering charge of $10.00 per month shall be assessed to cover the additional cost of installing, operating, and maintaining a time-of-use meter.

C. TERMS OF CONTRACT:

1. The initial term of contract shall be at least 3 years. Thereafter, the contract will be automatically renewed in 3-year increments until terminated by either party by a 30-day written notice.

2. A customer applying for service under this Rider shall sign a standard Rider M contract form with the Company.

3. The customer shall be allowed to take service under this Rider for a six-month trial period without penalty for termination within this period.

4. If the contract is terminated after the six months trial period, but before the first three-year period which begins from the start date of the customer's service under this Rider, the customer shall be assessed a termination charge equal to the last six months discount received under this Rider.

5. The customer may request a change of Rider options (Option A - Off-Peak Service or Option B - Curtailable Service) or curtailment hours (Options 1 or 2 under Curtailable Service) by providing a 30-day written notice to the Company. The change

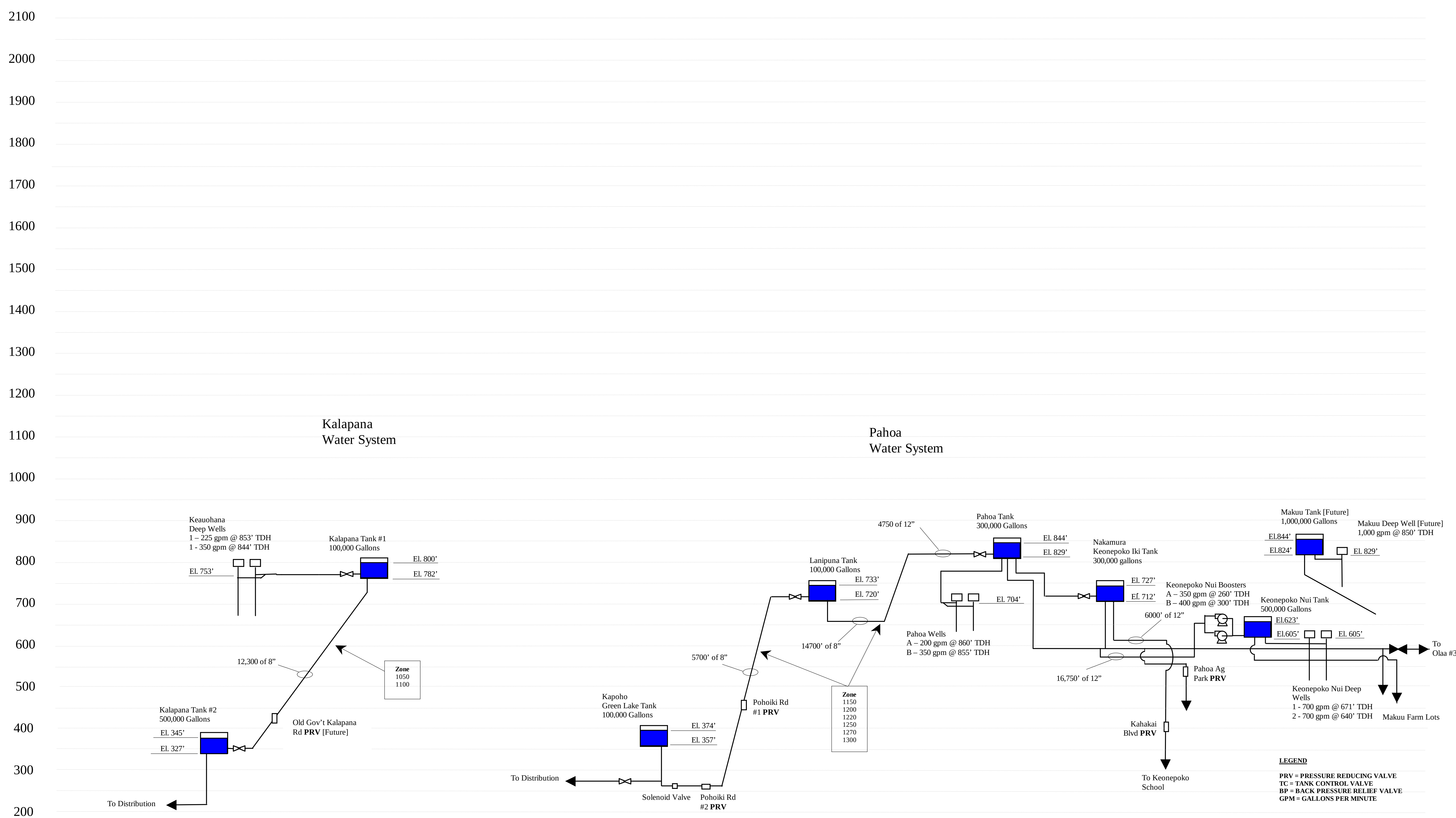
Rider "M" - Continued

will become effective after the next regular meter reading following the receipt of such written notice by the Company, provided however, the Company may not be required to make such change until 12 months of service has been rendered after the last change, unless a new or revised Rider has been authorized, or unless a customer's operating conditions have altered so as to warrant such change.

6. If under the curtailable service option the customer fails to curtail his maximum demand during the curtailment period three times within a twelve-month period, the Company may terminate the Rider M contract by a 30-day written notice to the customer. If service under this Rider is terminated due to the customer's failure to curtail his demand as provided in the contract, the customer shall be assessed a termination charge equal to the last six-months discount received under this Rider.

7. Service supplied under this Rider shall be subject to the Rules and Regulations of the Company.

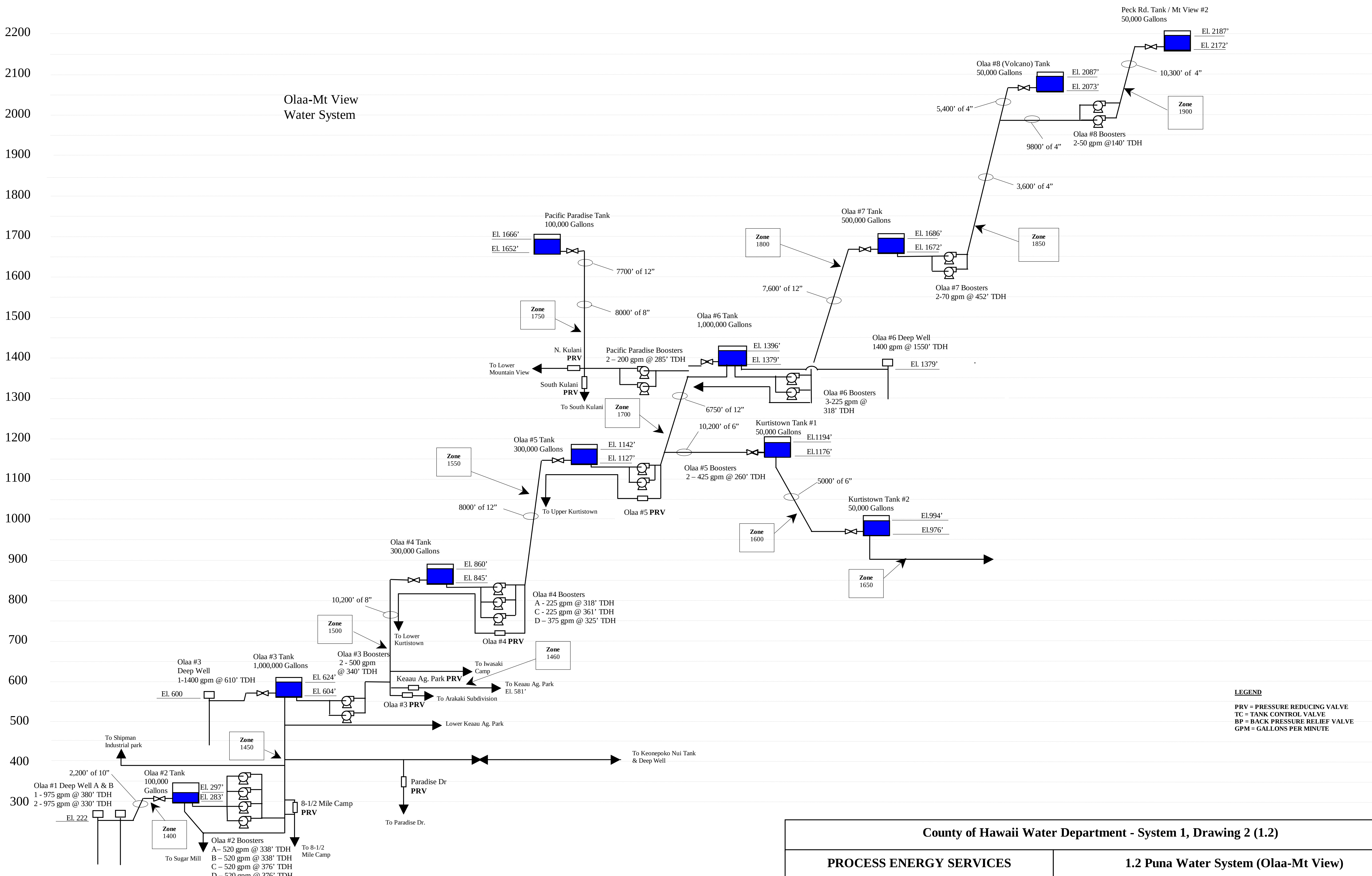
APPENDIX B: DRAWINGS



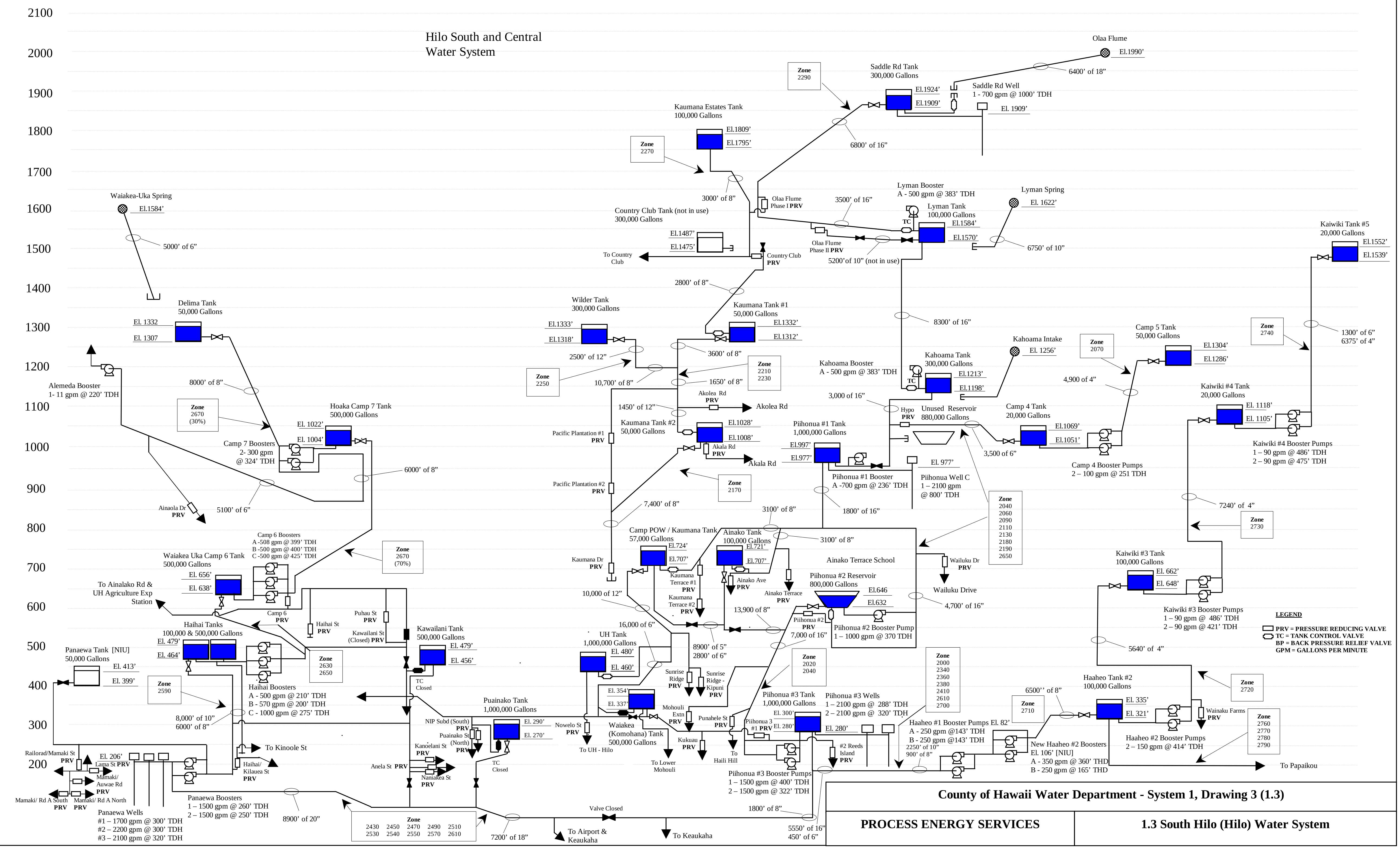
County of Hawaii Water Department - System 1, Drawing 1 (1.1)

PROCESS ENERGY SERVICES

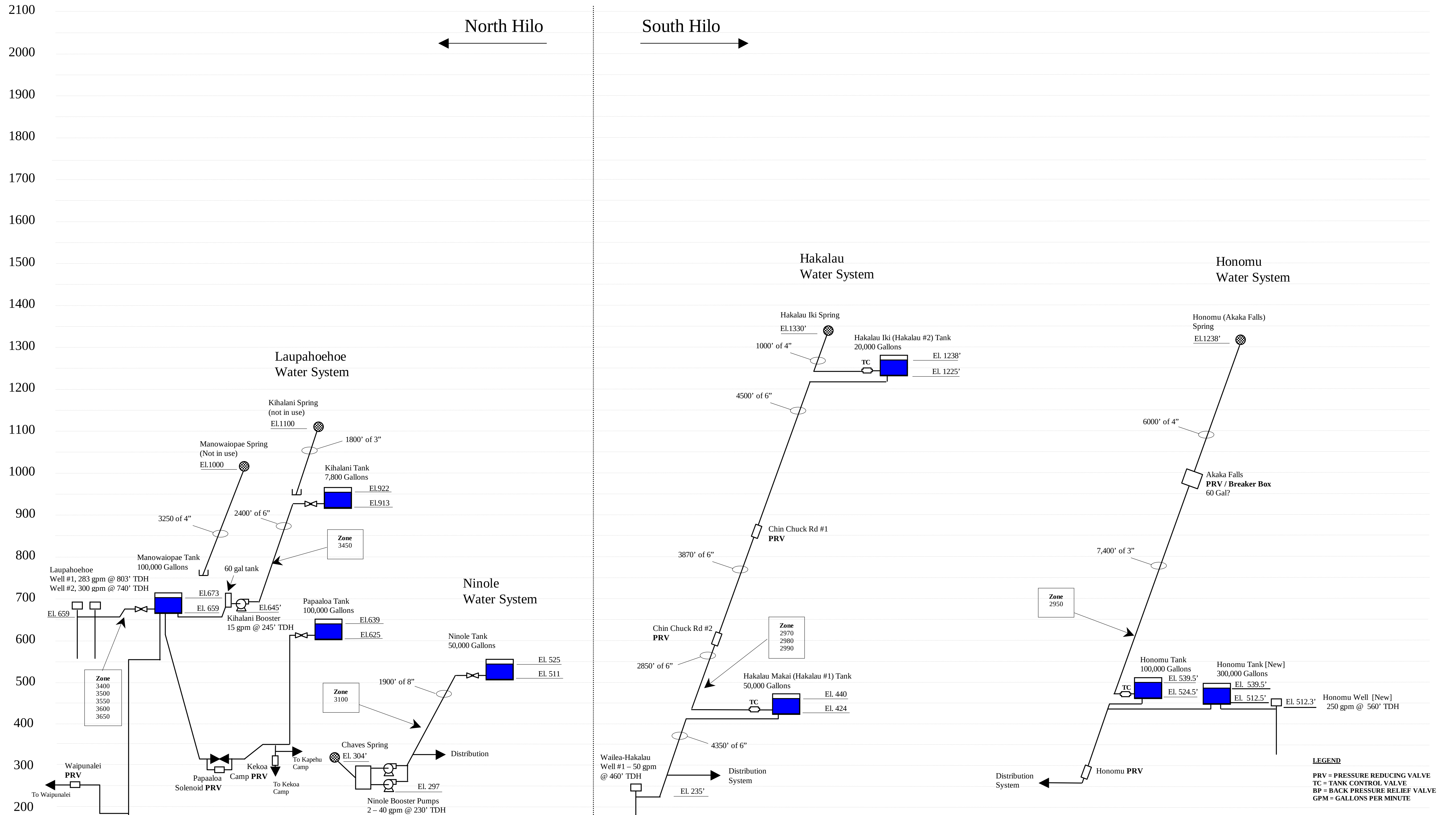
1.1 Puna Water System (Kalapana, Pahoa)



County of Hawaii Water Department - System 1, Drawing 2 (1.2)	
PROCESS ENERGY SERVICES	1.2 Puna Water System (Olaa-Mt View)

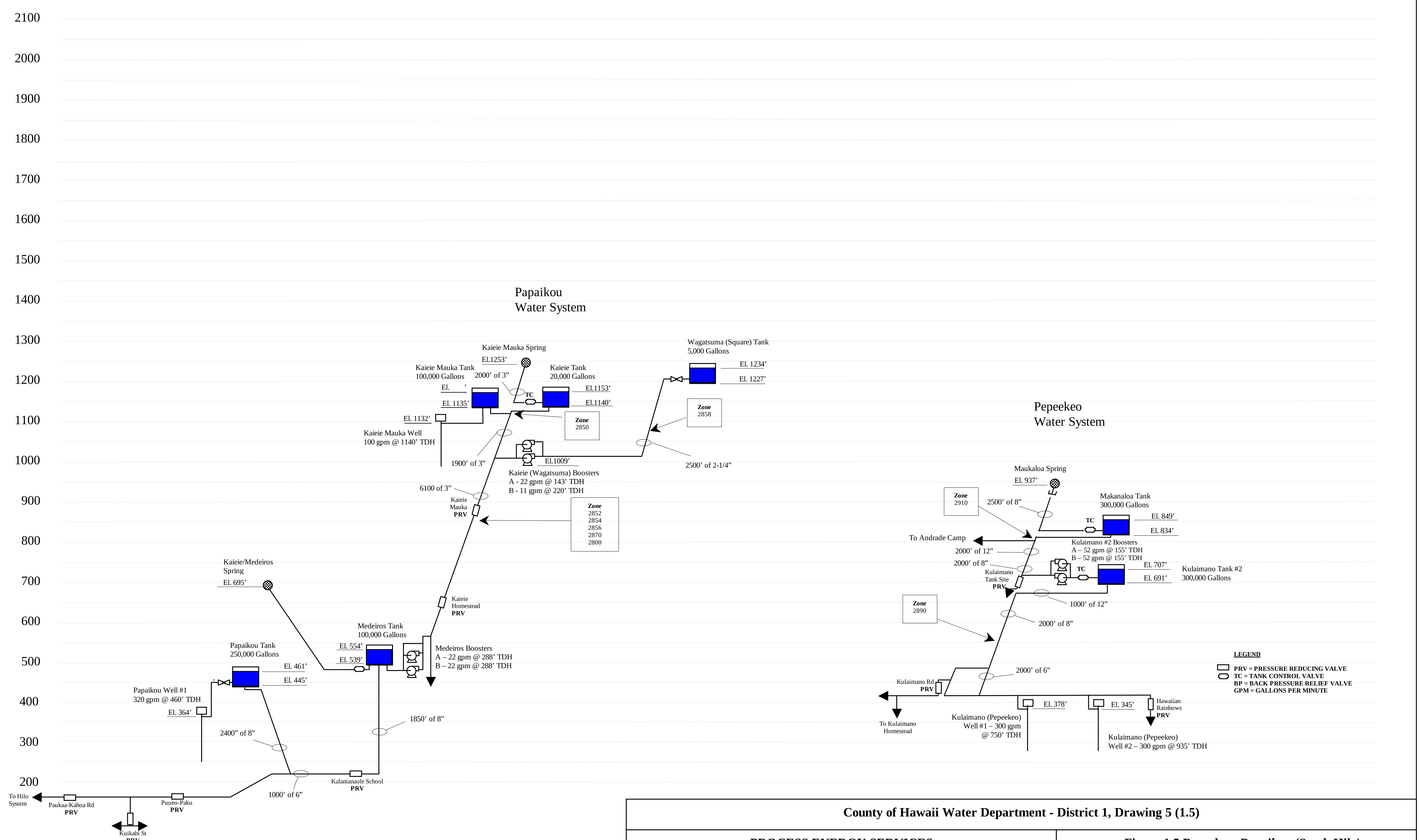


County of Hawaii Water Department - System 1, Drawing 3 (1.3)	
PROCESS ENERGY SERVICES	1.3 South Hilo (Hilo) Water System



County of Hawaii Water Department - System 1, Drawing 4 (1.4)

PROCESS ENERGY SERVICES	1.4 South/North Hilo (Laupahoehoe, Ninole, Hakalau, Honomu)



County of Hawaii Water Department - District 1, Drawing 5 (1.5)

PROCESS ENERGY SERVICES	**Figure 1.5 Pepeekeo, Papaikou (South Hilo)**

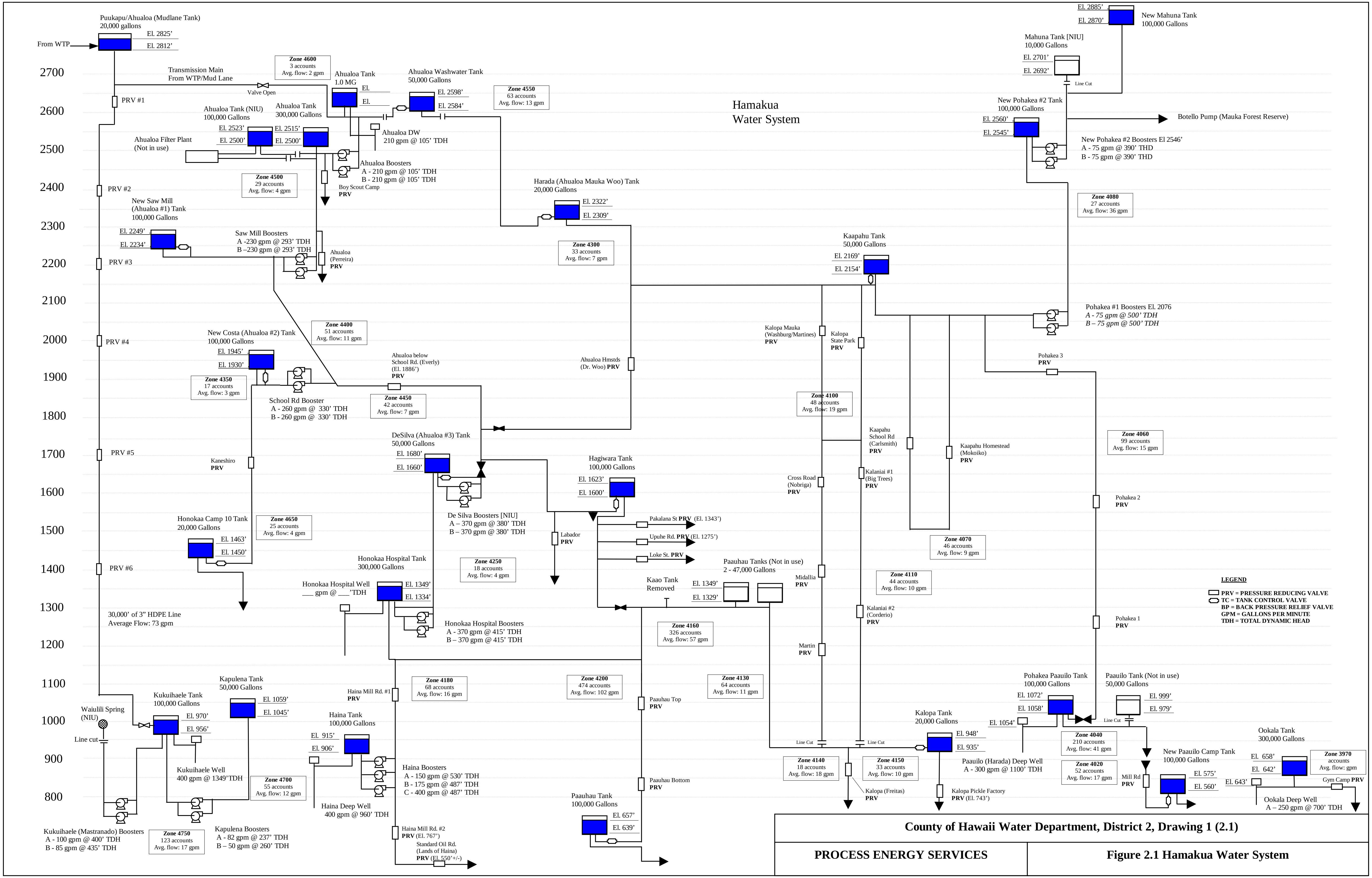
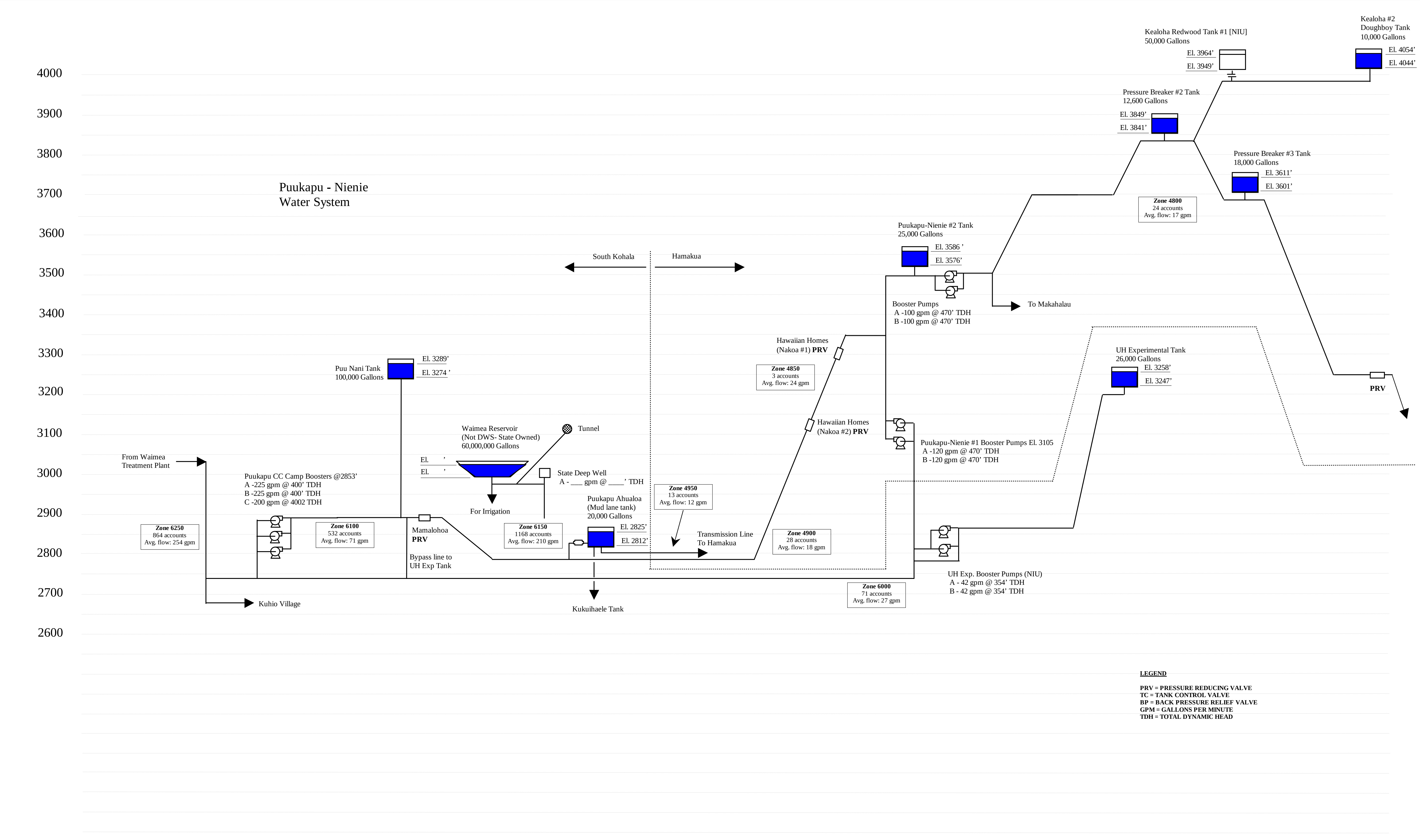
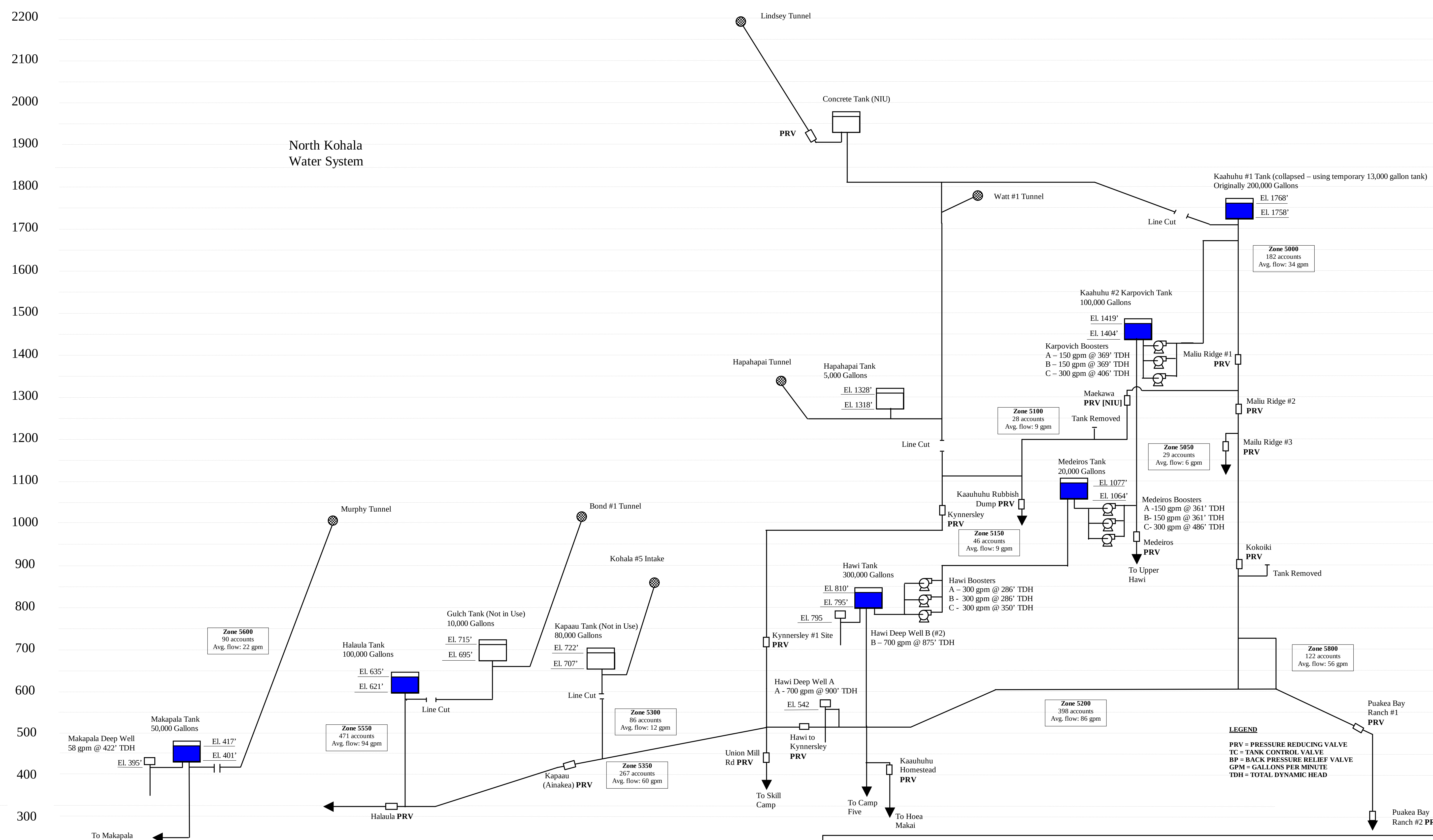


Figure 2.1 Hamakua Water System

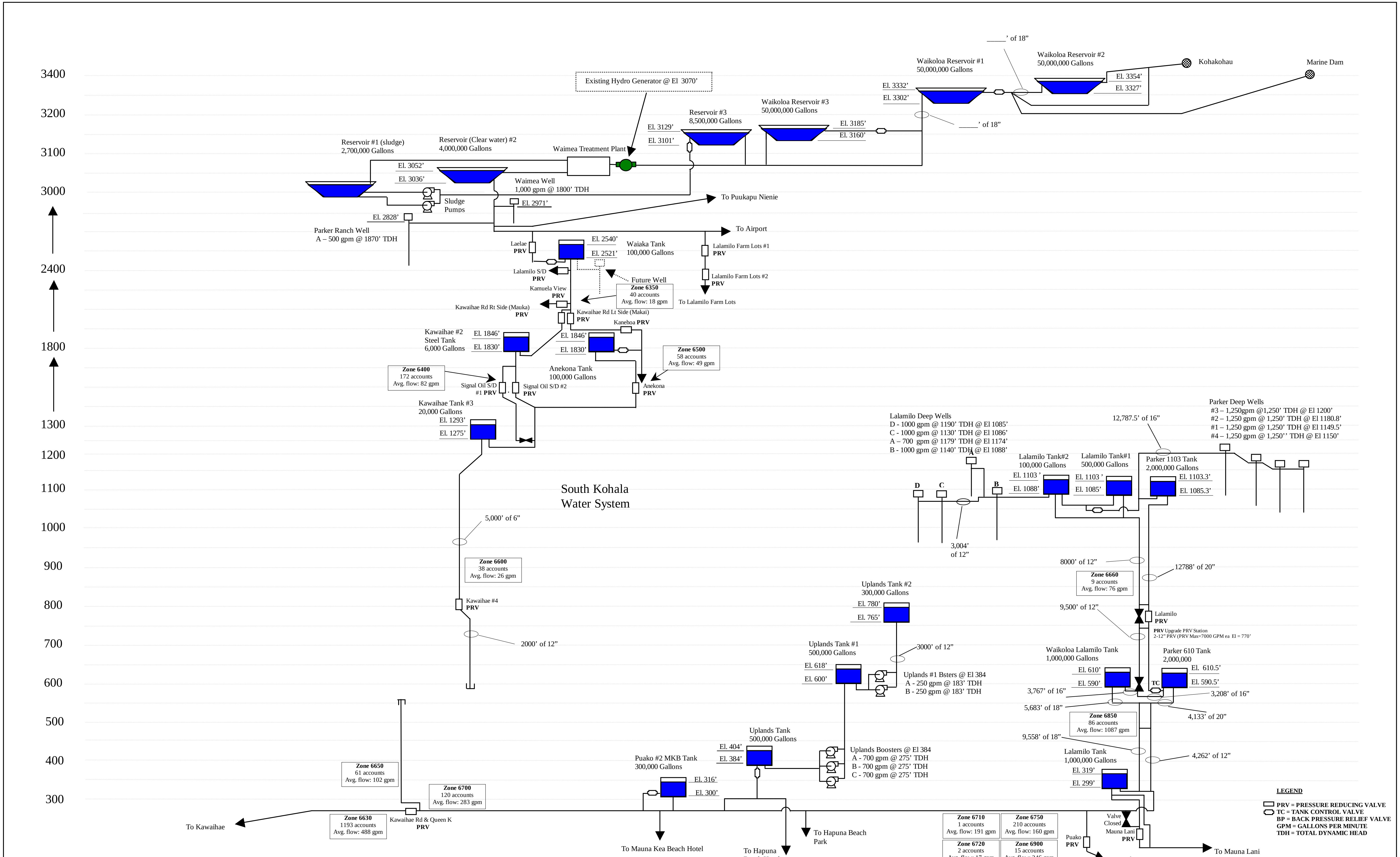


County of Hawaii Water Department, District 2, Drawing 2 (2.2)

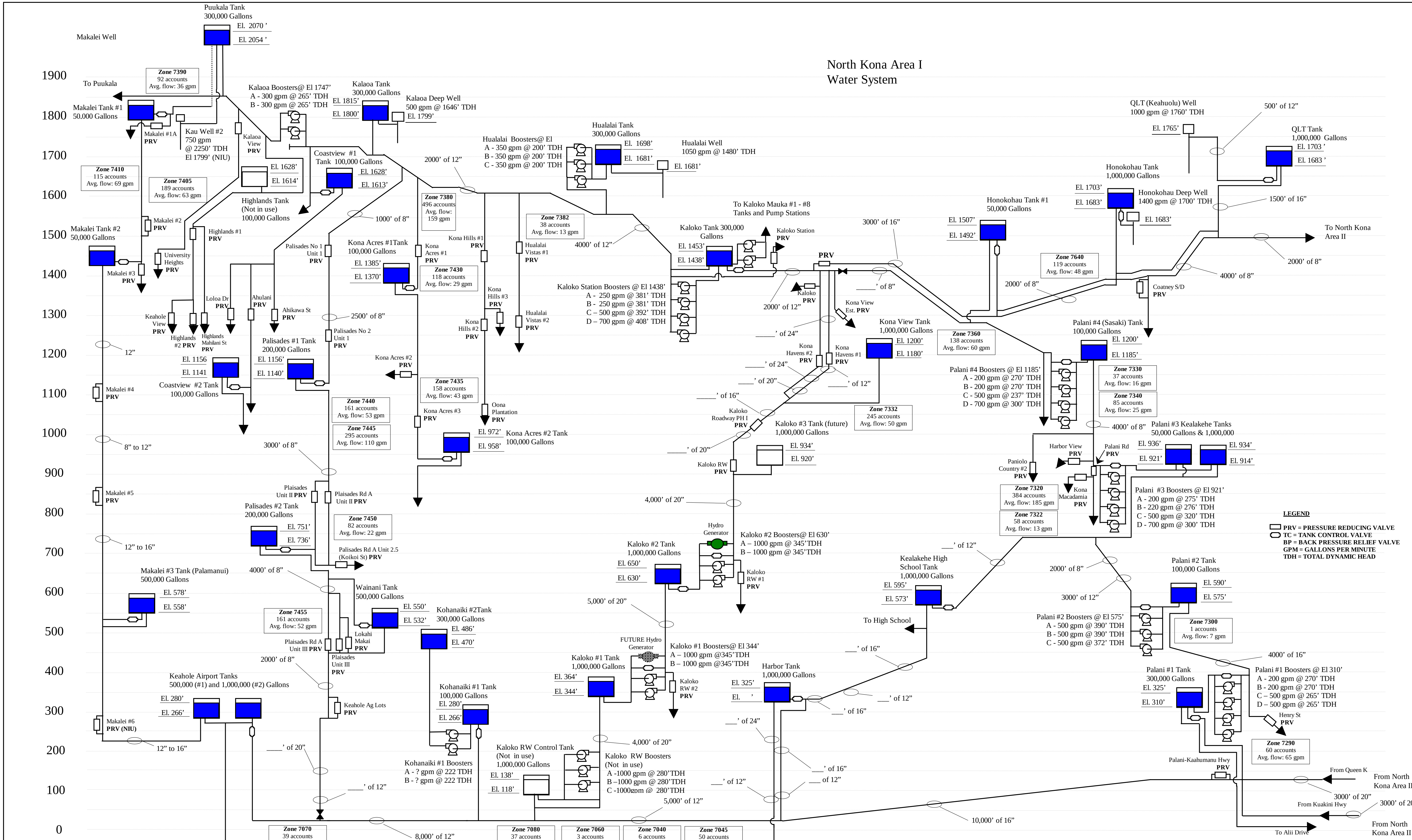
PROCESS ENERGY SERVICES	**Figure 2.2 Pukkapu-Nienie Water System (Hamakua)**



County of Hawaii Water Department, District 2, Drawing 3 (2.3)	
PROCESS ENERGY SERVICES	Figure 2.3 North Kohala Water System



County of Hawaii Water Department, District 2. Drawing 4 (2.4)	
PROCESS ENERGY SERVICES	Figure 2.4 South Kohala Water System



County of Hawaii Water Department, District 3, Drawing 1 (3.1)

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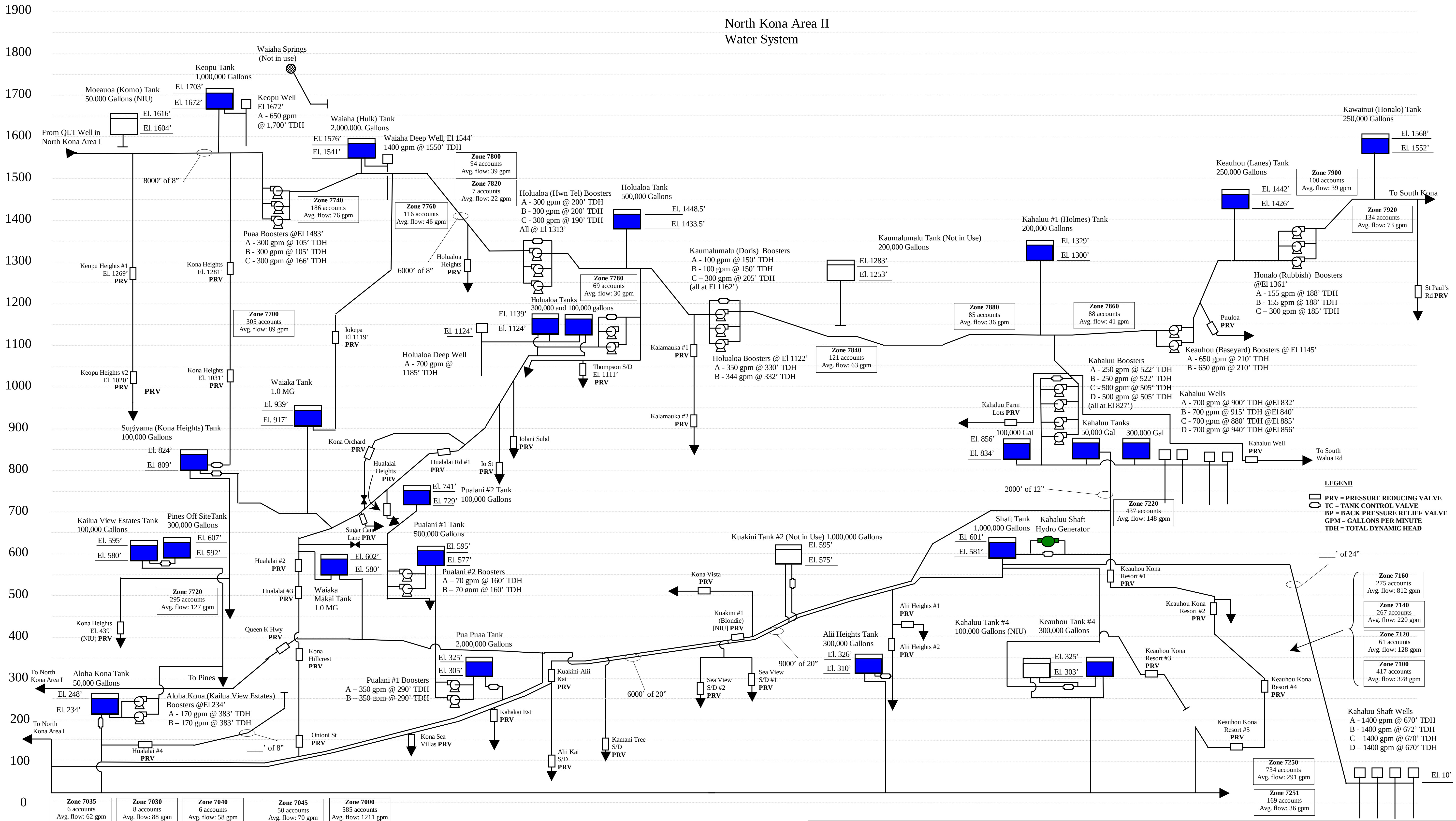
Figure 3.1 North Kona Area I Water System



County of Hawaii Water Department, District 3, Drawing 2 (3.2)

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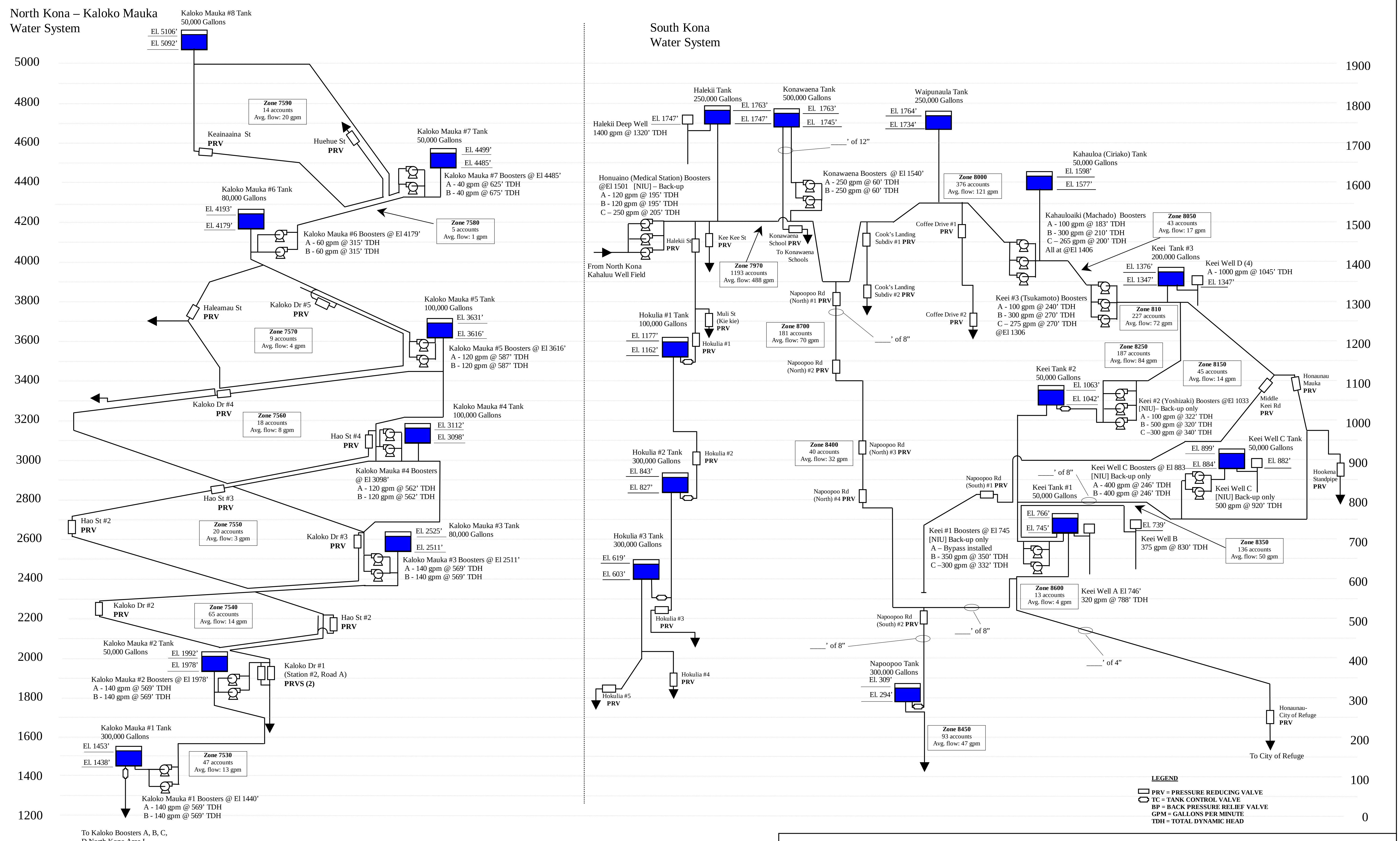
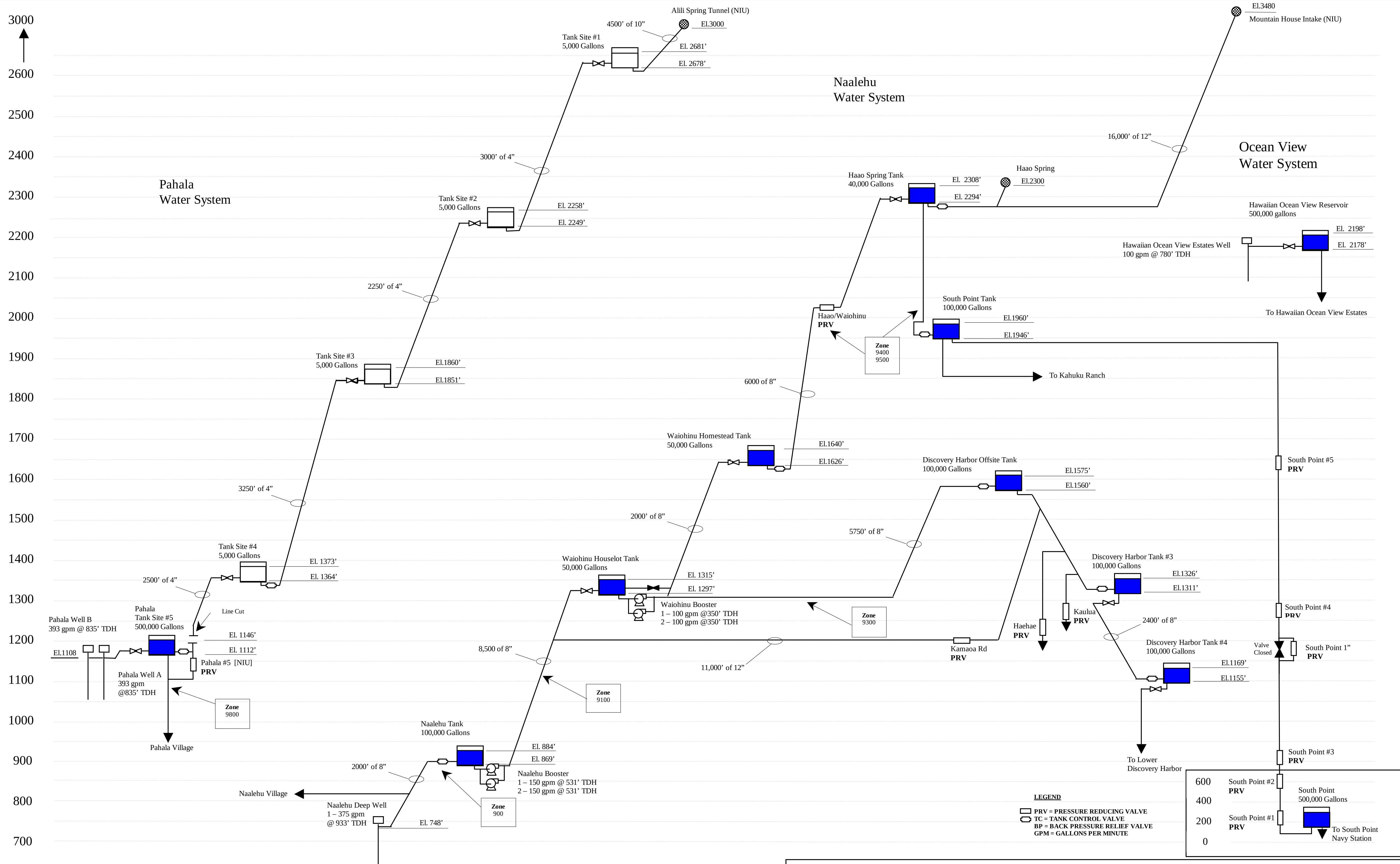
Figure 3.2 North Kona Area II Water System



County of Hawaii Water Department, District 3, Drawing 3 (3.3)

PROCESS ENERGY SERVICES	Figure 3.3 North Kona -Kaloko Mauka and South Kona Water System



County of Hawaii Water Department, District 4, Drawing 1 (4.1)	
PROCESS ENERGY SERVICES	**Figure 4.1 Kau Water System Elevation**

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